Universidade do Minho
Escola de Engenharia

Marcos Daniel Xavier Batista

A BIM-Based Computational Framework for Design with Reclaimed Building Elements

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Master Dissertation
European Master in Building Information Modelling

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August, 2026

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RESUMO

Framework Computacional em BIM para Projetos com Elementos Construtivos Reaproveitados

O setor da construção está entre os maiores consumidores de matérias-primas e geradores de resíduos a nível global. Ao mesmo tempo, uma parte significativa dos materiais com potencial de reutilização já se encontra incorporada nos edifícios existentes. Os métodos de Design for Disassembly (DfD) desenvolvidos nas últimas décadas oferecem uma base útil para avaliar componentes discretos e ligações reversíveis, mas são menos adequados a construções monolíticas e irregulares, como paredes de adobe, taipa ou alvenaria de pedra, onde os elementos não foram concebidos como partes separáveis. Além disso, mesmo quando o potencial de reutilização pode ser avaliado, essa informação nem sempre permanece associada ao elemento ao longo do tempo, sobretudo em edifícios antigos com pouca documentação disponível.

Esta dissertação desenvolve um framework de avaliação de potencial de reutilização baseado em BIM, aplicável tanto a elementos componentizados como a construção monolítica. A avaliação é registada diretamente no modelo através de parâmetros compatíveis com IFC, permitindo que os dados possam ser exportados, lidos e transferidos entre projetos. O trabalho segue uma estratégia de Design Science Research e o framework foi implementado através de um plugin funcional e aplicado a um edifício existente que reúne diferentes tipos de construção.

No estudo de caso, foram avaliados oitenta elementos. Os resultados foram organizados num painel público e foi também testada a transferência de um passaporte digital para outro projeto BIM, mantendo a identificação do elemento, os dados de avaliação e o respetivo histórico de ciclo de vida. A aplicação mostrou que o mesmo fluxo de trabalho pode ser usado para avaliar elementos sujeitos a lógicas construtivas distintas e que a informação gerada pode continuar associada ao elemento para além do projeto de origem.

O principal contributo do trabalho está na extensão da avaliação de reutilização baseada em BIM a elementos que não se enquadram bem nos métodos convencionais de DfD centrados em componentes. O estudo de caso demonstra essa aplicação num edifício histórico com construção predominantemente monolítica e mostra como os resultados da avaliação podem ser integrados num registo digital transferível para contextos futuros de reutilização.

Palavras-chave: BIM; Circularidade; Desmontagem; Passaporte digital; Reutilização.

ABSTRACT

The construction sector is one of the largest consumers of raw materials and generators of waste worldwide. At the same time, a large share of the material that will need to be managed in the coming decades is already contained in the existing building stock, making the recovery and reuse of existing elements particularly important. Design for Disassembly (DfD) methods developed over recent decades provide a useful basis for assessing discrete components and reversible connections, but they are less suited to monolithic and irregular construction, such as adobe walls, rammed earth, or stone masonry, where elements were not conceived as separable parts. In addition, even when reuse potential can be assessed, this information does not always remain associated with the element over time, particularly in older buildings with limited documentation.

This dissertation develops a BIM-based framework for assessing reuse potential, applicable to both componentised elements and monolithic construction. The assessment is recorded directly in the model through IFC-compatible parameters, allowing the data to be exported, read, and transferred between projects. The research follows a Design Science Research strategy, and the framework was implemented through a functional plugin and applied to an existing building that combines different construction types.

In the case study, eighty elements were assessed. The results were organised in a public dashboard, and the transfer of a digital passport to a separate BIM project was also tested, preserving the element identification, assessment data, and lifecycle history. The application showed that the same workflow can be used to assess elements governed by different construction logics and that the information generated can remain associated with the element beyond the project in which it was originally created.

The main contribution of this work lies in extending BIM-based reuse assessment to elements that are not adequately addressed by conventional component-centred DfD methods. The case study demonstrates this application in a historic building with predominantly monolithic construction and shows how assessment results can be incorporated into a transferable digital record for future reuse contexts.

Keywords: BIM; Circularity; Design for Disassembly; Digital Passport; Reuse.

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LIST OF ACRONYMS AND ABBREVIATIONS

API	Application Programming Interface
BIM	Building Information Modelling
BIM-DAS	BIM-based Deconstructability Assessment Score
bSDD	buildingSMART Data Dictionary
CA	Connection Accessibility
CEN	European Committee for Standardization
CPR	Construction Products Regulation
CT	Connection Type
D-DAS	Disassembly and Deconstruction Analytics System
DfADR	Design for Adaptability, Disassembly and Reuse
DfD	Design for Disassembly
DPP	Digital Product Passport
DSR	Design Science Research
ESPR	Ecodesign for Sustainable Products Regulation
EU	European Union
GPE	Geometry/Product Edge
GUID	Globally Unique Identifier
ID	Independency
IFC	Industry Foundation Classes
ISO	International Organization for Standardization
MP	Material Passport
Pset	Property Set
SJM	São José de Mipibu
TRACE	Tangible Reuse Assessment for Construction Elements

INTRODUCTION

Context and motivation

The construction sector is one of the largest consumers of raw materials and generators of waste worldwide. A large share of the material that will need to be managed in the coming decades is already contained in the existing building stock, which makes the recovery and reuse of existing elements particularly important. Over the last two decades, Design for Disassembly (DfD) research has developed methods for assessing how easily building components can be removed and reused. More recently, the EU Ecodesign for Sustainable Products Regulation and the Construction Products Regulation have reinforced this direction by introducing requirements for structured digital information linked to construction products over their lifecycle.

The principle behind material circularity, however, is much older than the contemporary circular economy debate. In Book XV of Ovid's *Metamorphoses*, transformation is presented as a condition of continuity rather than disappearance: everything changes, but nothing simply ceases to exist. Centuries later, the same underlying idea acquired a scientific basis through the law of conservation of mass associated with Antoine Lavoisier, commonly summarised by the phrase that nothing is created, nothing is lost, and everything is transformed. In a very different cultural context, Jorge Drexler returns to almost the same idea in *Todo se transforma*: "Nada se pierde, todo se transforma." Across literature, science, and music, the language changes, but the underlying principle remains remarkably consistent: transformation does not necessarily imply loss. For the built environment, this distinction is particularly relevant. A building element that reaches the end of one use does not automatically lose its material value; what changes is its condition, context, and possible future role. The challenge is to recognise that value before it is discarded and to preserve enough information for it to be considered again.

These approaches, however, are generally based on the idea of a building element as a discrete and identifiable product. Many existing buildings do not fit this logic, especially older and vernacular structures. Adobe walls, rammed earth, rubble stone, and other monolithic or irregular forms of construction were not assembled from clearly separated components and cannot always be evaluated using the same criteria as modern component-based systems. This leaves an important part of the existing building stock only partially addressed by current assessment methods and emerging passport approaches.

Even when reuse potential can be assessed, the information has limited value if it is not preserved beyond the moment of assessment. Building Information Modelling has become an important means of managing construction information digitally, while material passport initiatives have shown how lifecycle data can be linked to individual building elements and transferred through digital models, including Industry Foundation Classes (IFC). These systems, however, tend to work most naturally with elements that already exist as identifiable products with defined properties and boundaries. Monolithic and irregular building fabric presents a more difficult case.

For this reason, an assessment method alone is not sufficient. The information produced during the assessment also needs a digital structure that can preserve the element's identity, condition, reuse potential, and lifecycle history over time. Without that continuity, valuable information may be lost when the element is removed, transferred, or considered for another use. The challenge addressed in this dissertation is therefore both methodological and digital: how to assess building elements that fall outside conventional component-based DfD logic, and how to carry the resulting information forward in a form that remains usable beyond the original assessment.

Problem statement

The problem addressed in this dissertation concerns the reuse potential of existing building elements and the way that potential is assessed and recorded. A significant part of the existing building stock could, in principle, provide materials and components for reuse rather than becoming waste. For elements with defined geometry and discrete, reversible connections, Design for Disassembly methods already provide a relatively established basis for this assessment. Since Durmisevic's (2006) original work, several scoring methods have been developed to evaluate how easily such components can be removed and reused.

The situation is less clear for monolithic and irregular construction. Adobe, rammed earth, rubble stone, and similar forms of building fabric were not assembled from separable components and cannot be evaluated in the same way. In many cases, these elements fall outside the criteria used by conventional DfD methods, which means that their reuse potential may never be formally assessed before demolition.

This difference can also be seen in the broader end-of-life pathways available to building elements. Figure 1, adapted from Akinade et al. (2015), shows the possible routes from demolition or deconstruction to different end uses. Discrete components can follow a direct reuse route when they can be recovered intact and transferred to another building. Monolithic and irregular materials are less clearly represented in this logic. Without an assessment method suited to their physical characteristics, they are more likely to remain within the demolition and waste-management route, even when some form of recovery or reuse may still be possible.

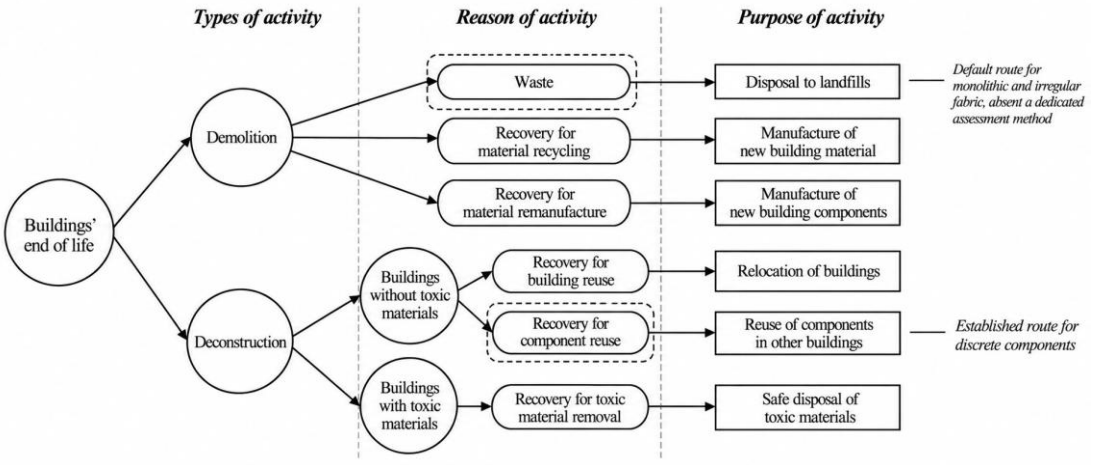


Figure 1 - Building end-of-life pathways and reuse routes. Adapted from Akinade et al. (2015).

This limitation is particularly relevant for older and vernacular buildings, where monolithic construction is common. Many of these buildings are now undergoing major renovation, adaptation, or demolition, which is precisely when decisions about recovery and reuse need to be made. A framework intended to support circularity in the existing building stock therefore needs to address more than modern, component-based construction.

A second issue concerns what happens to the information once an assessment has been carried out. Material passports and BIM-based approaches have shown that lifecycle information can be linked to individual building elements and transferred through digital models, while emerging EU regulation is moving in the same direction for construction products placed on the market. However, an assessment is of limited practical value if its results cannot remain associated with the element after removal, transport, storage, or reinstallation.

The problem is therefore both methodological and digital. Some existing building elements are difficult to assess using current DfD methods, while the information produced during assessment may also be lost if it is not recorded in a structure that can persist over time. This is particularly relevant for vernacular and non-standard construction, where both the assessment method and the digital record are often missing. The dissertation addresses these two issues together: how to assess reuse potential in elements that fall outside conventional component-based DfD logic, and how to preserve that assessment in a digital form that can support later reuse decisions.

Research questions and sub-questions

The problems identified above lead to three research questions, together with a broader question that applies across the framework. The first concerns how the reuse potential of existing building elements can be assessed in a consistent and operational way. The second focuses specifically on monolithic and irregular elements that cannot be meaningfully evaluated using conventional component-based Design for Disassembly criteria. The third addresses the continuity of the information produced during assessment and asks how this information can be structured, preserved, and transferred through a BIM-based digital material passport workflow so that it remains available for future reuse decisions.

Across these three questions is a broader concern: what information is actually needed to support a credible reuse decision? Assessing the present condition of an element is not necessarily enough to determine whether it can be reused. Its potential also depends on whether it can be recovered without unacceptable damage and whether a realistic second use can be identified. This distinction between describing an element and supporting a decision informed the development of the two-level framework presented in Chapter 2, particularly the assessment of monolithic and irregular elements that fall outside conventional DfD methods.

Objective and scope

The objective of this dissertation is to develop and validate a BIM-based assessment framework for establishing the reuse potential of existing building elements, covering both discrete, component-based construction and monolithic or irregular fabric. The framework also records the results of that

assessment within a digital, IFC-native passport structure that can remain associated with the element beyond the project in which it was first created.

The framework is validated through a single existing building, presented in detail in Chapter 4. The study is therefore limited to one case, one constructive context, one climate, and assessments carried out by a single assessor. The results are not intended to demonstrate that the framework will perform in the same way across other construction techniques, climatic conditions, or independent assessors without further testing.

The framework assesses reuse potential based on the evidence available at the time of assessment. It does not attempt to predict whether a receiving project, buyer, or processing route will later become available. This dissertation also does not claim compliance with the EU Digital Product Passport for construction products, as the delegated act defining its detailed technical data fields had not been published at the time of writing. Any alignment discussed later in the dissertation should therefore be understood as structural rather than as a claim of regulatory conformity. Automated inference of assessment criteria for elements that are not already represented in a suitable digital format is also outside the scope of this research.

Research methodology

Design Science Research (DSR) was adopted as the research strategy because the main contribution of this dissertation is a designed artefact rather than a purely descriptive account of an existing phenomenon. The artefact consists of a two-level assessment framework and its BIM-based implementation, developed to address the methodological gap identified in Chapter 1. In this context, the purpose of the research is not only to describe limitations in current Design for Disassembly and material passport approaches, but to propose, implement, and evaluate a practical response to them.

Hevner et al. (2004) describe design science as research centred on the creation and evaluation of artefacts intended to address identified problems. This approach is particularly suited to the present work because the framework itself is the main research output. Its relevance therefore depends not only on the reasoning behind its design, but also on whether it can be implemented and applied in a real setting.

The research follows the three-cycle model of Design Science Research. The relevance cycle connects the work to the practical problem addressed by the dissertation, namely the difficulty of assessing reuse potential across both component-based and monolithic construction. The rigor cycle connects the framework to the existing body of knowledge reviewed in Chapter 1, including Design for Disassembly, material passports, BIM, and circularity assessment methods. The design cycle covers the iterative development and refinement of the artefact itself, including the assessment framework, its parameter structure, and its digital implementation. These cycles were not treated as a fixed sequence. Development repeatedly returned to the literature, while observations made during implementation and field application informed later adjustments to the framework. Figure 02 illustrates this relationship between the problem environment, the knowledge base, and the design process.

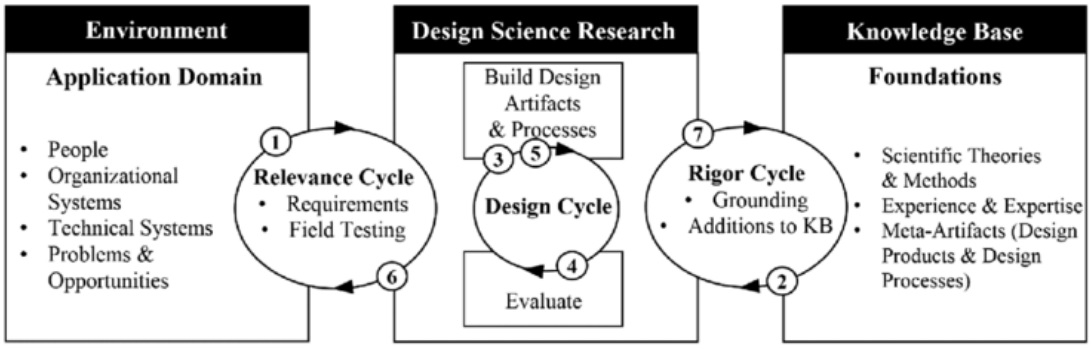


Figure 2 – Design Science Research three-cycle model. Source: Adapted from Hevner (2007).

Within this research strategy, evaluation is used to determine whether the artefact performs the function for which it was designed. The case study presented in Chapter 4 therefore serves as an evaluation environment rather than as a statistically representative sample. The aim is to examine whether the framework can be applied consistently and transparently to a real building containing the types of construction that motivated its development. The specific case-selection criteria and the limits of this validation are discussed separately in Chapter 4 and in the final discussion.

Thesis outline

Following this introduction, Chapter 1 reviews the state of the art in Design for Disassembly, material passports, and BIM-based circularity information. It traces the development of disassembly scoring methods from Durmisevic's (2006) original model through its later adaptations, examines how material passport and BIM literature has addressed information continuity for building components, and situates both against the EU's emerging regulatory landscape for digital product passports (DPP), before establishing the specific research gap this dissertation addresses.

Chapter 2 develops the assessment framework itself. It sets out the overall workflow linking field observation to digital output, the reasoning behind treating componentised and monolithic construction as requiring distinct assessment logics, the specific criteria underlying each, and the score-to-destination mapping that translates a numerical result into a practical reuse recommendation.

Chapter 3 describes the framework's technical implementation within a BIM environment, covering the shared property set the framework depends on, the two implementation pathways developed to write and read it, and the plugin and online component library built around them.

Chapter 4 presents the framework's validation against a real case study, from the building's historical and architectural context, through its construction across successive temporal layers, to the development of its BIM model, the classification of its surveyed elements, and the resulting assessment output.

Chapter 5 discusses these results in relation to the research questions set out above, considers how the framework might apply beyond this single case, and reflects critically on the two-level structure itself, before closing with the dissertation's overall contributions and limitations, as shown in Figure 3.

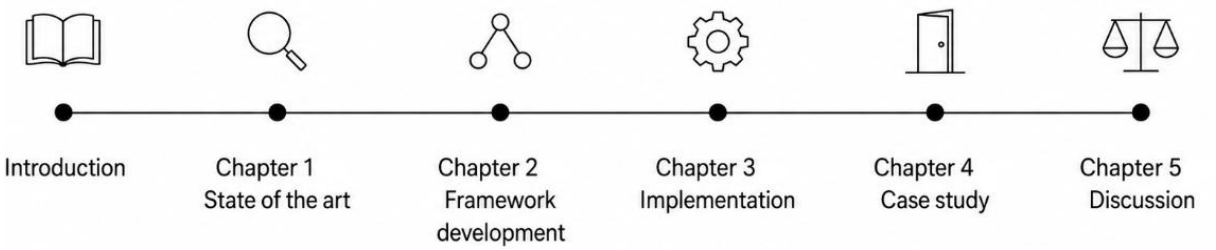


Figure 3 - Roadmap of this dissertation, from introduction to discussion. Source: Author.

Read together, these chapters move from a documented absence in the literature to a working artefact tested against a real building, and finally to a reflection on what that test does and does not establish.

1. STATE OF THE ART

This chapter builds the case for the proposed framework, section by section. It proceeds in seven sections, moving from the circular economy in construction (Section 1.1) through Design for Disassembly (Section 1.2) and its limitations for monolithic materials (Section 1.3), to material passports and BIM (Section 1.4), the EU Digital Product Passport (Section 1.5), the Industry Foundation Classes (IFC) data standard and property sets (Section 1.6), and the research gap this dissertation addresses (Section 1.7). The sequence is deliberately cumulative: each section identifies a limitation that the next begins to address. By Section 1.7, the case has been built from multiple directions, not asserted from a single premise.

1.1. Circular economy in construction

Buildings and construction activities together account for over 34% of global final energy use and 37% of energy and process-related carbon dioxide emissions (United Nations Environment Programme [UNEP], 2022), figures that have shown only modest improvement despite more than a decade of climate policy attention. The sector's environmental footprint is structurally embedded in a linear model of resource consumption, in which raw materials are extracted, processed into building components, used for the functional lifetime of a structure, and ultimately discarded as waste upon demolition (Ellen MacArthur Foundation, 2013). Within this linear logic, the end-of-life phase of a building is a disposal event, not a recovery opportunity. Table 1 summarises these figures alongside related indicators of circularity and reuse discussed in this section.

Table 1 - Key indicators of construction sector sustainability.

Indicator	Value	Source
Share of global final energy use attributed to buildings and construction.	~34%	UNEP (2022)
Share of global energy and process-related CO2 emissions attributed to buildings and construction.	~37%	UNEP (2022)
Share of the global economy currently operating according to circular principles.	7.2%	Circle Economy (2023)
Estimated share of CDW materials effectively reused in Europe	<1%	Deweerdt and Mertens (2020), as cited in Pristerà et al. (2024)
Estimated technical potential for reuse across the existing European building stock.	Up to 80%	Pristerà et al. (2024)

Construction and demolition waste (CDW) constitutes one of the largest waste categories generated within the European Union (EU), and comparable patterns are observed in other industrialized economies (Purchase et al., 2022). What is striking, however, is not its volume but the gap between what could be recovered and what actually is. Deweerdt and Mertens (2020, as cited in Pristerà et al., 2024) report that less than 1% of CDW materials are effectively reused in Europe, while the reuse potential reported for different building materials and components can reach up to 80% (Pristerà et al., 2024). That gap is the central empirical problem this dissertation addresses.

Policy has not been silent on the issue. The circular economy (CE) concept has shaped European regulatory frameworks for over a decade, from the EU Circular Economy Action Plan (European Commission, 2015) to more recent binding instruments on product sustainability and construction materials, discussed in detail in Sections 1.5 and 1.6. Yet macroeconomic data tells a sobering story: only 7.2% of the global economy currently operates according to circular principles, and that share is declining rather than growing, driven by rising material extraction and consumption worldwide (Circle Economy, 2023). More policy has not yet translated into a corresponding increase in measured circularity.

The barrier to circular construction practice is unlikely to lie primarily at the level of policy intent or technical feasibility, both of which have advanced considerably since the early 2000s. Rather, the persistence of this gap points toward deeper methodological shortcomings: an absence of standardized, objective, and scalable means of identifying which building elements are genuinely suitable for reuse, of quantifying their reuse potential, and of translating that potential into operational decisions at the scale of individual construction and demolition projects. It is precisely this methodological gap, rather than the conceptual case for circularity itself, which is by now well established, that constitutes the central concern of the present work.

The concept itself predates this policy moment by several decades Ghisellini, Cialani, and Ulgiati (2016) took a broad perspective in a comprehensive literature review, defending that the origins of CE are primarily rooted in ecological and environmental economics and industrial ecology. Wautelet (2018) identified five primary schools of thought from which CE developed: industrial ecology, cradle-to-cradle, performance economy, blue economy, and biomimicry. Each tradition emphasizes a different mechanism for closing material loops, industrial symbiosis, design for material recovery, product-as-service business models, resource cascading, and the emulation of natural systems, respectively, and each has left a distinct imprint on how circularity is operationalized across sectors.

For construction specifically, this conceptual plurality has direct practical consequences. Geissdoerfer et al. (2017) show that the circular economy has been defined in markedly different, sometimes incompatible ways across the literature, from closed-loop economic systems to business model strategies and product design approaches, with no consensus on its broader relationship to sustainability. Because construction projects routinely bring together architects, structural engineers, demolition contractors, waste management authorities, and policymakers, this ambiguity can resurface as a coordination failure: each stakeholder group may operationalize circularity differently, with correspondingly different criteria for what counts as a circular outcome. This makes a shared operational definition especially important when circularity is translated from policy and theory into project-level decisions.

The most widely cited operational definition remains that of the Ellen MacArthur Foundation (2013), which characterizes CE as restorative or regenerative by intention and design, explicitly replacing the end-of-life concept inherent to linear models with strategies of reduction, reuse, recycling, and recovery, often summarized as the 3R or, in extended formulations, the 6R framework covering reduce, reuse, recycle, redesign, remanufacture, and recover Jawahir & Bradley (2016). Figure 4 illustrates this framework, distinguishing the biological cycle, where materials return safely to natural systems, from the technical cycle, where products and components are kept in use through maintenance, reuse, and remanufacture. Within this framework, strategies that preserve the highest degree of material and product integrity, direct reuse chief among them, are positioned as preferable to strategies such as recycling, which require energy-intensive reprocessing and entail a corresponding loss of embodied value. The European Union's Waste Framework Directive 2008/98/EC formally reflects this priority, placing "preparing for re-use" ahead of recycling in its waste management hierarchy (European Parliament, 2008).

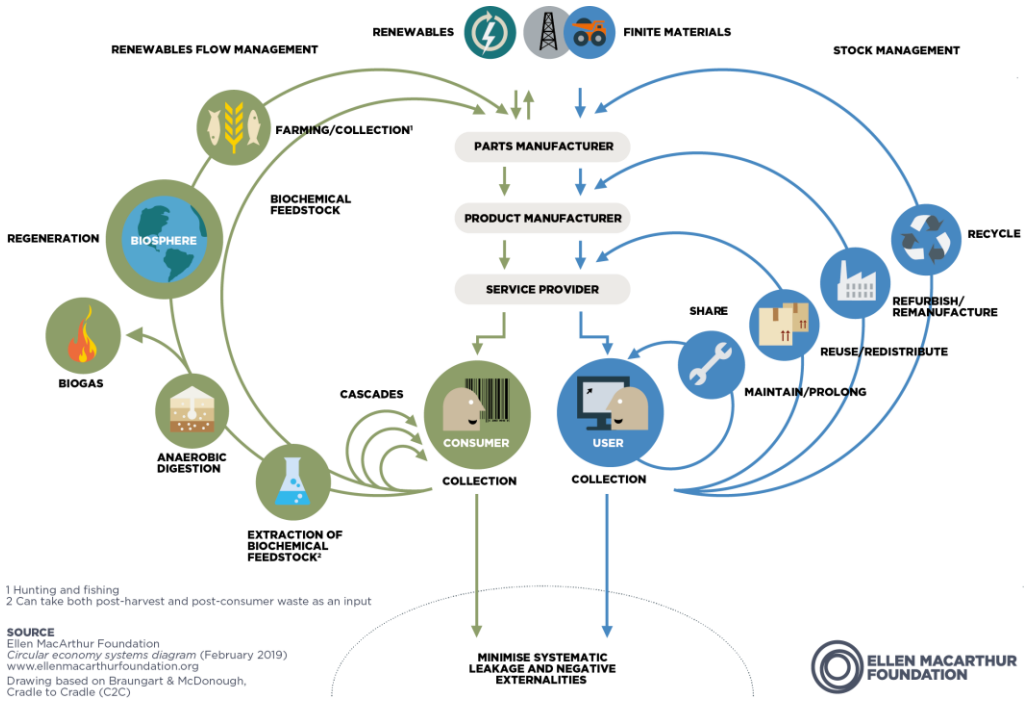


Figure 4 - Circular economy systems diagram illustrating biological and technological cycles. Source: Ellen MacArthur Foundation (2019).

Figure 5 sets out this hierarchy, placing prevention and preparing for re-use above recycling, recovery, and disposal. That hierarchy, while conceptually well established, has not been mirrored by an equivalent hierarchy of technical and methodological support. The construction sector has developed comparatively mature tools for waste sorting, recycling certification, and material flow accounting, while methodologies for assessing and operationalizing component-level reuse remain fragmented, inconsistently applied, and in many documented cases entirely absent from standard project workflows (Lambec et al., 2025). Recognizing this asymmetry is not a minor observation. It reveals a persistent gap between the theoretical ambitions of the circular economy and the practical mechanisms required to implement them within the built environment. Addressing this gap requires methodologies capable of translating circular principles into measurable design criteria and actionable workflows.



Figure 5 - Waste hierarchy established by Directive 2008/98/EC. Source: European Environment Agency / European Parliament (2008).

Institutional inertia is part of the explanation for why recycling continues to dominate over reuse in practice. Demolition practices, contractual structures, and waste management infrastructure have, for decades, been optimized around the logistics of bulk material disposal and reprocessing, rather than around the careful extraction, characterization, and redistribution of individual building elements (Addis, 2006). Küpfer et al. (2023) document a case in which deconstruction and reassembly were handled by separate contractors, a split that undermined coordination and left the deconstruction firm with no incentive to protect the components from damage, resulting in delays and storage difficulties. Even as policy rhetoric increasingly invokes circularity, the path of least resistance for most demolition contractors remains the crushing, shredding, or melting of building components for downstream recycling, rather than their preservation for direct reuse.

The environmental cost of that default is substantial. Recycling processes, while preferable to landfilling, remain energy-intensive and impose considerable environmental burdens of their own, particularly in terms of greenhouse gas emissions associated with reprocessing (Addis, 2006). Reuse, by contrast, preserves the labor, energy, and material integrity already embodied in a component, largely bypassing the need for reprocessing. The environmental impact of producing new steel sections containing 60% recycled content remains approximately 25 times higher than reusing equivalent reclaimed sections directly (WRAP, 2008, as cited in Lambec et al., 2025). The direct reuse of reclaimed structural steel and timber sections reduces associated environmental impacts by as much as 96% and 83%, respectively, relative to new production (Brütting et al., 2019; Lazarus, 2003). The scale of environmental value currently being destroyed in demolition is not marginal. It is systematic.

Recycling and reuse correspond to structurally different positions within a building's life cycle, not merely different degrees of the same strategy. Lambec et al. (2025) make this point clearly: reaching the end of a building's functional life does not mean the end of life for its constituent elements, but conventional demolition treats it as though it does. Where demolition collapses a building directly into an undifferentiated waste stream, deconstruction interposes a careful, sequential disassembly process that recovers individual elements as discrete, reusable units rather than as homogeneous debris. The choice between demolition and deconstruction is made early, and it is often irreversible. Once a building has been conventionally demolished, no assessment framework, however sophisticated, can recover what has been lost.

At the level of European policy, the Waste Framework Directive 2008/98/EC explicitly prioritizes "preparing for re-use" as the second-best end-of-life strategy after waste prevention itself, ahead of recycling, energy recovery, and disposal (European Parliament, 2008). In practice, most regulations and policies addressing post-obsolescence building assessment continue to focus predominantly on sorting and classifying demolition waste for efficient recycling, rather than on identifying which specific elements might be candidates for direct reuse (Lambec et al., 2025). The result is a persistent gap between what policy formally privileges and what technical practice is actually equipped to deliver.

Research from the Structural Xploration Lab (SXL) at EPFL has added precision to this diagnosis (Sivers & Fivet, 2025a). Existing circularity assessment tools, such as the Material Circularity Indicator (MCI) and BSI, primarily quantify material circularity at aggregate levels and do not directly evaluate project-specific reuse feasibility. While useful for measuring material circularity at broader scales, these indicators do not directly assess whether a particular component can realistically be reused in a specific project context.

Recent work by Sivers and Fivet (2025b) further argues that reuse decisions depend on dynamic, context-dependent factors that are not adequately represented by existing circularity metrics, including market demand, technical feasibility, regulatory conditions, and residual value. As a result, a component may perform well according to a circularity indicator while remaining effectively unreusable because no receiving project has been identified, transport distances are prohibitive, or no market actor is available to assess, certify, and acquire it within a viable timeframe.

Sivers et al. (2022) had already pointed toward a constructive response, cataloguing and taxonomizing the digital market solutions that cross-match supply and demand for reused building components across the European construction sector. If the central obstacle to reuse is not the absence of technical data but the failure to translate available data into operational decisions, then a digital infrastructure capable of capturing and propagating that data throughout a building's life cycle becomes a natural candidate for addressing the problem. Building Information Modeling (BIM), with its capacity to attach structured, queryable information to individual building elements and carry that information across project phases, is precisely such an infrastructure.

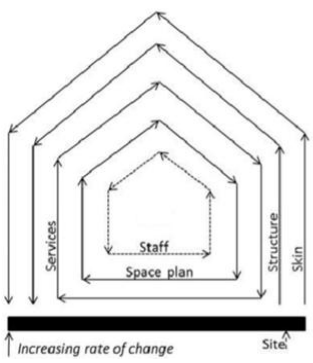
Sections 1.2 through 1.7 trace how the literature has engaged with component-level reuse assessment: beginning with the Design for Disassembly frameworks developed by Brand (1994) and Durmisevic (2006), moving to their limitations when confronted with monolithic and irregular materials such as earthen construction, through the landscape of material passports and digital product passport legislation, and concluding with a critical review of existing assessment procedures that reveals, in concrete terms, where the methodological gap identified here is most acutely felt.

1.2. Design for disassembly and reuse

By the early 1990s, a growing number of researchers and practitioners had begun to document a structural contradiction in conventional construction: buildings were designed and built as though they would never need to be changed, altered, or taken apart, yet the reality of how they were actually used told a different story. Kibert (1994), contributing to the First International Conference of CIB TG 16

on Sustainable Construction, was among the first to articulate this formally, proposing principles for sustainable construction that explicitly included maximizing resource reuse as a design objective, not simply an end-of-life consideration. Resource efficiency could not wait for demolition.

Explaining why conventional buildings resisted disassembly in the first place required a different kind of analysis. Stewart Brand, writing not as an engineer or environmental scientist but as an architectural critic, proposed in How Buildings Learn (1994) that all buildings are composed of multiple layers, each operating at a fundamentally different timescale. Brand identified six layers: Site, effectively permanent; Structure, lasting between thirty and three hundred years; Skin, replaced every twenty years or so as materials and fashions change; Services, including electrical, plumbing, and HVAC systems, turning over every seven to fifteen years; Space Plan, referring to interior partitions and layouts, shifting every three to thirty years depending on occupancy; and Stuff, the moveable objects of daily life, changing continuously. Figure 6 depicts these six layers and their typical lifespans. Each layer is governed by its own logic of use and obsolescence, and the fundamental problem with most buildings is that these layers are physically entangled with one another in ways that make it impossible to modify or replace one without damaging or destroying another.



Shearing layers	Description	Typical lifespan/activity
Site	Location and context	Permanent
Structure	Bones	30-300 years
Skin	Envelope	20+ years
Services	Lifeblood	7-20 years
Space plan	Interior layout	3 years
Stuff	Furniture and equipment	Under 3 years

Figure 6 - Shearing Layers of Change framework. Adapted from Brand (1994).

For disassembly and reuse, the implications are direct. If a building's services are embedded within its structure, replacing them at year fifteen requires damaging fabric built to last a century. If the skin is mechanically bonded to the services behind it, renewing the cladding at year twenty means tearing out systems not yet due for replacement. Brand did not use the language of Design for Disassembly, and his book was not a technical manual. His Shearing Layers framework nonetheless provided one of the first coherent theoretical account of why conventional construction generates waste: not because buildings fail uniformly, but because layers with incompatible lifespans are locked together, so that the obsolescence of any one triggers premature disposal of others. Layers with different lifespans should, in principle, be physically independent of one another. Translating that into measurable criteria proved harder than stating it.

1.2.1. Decomposition design factors and disassembly scoring

Brand's framework established the conceptual case for layer independence, but offered no method for measuring it. Against the Shearing Layers model, a building could be assessed in qualitative terms, but there was no systematic way to determine whether a specific element (a wall panel, a structural connection, a window assembly) was genuinely designed for disassembly or merely assumed to be

recoverable. Figure 7 illustrates this qualitative reading, showing disassembly potential attributed by layer, from Stuff and Space Plan, closest to the building's use, to Structure and Site, its most permanent components. That gap persisted for over a decade, until Durmisevic's doctoral dissertation at TU Delft in 2006 proposed one of the first comprehensive scoring system for quantifying the disassembly potential of individual building elements.



Figure 7 - Disassembly potential within the Layers of Brand. Redrawn by the author from van Vliet, van Grinsven and Teunizen (2021), adapted from Brand (1994).

Durmisevic (2006) built her framework on a distinction between buildings that are merely decomposable, that can be taken apart under the right conditions with sufficient effort, and buildings that are genuinely transformable, designed from the outset so that disassembly is routine rather than exceptional. Her Transformation Capacity (TC) model operationalises this distinction through a hierarchical knowledge model comprising 17 independent and 14 dependent variables (Durmisevic, 2006). At the base of this hierarchy, the 17 determining factors are organised into eight design for disassembly aspects, Functional Decomposition, Systematisation, Base Element specification, Life Cycle Coordination, Relational Pattern, Assembly process, Geometry, and Connections, themselves grouped under three types of decomposition: functional, technical, and physical (Durmisevic, 2006). These eight aspects converge, in turn, into two indicators of transformation, Independence and Exchangeability (Figure 8), whose combined result constitutes a structure's TC (Durmisevic, 2006).

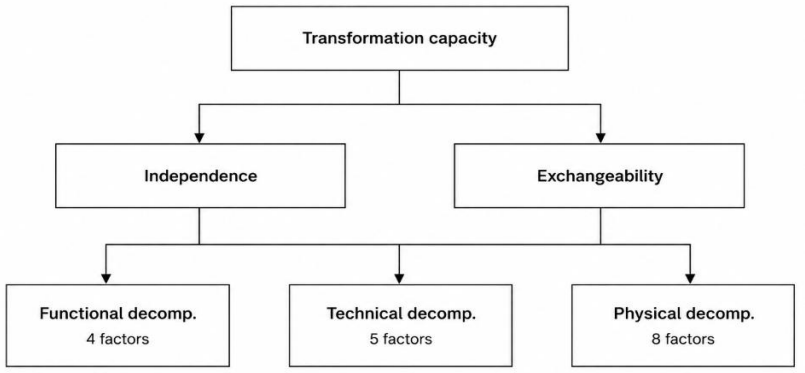


Figure 8 - Durmisevic's (2006) Transformation Capacity model. Source: Adapted from Durmisevic (2006) by the author.

Each of the 17 factors is graded on a scale from 0.1 to 1.0 against criteria specific to that factor (Table 2), and the resulting scores are aggregated through a weighted calculation involving 40 relations between variables, reflecting the differing influence each factor has on the final result (Durmisevic, 2006). Durmisevic (2006) further classifies the outcome into three categories: a TC above 0.67 indicates high disassembly potential, associated with less than 25% construction waste at deconstruction; a TC between 0.33 and 0.67 indicates medium potential, associated with 20-80% waste; and a TC below 0.33 indicates low potential, associated with more than 80% waste.

Table 2 - Durmisevic's (2006) 17 determining factors, organised by decomposition type.

Type of decomposition	DfD Aspect	No.	Determining factor
Functional decomposition	Functional decomposition	1	Functional separation
		2	Functional dependence
	Systematisation	3	Structure of material level
		4	Type of clustering
Technical decomposition	Base Element	5	Type of base element
	Life cycle coordination	6	Use life cycle coordination
		7	Technical life cycle coordination
		8	Coordination of life cycle and size
	Relational pattern	9	Type of relational pattern
Physical decomposition	Assembly process	10	Assembly direction
		11	Assembly sequences
	Geometry	12	Geometry of product edge
		13	Standardisation of product edge
	Connections	14	Type of connections
		15	Accessibility to fixings
		16	Tolerance
		17	Morphology of joints

Durmisevic's (2006) original model, with its 17 factors and weighted fuzzy calculation, was developed to assess transformation capacity at the building scale rather than to score individual elements in a design or procurement workflow. Later studies have adapted the model into simpler sets of parameters that are easier to apply at element level. Van Vliet, van Grinsven and Teunizen (2021), for example, reduce it to four parameters in the Dutch Green Building Council's Disassembly Potential Measurement Method: connection type, connection accessibility, independency, and geometry of the product edge. These draw on three of Durmisevic's determining factors and her Independence indicator (Table 2). Figure 9 situates these four parameters within the DGBC method's broader structure, where they form the technical branch of a three-part assessment alongside process aspects, such as safety and disassembly instructions, and financial aspects, such as disassembly time and residual value. Deru et al. (2026) take a similar approach, applying connection type and accessibility from Durmisevic's system in their assessment of prefabricated facade systems. Taken together, these studies suggest that later element-level applications have largely retained Durmisevic's individual factors while leaving aside the full weighted calculation of the original model.

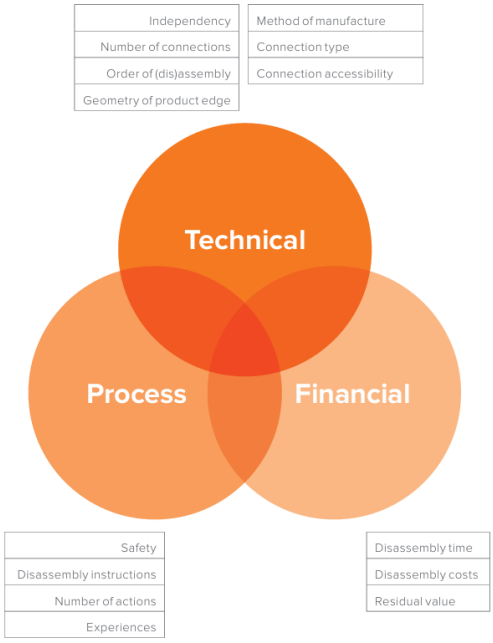


Figure 9 - Overview of aspects of disassembly potential. Redrawn by the author from van Vliet, van Grinsven and Teunizen (2021), originally from van Vliet (2018).

This model represented a genuine advance, moving the field from qualitative judgement toward reproducible scoring, though it was not the only attempt to formalize DfD principles during this period. Crowther (1999, 2005), working independently at Queensland University of Technology, arrived at a compatible set of principles through a different methodological route, emphasizing layer separation, accessible connections, and clear material hierarchies. That two research groups, working on different continents without direct collaboration, reached broadly similar conclusions gave the field a degree of credibility it had previously lacked.

Despite this convergence, adoption remained limited. Two decades after Kibert's original call, and more than fifteen years after Durmisevic's framework, Design for Disassembly was still largely absent

from standard construction practice across Europe. Anastasiades et al. (2023) investigated this systematically, surveying practitioners across the network of the Green Deal on Circular Construction in Belgium. Their finding was precise: practitioners were not unaware of DfD principles, nor did they dispute the environmental case. The construction market simply lacked the standardized component dimensions, connection geometries, and performance certification systems that would allow reclaimed elements to be specified and integrated with the same confidence as new products. Without that infrastructure, each reuse transaction requires bespoke engineering assessment and individual liability negotiation, making transaction costs systematically higher than those of new production regardless of the material's physical condition.

Although International Organization for Standardization (ISO) 20887 represents a step in the right direction, advocating for standard-sized components and design for disassembly, Anastasiades et al. (2021) are explicit that the standard exists without the complementary ecosystem of regulations, certifications, and market mechanisms needed to operationalize it. The implication for this dissertation is specific. Better scoring systems would address a technical barrier; the evidence suggests the barrier is not primarily technical. What the field lacks is infrastructural: shared information systems capable of documenting what a reclaimed element is, what condition it is in, and where it is available. BIM-based material passport systems are positioned precisely at this gap.

1.2.2. Limitations of component-based frameworks

Akinade et al. (2015, 2017) approached the same problem from the design side, demonstrating through their BIM-based Deconstructability Assessment Score (BIM-DAS) that design intent is the most critical factor affecting deconstructability. Most existing buildings were never designed with deconstruction in mind, and no retrospective framework can recover potential that was never built in. Although this finding does not invalidate Design for Disassembly (DfD) as a design philosophy for new construction, it does raise a separate and underexplored question: how should the reuse potential of existing elements be assessed when the buildings that contain them were designed under entirely different assumptions?

Both the DfD frameworks reviewed above and the standardization critique leveled against them share an assumption that, for most of the field's history, went largely unexamined: that elements under assessment have defined, measurable geometry, identifiable connections, and a form at least in principle separable from adjacent components. This reflects the material reality of the typologies for which DfD was developed, prefabricated concrete panels, steel structural sections, demountable partition systems, curtain wall assemblies. These are elements whose boundaries are visible, whose connections are discrete, and whose dimensions can be recorded in a BIM model with reasonable precision. The assumption is reasonable for those contexts.

Applied to monolithic and irregular materials, it does not hold. Adobe walls, rammed earth sections, rubble stone masonry, and lime-bonded earthen renders have no discrete connections in the sense that Durmisevic's Connections aspect requires. Their boundaries are defined not by joints or fasteners but by the material itself, continuous, often irregular, and physically inseparable from its substrate without fragmentation. Applying the 17 determining factors to a section of colonial adobe wall produces scores that are technically assignable but operationally meaningless: Type of connections registers as

the lowest possible value, because there are no reversible connections to evaluate. Accessibility to fixings, Tolerance, and Morphology of joints are similarly undefined, because the model's categorical structure was not built to accommodate material that was never assembled as discrete components.

This does not mean such materials are inherently unsuitable for reuse. It means the existing frameworks cannot evaluate whether they are. Lambec et al. (2025), in their systematic review of twenty-one assessment procedures used across Europe and the United States, find that the field as a whole is predominantly descriptive rather than projective, effective at characterizing a material's current physical state, weak at evaluating its potential in a specific receiving context. Monolithic materials are doubly disadvantaged: they face the projective gap Lambec et al. (2025) identify across the field, and a prior descriptive gap, because the vocabulary of connections and geometric separability simply does not map onto their physical reality. Crowther's own emphasis on historical and vernacular precedent (1999, 1999b, 2001) as inspiration for DfD principles sits uneasily with the componentry logic those same principles came to assume, an unresolved tension the field has not directly addressed. Crowther's vernacular examples, drawn overwhelmingly from timber-frame traditions, are themselves discrete-component systems; the question of whether the same layering logic extends to monolithic, continuously-formed materials such as adobe or rammed earth remains unexamined in this literature. Section 1.3 takes that acknowledgment as its point of departure.

Before proceeding, a terminological clarification is necessary. Throughout this dissertation, DfD refers exclusively to the existing body of literature and its established frameworks, particularly those of Brand (1994), Kibert (1994), Crowther (1999, 2005), and Durmisevic (2006), in which disassembly potential is treated as a function of physical and geometric component characteristics. Design for Adaptability, Disassembly and Reuse (DfADR), following Walsh and Shotton (2024), is the term adopted throughout this dissertation instead of DfD, reflecting the recognition that disassembly potential is a necessary but insufficient condition for reuse: equally relevant are adaptability to new use and the existence of a viable second-use context. It is a deliberate distinction, not inconsistency.

1.3. Beyond componentry: monolithic and irregular materials

The two preceding sections established both the conceptual foundations of Design for Disassembly and the scoring infrastructure developed to operationalize them. That infrastructure represents a genuine contribution to the field. It was, however, built around a specific material assumption: that building elements have defined geometry, discrete connections, and boundaries that can be recorded and measured. For a significant portion of the existing building stock, that assumption does not hold. This section examines what happens at that boundary.

1.3.1. Material recovery strategies beyond componentry

The limitations identified at the close of Section 1.2 are not peripheral to the DfD literature. They are structural. Crowther's own framework (2000, 2001), read in the context of his later work revisiting and extending his earlier principles, rests on a componentry logic: it assumes that buildings are assemblies of discrete, bounded parts, each with identifiable edges, joints, and connections. Crowther himself never named this assumption explicitly, but it runs through his 27 principles of design for deconstruction, nearly all of which concern connection type, component boundaries, and assembly

sequence. For the typologies that dominated late twentieth-century construction in industrialized economies, prefabricated panels, modular service systems, curtain wall assemblies, that assumption was largely valid. For much of the world's existing building stock, it is not.

Morel et al. (2021), in a survey of earthen construction practitioners across Western Europe published in the Philosophical Transactions of the Royal Society B, found that the barriers to incorporating earth-based materials into circular construction strategies were predominantly non-technical. Two thirds of the barriers identified by practitioners fell outside the technical domain entirely, relating instead to regulatory frameworks, market structures, insurance and liability issues, and cultural attitudes toward vernacular materials. The scientific community, Morel et al. (2021) note, has focused almost exclusively on the technical third. Whether this reflects a genuine belief that technical barriers are primary, or simply a disciplinary preference for problems that yield to quantitative methods, the survey does not say. What it does show is that the gap between the environmental potential of earthen materials and their actual circulation in reuse markets is not primarily a measurement problem.

That observation sits in some tension with the premise of the present dissertation, which does, after all, propose a measurement framework. A more plausible interpretation is that technical and non-technical barriers operate at different scales and require different responses: regulatory and market barriers shape whether reuse is attempted at all, while assessment frameworks shape whether it is done well when it is attempted. Both matter. Neither substitutes for the other.

Nowak et al. (2026) assessed end-of-life scenarios for an experimental earthen building in Pasłęk, Poland, covering rammed earth, adobe, and cement-stabilized compressed earth blocks across multiple demolition and reuse configurations. Manual deconstruction combined with local reuse produced the lowest carbon footprint across all scenarios, whereas long-distance transport substantially reduced the environmental benefits of material reuse. Figure 10 presents the greenhouse gas emissions reported across the eight scenarios assessed, confirming this pattern. The study is, to the author's knowledge, among the very few quantitative life-cycle assessment of rammed earth demolition and reuse currently available in the peer-reviewed literature, which itself reflects how little empirical attention this material category has received. The implications of this finding extend beyond earthen construction. Any framework that treats receptor distance as secondary may systematically underestimate the conditions under which reuse delivers genuine environmental benefits.

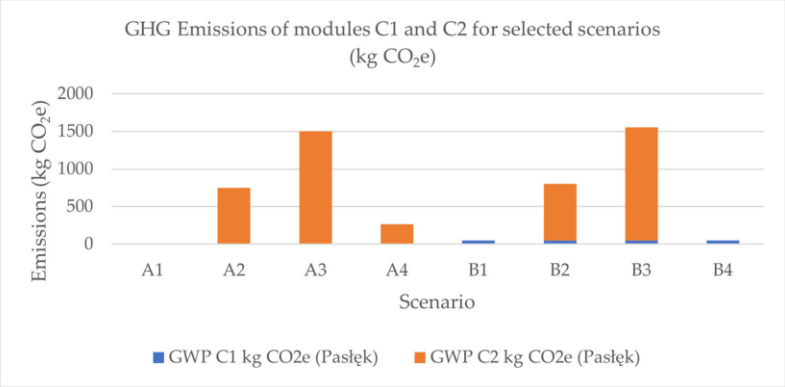


Figure 10 - Greenhouse gas emissions for eight end-of-life scenarios of a rammed earth building in Pasłęk, Poland. Source: Nowak et al. (2026), CC BY 4.0.

1.3.2. Structural reuse at the element level

Research from the Structural Xploration Lab (SXL) at EPFL, conducted primarily in the context of structural steel and timber components, demonstrates that element-level reuse is both technically viable and environmentally compelling even when source elements were not originally designed for disassembly. Brütting et al. (2019) showed that, for a train station roof structure designed from reclaimed steel elements, direct reuse reduces embodied energy and embodied carbon by as much as 63% and 56%, respectively, relative to a weight-optimized structure made of new steel elements. Figure 11 illustrates this approach realised in built form, the rebuiLT pavilion (Küpfer et al., 2024), constructed largely from reclaimed structural and bio-based elements, including reused timber and reinforced concrete saw-cut from a monolithic donor building, recovered from sources not originally designed for disassembly. The steel and timber elements discussed above had defined geometry and discrete connections; the earthen materials this dissertation addresses, like the pavilion's monolithic concrete assemblies, do not. The environmental logic, however, transfers more readily than the methodological one: what determines whether reuse is worthwhile depends not only on whether a material retains sufficient integrity for a second application, but also on the conditions under which that application can take place.

Devènes et al. (2024), working within the same laboratory, addressed the assessment problem directly for reinforced concrete components in buildings scheduled for deconstruction. Their procedure separates two operations that are often conflated: an audit of the obsolete structure, combining review of existing documentation with destructive and non-destructive investigation and a damage assessment across five levels, and a subsequent grading of reusability that combines the recorded damage with the intended use in a specific receiving structure and with any interventions planned before reinstallation. The material category is remote from the one this dissertation addresses, and the investigation techniques do not transfer to earthen fabric. The structure of the reasoning does. Assessment of an existing element proceeds from what can be established about its current physical state, and reuse potential is not a property of the element alone but of the element in relation to a specific receiving context. Both propositions inform the protocol developed in Chapter 2.

Addis (2006) documented a related but distinct phenomenon. He noted that, unlike conventional design, where an established market allows components to be specified and procured directly, no equivalent market exists for reclaimed materials and products. Project teams must instead identify the source of suitable materials before detailed design, specification, or tendering can begin. This absence of a standardized supply chain points to a sourcing and assessment process that is inherently project-specific, rather than governed by the generic frameworks that apply to standardized new products. The observation is unremarkable in isolation. In the context of the DfD literature, it carries more weight.

Taken together, the SXL work on the rebuiLT pavilion (Küpfer et al., 2024; Figure 11), Devènes et al. (2024) and Addis (2006) ground the case for element-level reuse of materials outside the DfD framework's scope in built precedent. Addis (2006) explicitly separates reclamation and reuse from design for deconstruction, addressing materials recovered from buildings never intended for disassembly. Devènes et al. (2024) go further, proposing a field-based assessment procedure, combining documentation with destructive and non-destructive testing, for reinforced concrete components recovered through selective demolition. What is missing is not a field-based assessment

approach as such, but one that generalizes beyond concrete to material categories such as earthen construction, for which the investigation techniques Devènes et al. developed do not transfer.

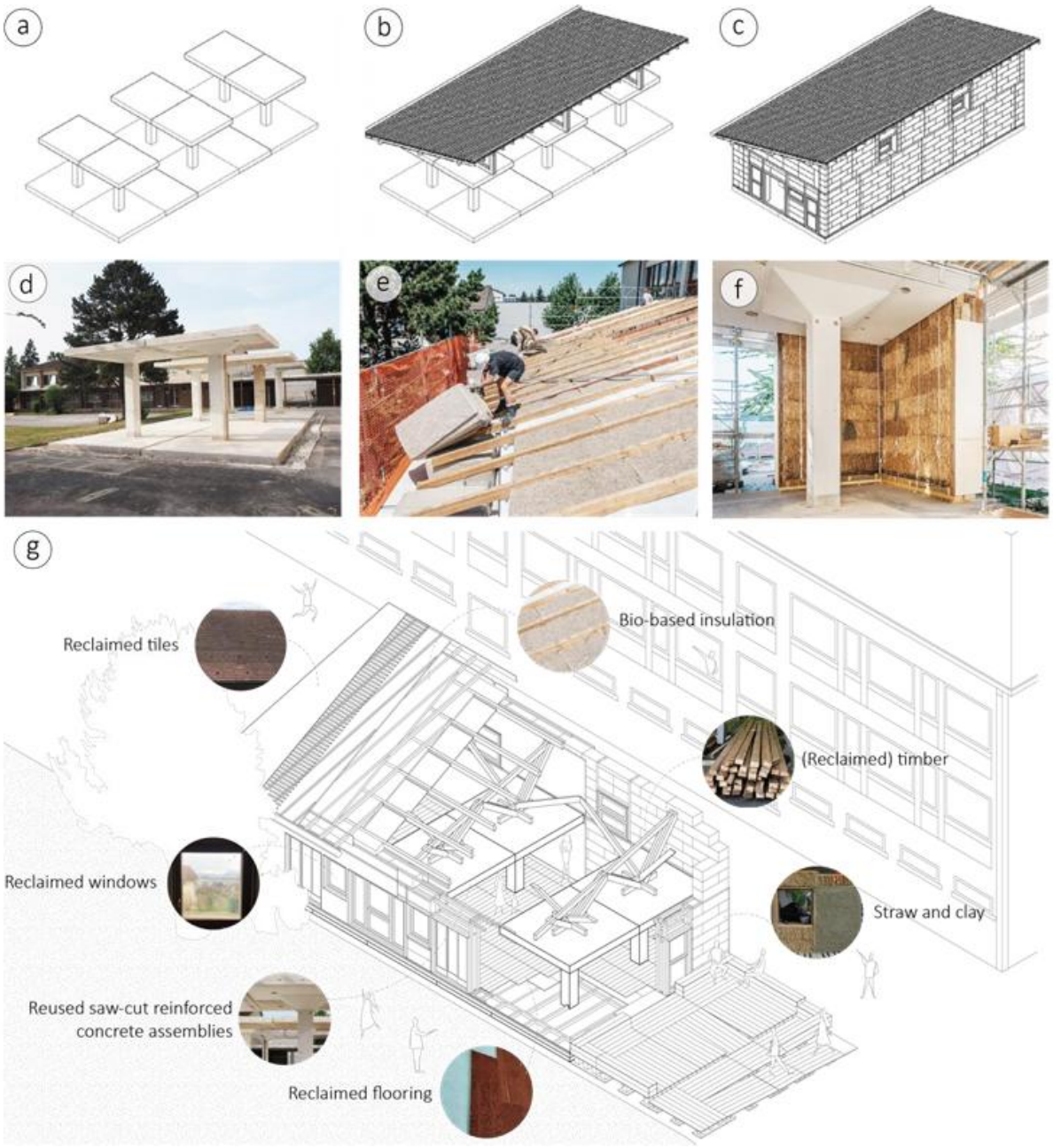


Figure 11 - The rebuiLT pavilion. Source: Küpfer et al. (2024), adapted by the authors; EPFL/rebuiLT (CC BY)

1.4. Material passports and BIM

The preceding section concluded with a practical observation: element-level assessment of monolithic materials is methodologically possible, but only useful if its outputs can be structured, stored, and communicated to the actors who need them. A field assessment that exists only in a practitioner's notes, or in a spreadsheet that does not travel with the element, contributes nothing to a reuse

transaction. It disappears. How that information is documented and transferred matters as much as the assessment itself.

Two distinct but converging bodies of work have attempted to answer that question. The material passport literature, emerging primarily from the built environment research community in Europe (Honic et al., 2019a, 2019b, 2021; Munaro & Tavares, 2021; Çetin et al., 2023), has focused on what information needs to be captured about building elements and at what point in their lifecycle. The BIM literature, and in particular research on IFC-based information exchange (buildingSMART International, 2024; ISO, 2024), has focused on how that information can be structured, stored, and exchanged between actors and software systems across project phases. Neither is sufficient on its own. A material passport without a digital infrastructure to carry it is a document that gets lost. A BIM model without a defined information schema for circularity data is a geometric representation that tells a receiving project nothing about what a reclaimed element is worth or what condition it is in. The present section reviews both bodies of work and identifies where the gap between them remains open.

1.4.1. The material passport concept and its development

The term material passport entered the built environment literature without a single agreed definition, and it has not acquired one since. Van Capelleveen et al. (2023) document the terminological proliferation directly: the concept appears under at least five alternative labels across the literature, including resource passport, recycling passport, cradle-to-cradle passport, and product passport, each reflecting a different disciplinary emphasis and a different idea of what the passport is primarily for. What the variants share is a common premise. Buildings contain material stocks whose value is systematically lost at end of life because no adequate documentation of what those stocks consist of, where they are located, and what condition they are in, exists at the point of demolition. A material passport is a structured attempt to provide that documentation before it is too late. By transforming scattered building data into structured and accessible information, material passports aim to support decision-making throughout the building lifecycle. They provide a foundation for future reuse scenarios by improving the traceability, assessment, and recovery potential of existing materials. In this sense, material passports represent not only documentation systems, but also instruments for enabling circular decision-making and extending the useful life of building resources.

The scale at which a passport operates matters more than the terminological debate surrounding it. Stella et al. (2023), in the Waterman Materials Passports Framework, propose a hierarchical structure in which passports are generated at multiple levels of aggregation, from the material level up through component, grouped component, product, elemental, and building levels, to complex and area levels, with information at each higher level produced by aggregating data from the level below. Each level serves different purposes and different actors. A material-level passport is useful for recyclers and material recovery facilities. A component- or element-level passport is what a reuse market needs: information specific enough to allow a receiving project to evaluate whether a particular element meets its structural, dimensional, and performance requirements. A building-level passport is more useful for urban planners and demolition contractors assessing the overall resource value of a structure before deciding whether to retrofit or demolish. Figure 12 summarises these differences through three representative aggregation levels and the types of decisions each is intended to support. The levels are

not mutually exclusive. Conflating them, however, tends to produce frameworks that serve none of their intended users well.

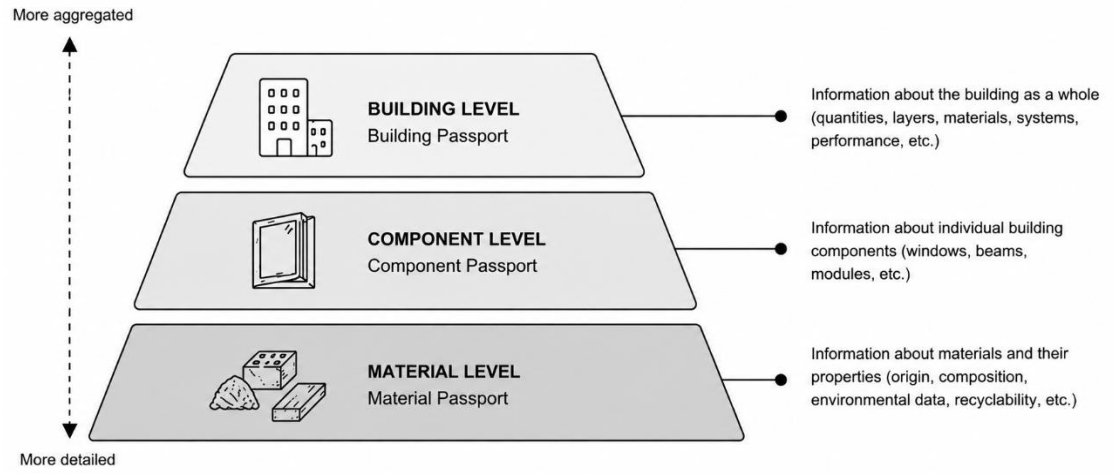


Figure 12 - Three aggregation levels of material passports. Source: Author.

Honic et al. (2019a), working at the Vienna University of Technology, were among the first to operationalize the material passport within a BIM environment. Their methodology linked BIM object data to material quantities and recyclability indices, producing a passport that could be generated semi-automatically from an existing building model. The case study was a three-storey office building modelled in concrete, with a comparative variant in timber construction, and its contribution was clear: BIM could serve as the primary data source for passport generation, reducing the manual effort that had previously made the concept impractical at scale. A companion paper extended the methodology to a broader set of components and proposed a stakeholder management framework for implementation across design teams (Honic et al., 2019b). Together, the two papers established the BIM-based material passport as a research trajectory.

The limitation that both papers acknowledged, and that subsequent work has struggled to resolve, concerns the gap between design-stage BIM models and the physical reality of existing buildings. Models created during design do not always reflect what was actually built; models for buildings constructed before BIM became standard practice often do not exist at all. Honic et al. (2021) addressed this directly, focusing specifically on material passports for the end-of-life stage rather than the design stage. Their findings were candid: data availability for existing buildings is patchy, material compositions recorded in design documentation frequently diverge from what is found during deconstruction, and the manual effort required to reconcile the two remains substantial even when a BIM model is available. Their findings highlight that, although the material passport concept is technically feasible, its implementation for existing buildings remains constrained by incomplete documentation, inconsistent material records, and the significant effort required to reconcile digital information with the physical building. That is not a reason to abandon it. It is a reason to be precise about what a passport can reasonably be expected to deliver in a retrospective application, and to design assessment frameworks accordingly.

Çetin et al. (2023) brought a different lens to the same problem, examining data requirements and availabilities for material passports across a set of existing Dutch residential buildings. Their central

finding was structural rather than technical: the data needed to generate a useful passport and the data that actually exists for most buildings are not the same set. Information about material composition, dimensions, connection details, and hazardous substance presence is routinely absent, inconsistently recorded, or scattered across systems that were never connected to a central digital record. Crucially, Çetin et al. (2023) locate this gap not in a failure of technology but in decisions made decades earlier about what was worth documenting. The implication is uncomfortable for anyone proposing a BIM-based passport system for existing buildings: the infrastructure for generating accurate passports was never built into the construction process in the first place, and no amount of retrospective digital effort fully compensates for that absence.

The material passport literature is, in short, a story of genuine promise and genuine difficulty. The concept is coherent, the environmental case for it is strong, and prototype implementations have demonstrated feasibility in controlled conditions. What the literature has not produced, at least not for the category of existing buildings with monolithic or irregular fabric, is a passport framework that is simultaneously field-applicable, BIM-integrated, and sensitive to the specific physical characteristics that determine whether a non-standard material can be reused. Filling that gap requires not just a passport schema but an assessment protocol designed for materials that were never documented in the first place. Section 1.4.2 examines how BIM provides the technical infrastructure for such a protocol; Chapters 2 and 3 describe how it was implemented in the present work.

1.4.2. BIM as enabler of circular information flows

Building Information Modelling entered mainstream construction practice primarily as a design and coordination tool: a way of detecting clashes between structural, mechanical, and architectural systems before they became expensive problems on site. That origin shapes how BIM is still understood in much of the industry. What the circular economy literature has been arguing, with increasing specificity, is that BIM's more consequential contribution may lie elsewhere: not in what it does during design, but in what it preserves afterward. A BIM model that accompanies a building through construction, occupancy, and eventual deconstruction is not a design tool. It is a structured, queryable record of what the building contains, how it is assembled, and, if the right parameters are populated, what its components are worth to a future project. The difference is not technical. It is a question of what the model is understood to be for. Figure 13 traces this flow of information across the building life cycle, from design through construction and operation to end of life.

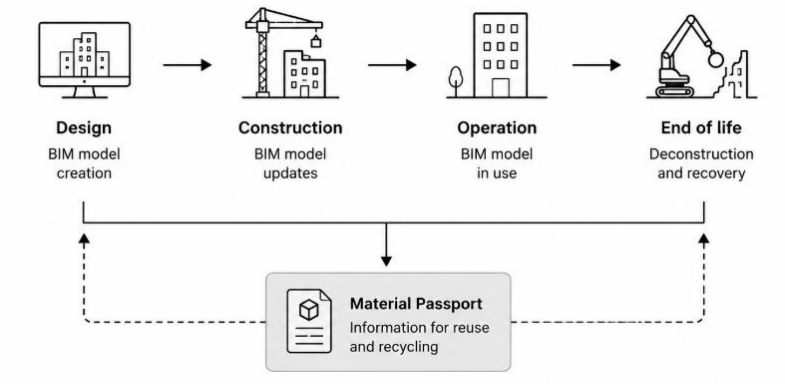


Figure 13 - BIM information flow across the building life cycle. Source: Author.

That distinction has practical consequences at every stage of a building's life. During design, BIM objects typically carry geometric data, material specifications, and performance parameters relevant to construction. What they rarely carry, because no standard workflow currently requires it, is the kind of information a receiving project would need to evaluate a reclaimed component: connection typology, disassembly sequence, expected condition at end of life, or receptor compatibility. The concept of Level of Information (LOI), developed within the BIM maturity framework, is relevant here. LOI describes the non-geometric attributes associated with a BIM object at a given project stage, and it increases progressively as a project moves from concept through detailed design to construction and handover. For most buildings, LOI drops sharply at handover: the as-built model, if it exists at all, is rarely updated to reflect the actual condition of components after years of occupation. By the time a building reaches end of life, the information available in its BIM model may be a decade or more out of date. Generating a useful material passport from that model requires not just accessing what is there, but acknowledging what is not.

Atta et al. (2021) proposed a BIM-integrated Material Passport framework that combines qualitative material information with quantitative indicators of deconstructability, recovery potential, and environmental performance, demonstrating how BIM can serve as the primary repository for circularity-related information throughout the building life cycle.

However, the proposed workflow assumes the availability of a complete and reliable BIM model. This assumption is generally valid for newly designed buildings but is far less representative of the existing building stock, where digital models are frequently incomplete or entirely absent. Consequently, although the framework is technically robust, its direct applicability to existing buildings remains limited.

Byers and De Wolf (2023), working at ETH Zurich's Chair of Circular Engineering for Architecture, took a different approach. Rather than anchoring the passport to a BIM model, they developed a QR code-based system designed to travel with individual components across multiple life cycle stages, accumulating information as each component moves from one project to the next. The system does not require a BIM model to function, which makes it applicable to contexts where no model exists, including small-scale vernacular construction of the kind this dissertation addresses. What it shares with the BIM-based approaches reviewed above is the underlying premise: useful reuse requires information continuity, and information continuity requires deliberate infrastructure. The two approaches are not competing. A QR code tag and a Property set (Pset) are different implementations of the same idea, suited to different scales and different levels of digital maturity in the actors involved.

The integration of assessment data into BIM objects, rather than in a separate document or database, was demonstrated earlier by Akinade et al. (2015) through their BIM-DAS framework. In Section 1.2, that work was discussed for what it revealed about design intent and the limits of retrospective assessment. Its relevance here is narrower and more technical: BIM-DAS showed that the attributes underlying an assessment, not just geometric and material data, could be stored as native BIM parameters; the score itself was still computed externally after export to a spreadsheet, a manual step the paper's own conclusion flagged as a limitation to be closed through tighter BIM integration. What

was missing was an assessment schema, built on this same technical precedent, designed for the material category this dissertation addresses.

The material passport and BIM literatures, taken together, point toward a consistent conclusion: the information infrastructure needed to support component-level reuse at scale is technically feasible, and multiple prototype implementations have demonstrated its viability in controlled conditions. Table 3 compares these approaches across the scale at which each operates, whether it requires BIM, and whether it addresses existing buildings and monolithic materials. What has not existed, at least for materials outside the componentry logic of conventional DfD frameworks, is a passport schema combined with an assessment protocol designed for the physical reality of those materials. The regulatory landscape reviewed in Section 1.5 adds a further dimension to this picture. The European Union's Digital Product Passport (DPP) framework gives this information continuity a regulatory basis.

Table 3 - Comparison of material passport approaches reviewed in Section 1.4.

Approach	Scale	Requires BIM	Applicable to existing buildings	Covers monolithic materials	Assessment integrated	Primary output
Honic et al. (2019a, 2019b)	Building	Yes	No	No	No	Recyclability index
Honic et al. (2021)	Building	Partially	Yes	No	No	End-of-life material inventory
Çetin et al. (2023)	Component	Yes	Yes	No	No	Data availability framework
Atta et al. (2021)	Component	Yes	Partially	No	Yes	Digital passport per component
Byers & De Wolf (2023)	Component	No	Yes	Partially	No	QR-linked lifecycle record

1.5. Digital product passport (DPP)

The material passport literature reviewed in Section 1.4 developed largely outside any regulatory mandate. The frameworks proposed by Honic, Çetin, Byers, and De Wolf were research contributions, not compliance instruments. Adoption depended on voluntary uptake. That changed, at least for new products placed on the EU market, with two regulatory instruments adopted in 2024: the Ecodesign for Sustainable Products Regulation (ESPR, Regulation EU 2024/1781) and the revised Construction Products Regulation (CPR, Regulation EU 2024/3110). Neither applies directly to the building

elements assessed in this dissertation. Both are nonetheless relevant, because they define the direction in which the sector is moving.

1.5.1. The ESPR regulation: scope and implications for construction

The Ecodesign for Sustainable Products Regulation (ESPR) entered into force on 18 July 2024, replacing the 2009 Ecodesign Directive and extending ecodesign requirements from energy-related products to virtually all physical goods placed on the EU market. Its three headline obligations are ecodesign performance and information requirements per product category, set via delegated acts; a DPP; and a ban on destroying unsold consumer goods. The regulation applies to products placed on the EU market, but the specific requirements applicable to an individual product group depend on the adoption of a corresponding delegated act. Construction products are among the product categories under consideration, though their DPP model is being developed primarily through the revised Construction Products Regulation (Regulation (EU) 2024/3110) rather than through the ESPR Working Plan alone. The ESPR establishes the DPP framework, but the specific data requirements applicable to individual product groups are established through product-specific delegated acts. No product-specific delegated act applicable to the heritage earthen elements assessed in this dissertation has been identified. The regulation does not apply retroactively.

The DPP introduced by the ESPR is the concept most directly relevant to this dissertation. As a regulatory instrument, it establishes that structured, machine-readable, lifecycle information should accompany products throughout their existence, from manufacture through use to end of life. Figure 14 shows how this information is expected to flow across the product lifecycle, from raw material extraction and design through manufacturing and distribution to use, repair, and end-of-life recovery. The specific data fields and formats are defined per product category through delegated acts. The underlying logic, however, is now a formal regulatory expectation: a product should carry a verifiable digital record of what it is, what it contains, and what can be done with it at end of life.

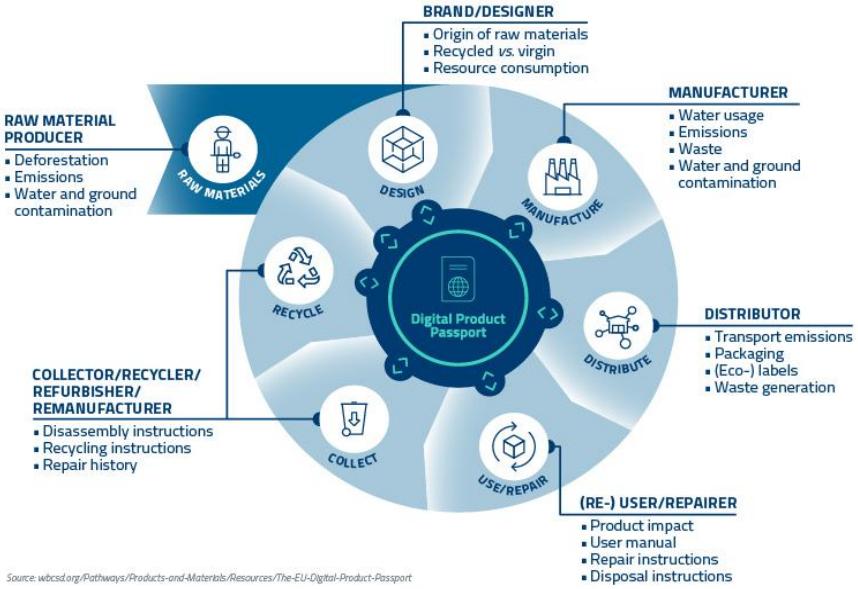


Figure 14 - Lifecycle information categories of the EU DPP. Source: WBCSD, reproduced in Optel Group (2024).

1.5.2. The CPR regulation: construction products and mandatory disclosure

The revised Construction Products Regulation, Regulation EU 2024/3110, entered into force on 7 January 2025 and became applicable from 8 January 2026. It replaces CPR 305/2011 and substantially expands the scope of EU construction product regulation, introducing mandatory environmental impact reporting, new digital documentation formats, and alignment with the ESPR framework. Construction products will carry a DPP with structured access to performance, conformity, and sustainability data.

Two provisions of CPR 2024/3110 are particularly relevant to the present work, though neither creates a compliance obligation for building elements of the kind assessed in this dissertation. Table 4 summarises these provisions alongside a third, on the extended scope to used products, discussed below. The first concerns cultural heritage. The regulation's preamble explicitly recognises that products linked to cultural heritage, that rely on materials available only in specific localities, or that face heterogeneous conditions across Member States, fall outside its harmonising scope (Regulation (EU) 2024/3110, recital 14). The colonial-era earthen building elements assessed in this dissertation fall squarely within this category: they are not standardized products placed on the market, and their material characteristics are specific to a geographic and constructive context that no harmonized standard currently covers. This regulatory position reinforces the need for assessment approaches that can accommodate existing and non-standardized building materials without imposing criteria developed exclusively for industrial products. In such cases, alternative frameworks must provide a structured method for documenting material characteristics, evaluating reuse potential, and supporting informed conservation and transformation strategies. Moreover, the absence of harmonised product requirements does not eliminate the need for reliable information about these materials; instead, it shifts the responsibility towards project-specific methodologies capable of capturing their technical, historical, and environmental value.

Table 4 - Key CPR provisions relevant to this dissertation.

Provision	CPR 2024/3110 text	Relevance to heritage and reclaimed elements
Cultural heritage exclusion	"Products which are not suitable for harmonisation, for instance due to their relation to cultural heritage, their usage of specific materials which can only be sourced in certain localities or to heterogeneous conditions between Member States, should not be subject to the harmonising effect of this Regulation."	Establishes that heritage and locally specific building elements, such as the earthen elements of the Fazenda Ribeiro (c.1820), fall outside CPR harmonisation obligations.
Reused elements exclusion	"Products directly reused in a construction work should not be considered as placed on the market again and therefore not be subject to any measures under this Regulation."	Confirms that reuse of existing elements within a construction project does not, by itself, trigger CPR compliance obligations.

Extended scope to used products	CPR 2024/3110 extends its scope to include used products placed on the market for the first time.	Signals that commercially traded reclaimed elements would enter CPR scope in the future.

Source: Regulation (EU) 2024/3110.

The second provision is simpler. Elements directly reused in a construction work are not considered placed on the market again. This means that recovering elements from an existing building and reintegrating them into a new project does not, in itself, trigger CPR compliance obligations for those elements. The regulatory framework recognises this pathway without regulating it in detail. A third provision, however, points in the opposite direction: the CPR extends its scope to used products placed on the market for the first time, meaning that reclaimed elements traded commercially, rather than reused within a single project, would fall under its requirements.

Taken together, the ESPR and CPR define a normative trajectory rather than an immediate obligation for the type of work this dissertation addresses. They establish that digital, structured, lifecycle information about building products is becoming a regulatory expectation across the EU construction sector. They also identify, through their explicit exclusions, the category of building elements, heritage, monolithic, locally specific, that existing regulatory frameworks are not yet equipped to address, and for which no assessment or documentation instrument currently exists.

1.6. IFC and property sets

Sections 1.4 and 1.5 converge on a shared requirement: structured, lifecycle information about building elements must travel between software systems, project phases, and actors without loss of integrity. Stating that requirement is straightforward. Meeting it depends on a specific technical infrastructure that the preceding sections did not address in detail. This section describes that infrastructure.

1.6.1. IFC as an open data standard for the built environment

Industry Foundation Classes, commonly referred to as IFC, is an open international standard for the digital description of the built environment. It is designed to be vendor-neutral and usable across a wide range of hardware devices, software platforms, and interfaces for many different use cases. Developed and maintained by buildingSMART International, IFC is formalised as ISO 16739-1, with the most recent edition, ISO 16739-1:2024, corresponding to IFC version 4.3 (buildingSMART International, 2024; ISO, 2024). The standard specifies a data schema, together with associated reference data for properties and quantities; serialization formats for file exchange are addressed through separate, related specifications rather than within ISO 16739-1 itself. IFC is referenced in numerous national BIM mandates, including in Finland, Norway, Denmark, and the Czech Republic, and is widely regarded as the dominant open exchange standard for digital construction data in Europe, though full mandatory adoption of openBIM workflows across the EU remains partial.

The IFC schema is organised as a hierarchical object model. At the highest level, an IfcProject contains one or more IfcSite instances, each of which contains one or more IfcBuilding instances, which in turn contain IfcBuildingStorey instances. Individual building elements, walls, doors, windows, columns, beams, slabs, sit at the lowest level of this hierarchy as subclasses of IfcElement. Figure 15 depicts this five-level hierarchy, from the overall project down to individual building elements. Each IfcElement instance carries a Globally Unique Identifier (GUID), inherited from IfcRoot, that is designed to persist across software exports and imports, enabling a specific wall or door to be unambiguously identified across different versions of a model and different software environments, though in practice many exporters regenerate GUIDs on each export unless deliberate measures are taken to preserve them. This persistent identification is what makes IFC a viable carrier for lifecycle information. An element tracked from its original building through deconstruction and reintegration into a receiving project remains the same object, provided its GUID is preserved. In practice, this allows lifecycle information to remain associated with the same physical element throughout successive digital exchanges, rather than being recreated at each project stage.

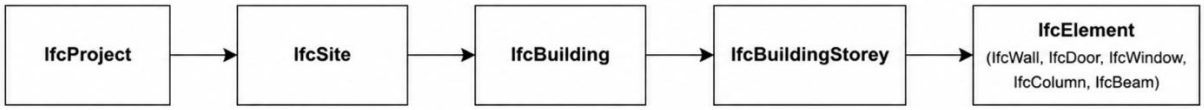


Figure 15 - Hierarchical structure of the IFC object model. Source: Author.

The schema separates geometric representations from semantic data. Geometry is handled through representation contexts; semantic data, including material properties, classification codes, performance characteristics, and custom parameters, is carried through a parallel system of property sets and quantity sets. This separation matters for reuse assessment: the scores, material condition data, and lifecycle destination classification attached to a building element can be updated or extended without requiring the geometry to be remodelled. A door assessed under both protocols carries those scores as semantic data attached to its IfcDoor instance. The geometry is unchanged.

Although proprietary Revit files preserve the same information within the Autodesk ecosystem, they require Autodesk software to access it and therefore do not satisfy the interoperability objectives that motivate the use of IFC in openBIM workflows. A building element assessed and documented in Revit by one practitioner needs to be readable by a receiving project using a different BIM platform, in a different country, by practitioners who may never have opened Revit. Given its open, vendor-neutral design (buildingSMART International, 2024), IFC is the most credible format for guaranteeing readability across the range of software environments in which reclaimed building elements might be reused. Without it, the digital passport generated at the source building is effectively locked to the software environment in which it was created.

The formalisation of IFC as EN ISO 16739 has established it as a European standard (European Commission, Interoperable Europe Portal), a status that carries practical implications for public procurement and regulatory compliance, where consistent and auditable data exchange is increasingly required. Several EU member states now mandate IFC-aligned submissions for publicly funded construction projects. The alignment between IFC and the EU DPP framework reviewed in Section 1.5 further reinforces this position: as DPP requirements extend progressively to construction products,

IFC provides a technically mature and institutionally recognised infrastructure for carrying the lifecycle data those requirements will demand. Future versions of the standard are expected to further strengthen support for these use cases (buildingSMART International, 2024), though the framework proposed in this dissertation operates entirely within the capabilities of the current IFC 4.3 release.

1.6.2. Property sets as carriers of lifecycle information

Within the IFC schema, the semantic layer that carries non-geometric information about building elements is organised through two complementary mechanisms: Property Sets and Quantity Sets. Quantity Sets carry measurable physical characteristics such as area, volume, and length, defined according to standardized calculation methods. Property Sets, the mechanism relevant to this dissertation, carry descriptive and parametric information: material composition, performance classifications, manufacturer data, assessment scores, and any other attribute that a practitioner or software developer wishes to attach to a building element. A Property Set, abbreviated as Pset, is technically a named container holding one or more property definitions, each with a name, a data type, and a value. The data types supported include strings, booleans, integers, real numbers, and enumerated lists. Collectively, they cover everything a material passport or reuse assessment framework needs.

Two categories of Pset exist within the IFC framework. The first are predefined Psets, maintained by buildingSMART International and documented in the IFC standard: these cover common information requirements such as fire resistance ratings, acoustic performance, and thermal properties, and are recognised by all IFC-compliant software by default. The second are custom Psets, defined by practitioners, software developers, or research teams to carry information that predefined Psets do not cover. Custom Psets can be carried within IFC files, but their interpretation and presentation may require explicit configuration in receiving systems. Table 5 summarises this distinction between predefined and custom Psets. Chapter 3 defines a custom Pset of this type for the assessment framework developed here.

Table 5 - Predefined and custom IFC Property Sets.

	Predefined Psets	**Custom Psets**
Defined by	buildingSMART International	Practitioners, developers, researchers
Recognised by default	All IFC-compliant software	Requires explicit configuration
Scope	Standard building performance data (fire resistance, acoustic, thermal)	Any information not covered by predefined Psets
Publishable in bSDD	Already published	Yes, if registered
Persists in IFC export	Yes	Yes

The buildingSMART Data Dictionary, commonly referred to as bSDD, serves this purpose, among others: publishing and sharing custom Pset definitions across projects and organisations. The bSDD is a cloud-based service that allows practitioners and developers to register property definitions, making them discoverable, machine-readable, and reusable across projects and software environments (buildingSMART International, 2024). A custom Pset registered in the bSDD can be referenced via a structured URI in IFC and IDS workflows, reducing the configuration burden for receiving projects and ensuring that the parameter definitions are consistent across different implementations, provided the receiving software supports bSDD integration, typically through a dedicated plugin or Application Programming Interface (API).

Tomczak et al. (2024), in a paper specifically addressing the use of IFC-based Information Delivery Specifications for requiring circularity data in BIM, demonstrate that Pset-based approaches provide a partially viable mechanism for embedding circular economy parameters into standard BIM workflows, cautioning that reliance on custom, unstandardised properties, the category into which the Pset developed in this dissertation falls, limits interoperability and consistent interpretation. The paper identifies the Information Delivery Specification, or IDS, a companion standard to IFC maintained by buildingSMART International, as a key enabler for making Pset-based circularity requirements enforceable across project teams rather than merely aspirational. IDS allows a project owner or client to specify which Psets, and which individual properties within those Psets, must be populated at each stage of a project, and to validate compliance automatically against an IFC export. Information carried in a custom Pset travels with the element geometry as a single, self-contained IFC file, accessible to any IFC-compliant environment, whether Revit, ArchiCAD, or an open-source viewer, without requiring the original authoring model. Chapter 3 describes how this capability is applied to the Pset developed in this dissertation.

1.7. Research gap

No existing framework has addressed all of these limitations in combination. Design for Disassembly frameworks, and the Durmisevic's (2006) Transformation Capacity model, provide reproducible, objective scoring for building elements with defined geometry and discrete connections. They do not, however, provide a meaningful assessment logic for materials that were never assembled from discrete components. The parameter-based adaptations of her model discussed in Section 1.2.1, such as van Vliet et al.'s (2021) four-parameter method, inherit the same constraint: connection type and connection accessibility cannot be scored for a material that was never assembled from discrete components in the first place. Continuous adobe walls, rubble stone foundations, and rammed earth sections cannot be evaluated under a system that presupposes the existence of reversible joints. This is not a marginal limitation. Earthen and rubble stone construction accounts for a significant share of the pre-industrial building fabric across Southern Europe, Latin America, and the Portuguese-speaking world (Houben & Guillaud, 1994; Morel et al., 2021).

The systematic review by Lambec et al. (2025) of twenty-one reuse assessment procedures used across Europe and the United States confirms that this limitation is not specific to Durmisevic. The field as a whole produces procedures that are predominantly descriptive rather than projective: they characterise the current physical state of an element with varying degrees of rigour, but consistently underrepresent the criteria that determine whether a specific element will actually be reused in a specific context,

including the physical recoverability of the element, the existence of a plausible receiving application, and the reliability of the information available about it. Monolithic materials are doubly disadvantaged. They face the projective gap that Lambec et al. (2025) identify across the field, and a prior descriptive gap: the vocabulary of connections and geometric separability simply does not map onto their physical reality.

The material passport and BIM literature has made substantial progress in establishing the information infrastructure needed to support component-level reuse at scale. The frameworks proposed by Honic, Çetin, and others have demonstrated that BIM-native parameter sets, carried through IFC and readable across software environments, provide a technically viable mechanism for attaching lifecycle information to individual building elements. Byers and De Wolf demonstrated a parallel path to the same end, information continuity without dependence on a BIM model, using QR-code tagging instead. None of these frameworks, however, integrates an assessment protocol designed for materials outside the component-based logic of classical DfD thinking. The passport schemas that exist assume the elements they document have already been assessed using DfD tools. They inherit the scope limitations of those tools.

The recent EU regulatory landscape adds a further dimension. The ESPR and CPR establish that structured, digital, lifecycle information about construction products is becoming a formal regulatory expectation across the European market. The exclusions the CPR contains, for heritage materials, locally specific construction techniques, and elements directly reused without being placed on the market again, identify precisely the category of building elements that existing assessment and passport frameworks do not adequately serve. There is a regulatory direction without a corresponding technical instrument.

No protocol identified in the literature reviewed combines structured field assessment with contextual reuse criteria for building elements outside the scope of classical DfD frameworks. Nor does any existing approach integrate that assessment natively within a BIM environment through IFC-compatible property sets while aligning the resulting digital record with the information structure of the EU DPP. This is the gap addressed in Chapters 2 through 4.

2. FRAMEWORK DEVELOPMENT

Chapter 1 identified a gap in current reuse assessment methods: existing Design for Disassembly approaches are well suited to discrete, component-based construction, but provide limited support for monolithic and irregular building fabric. A second gap concerns the way assessment information is recorded and maintained over time. This chapter responds to these two issues by developing the assessment framework and the digital structure used to support it.

The framework was developed within the Design Science Research strategy introduced in Chapter 1. Its main artefact is a two-level assessment system supported by BIM-native parameters and a digital implementation workflow. Level 1 addresses elements that can be evaluated through conventional disassembly criteria, while Level 2 extends the assessment to monolithic and irregular construction. Both levels are incorporated into the same digital passport structure, allowing the resulting information to be recorded, exported, and transferred independently of the assessment method used.

The chapter first presents the overall framework workflow and the logic used to route elements between the two assessment levels. It then defines the Level 1 and Level 2 criteria, the scoring and destination mapping, and the technical pipeline used to connect field assessment, BIM modelling, and digital passport generation. The final section sets out the strategy used to evaluate the framework before its application to the case study presented in Chapter 4.

2.1. Overall framework workflow

The sections that follow, from Section 2.3 through Section 2.8, each address one layer of the framework in isolation. That level of detail is necessary. It can also obscure how the parts connect. This section provides the connective tissue: a step-by-step account of how the framework operates in practice, from the moment a building is identified as a candidate for assessment through to the reintegration of its elements into a receiving project.

The workflow comprises ten steps organised into three broad phases. The first phase, Steps 1 through 4, covers fieldwork and BIM modelling, the activities that take place before any scoring or digital processing begins. The second phase, Steps 5 and 6, is where the two implementation pathways diverge: Pathway A routes assessment data through IFC export and Python post-processing, while Pathway B handles the entire assessment natively within Revit via the C# plugin. Both converge at Step 7, producing equivalent digital passport outputs. The third phase, Steps 7 through 10, covers passport generation, score-to-destination mapping, publication to the online library, and import into the receiving project. The workflow is presented in Figure 18.

2.1.1. Workflow overview

The workflow begins with a decision that is rarely treated as a methodological one: identifying a building as a candidate for deconstruction or restoration assessment. It should be. The building selected determines what the framework will encounter, and therefore what it can demonstrate. The

selection criteria described in Section 2.2 were applied to ensure the evaluation environment was varied enough to exercise both levels of the framework within a single case.

Step 2 is where the two-level structure becomes operational. The on-site survey classifies each element according to whether it will be assessed under Level 1 or Level 2. Elements with defined geometry, discrete connections, and identifiable boundaries, doors, windows, structural columns, timber beams, are routed to Level 1 and assessed using the component-based method.. Elements without those characteristics, continuous adobe walls, rubble stone masonry, irregular earthen renders, go to Level 2 and assessed using the criteria developed for this purpose. This classification is made in the field. Recording it explicitly matters more than it might seem: it is the first point at which the framework's logic becomes traceable. Figure 16 presents this field workflow, from arrival at the site to the recording of the classified element in the field documentation.

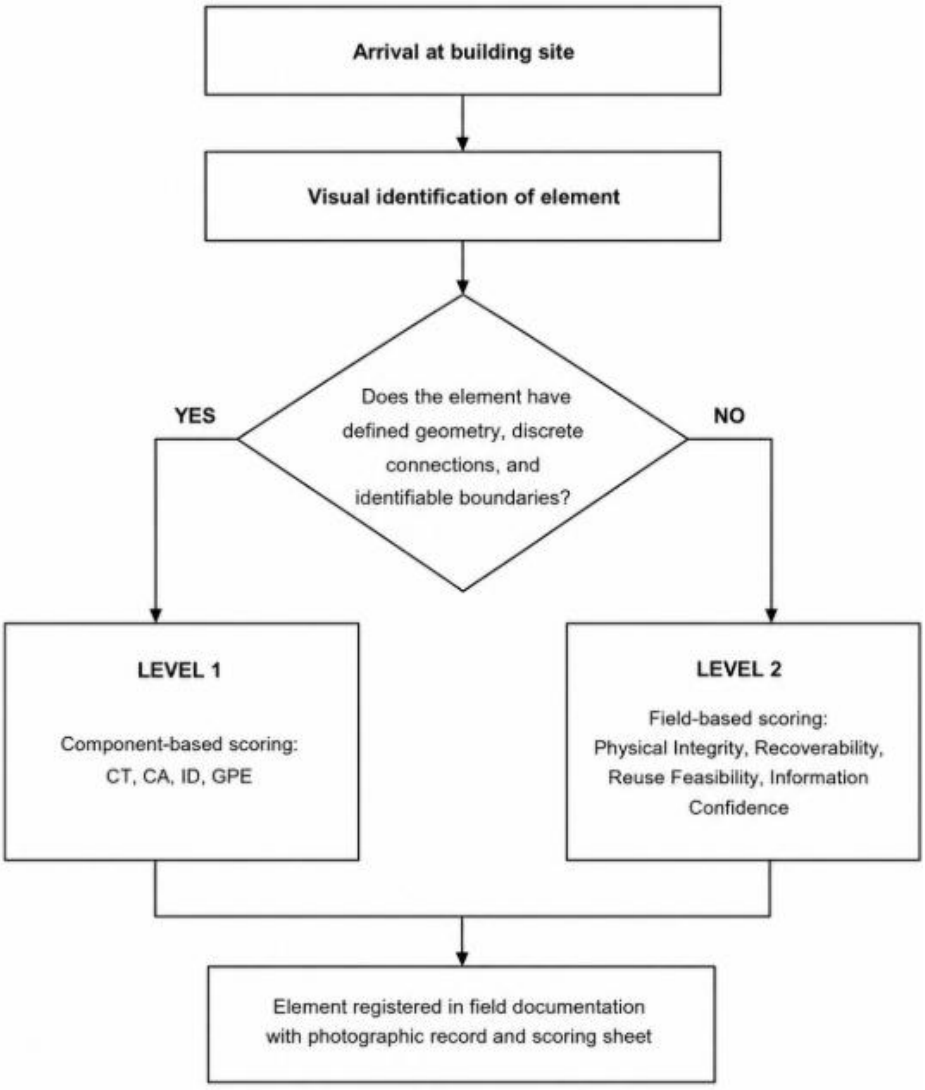


Figure 16 - Field workflow for Level 1 and Level 2 element classification. Source: Author.

Step 3 formalises what Step 2 initiated. Photographic records, physical measurements, and completed field assessment sheets. For Level 2 elements, this documentation is not supplementary to the assessment. It is the assessment.

Step 4 brings the field data into Revit. The model is built using the building's own Revit families, whether native system families or custom loadable families, each prepared to receive the structured information collected during the assessment. Geometrically, it is sufficient for identification and spatial coordination. Its primary function is informational: a structured container that attaches field data to digital objects readable by receiving systems. Figure 17 illustrates this transformation, from the photographic records, measurements, and field sheets collected on site into the structured digital container populated in the model.

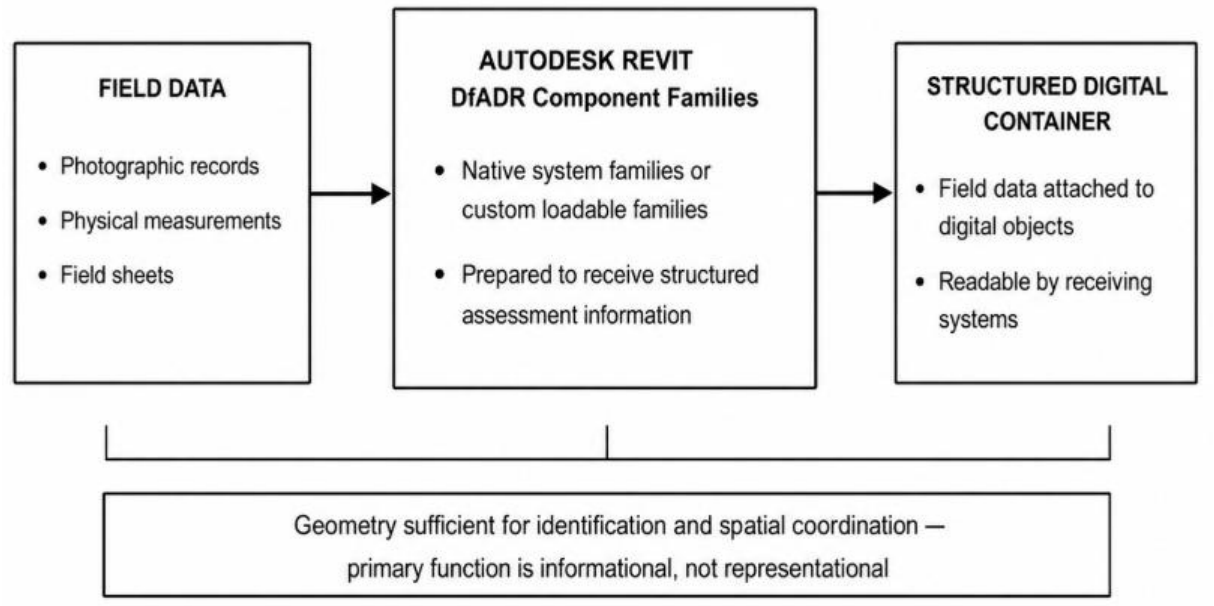


Figure 17 - Transformation of field data into BIM information. Source: Author.

Steps 5 and 6 are where the workflow bifurcates. Both pathways take the same input, the populated Revit model, and produce the same output, a structured digital passport per element. The choice between them depends on context and user preference. The pathways are described in Section 2.2.3 and covered technically in Section 2.8 and Chapter 3.

Steps 7 through 10 follow a fixed sequence. The digital passport generated in Step 7 carries assessment scores, material data, and lifecycle information for each element. Step 8 translates those scores into a destination classification: Direct Reuse, Conditional, or End of Life. Step 9 publishes reusable elements to the online 3D library, making them discoverable by receiving projects. Step 10 imports the passport data into the receiving project's Revit environment, where reclaimed elements can be specified alongside new components.

2.1.2. Workflow diagram

Figure 18 presents the complete workflow as a visual sequence. The diagram is organised vertically, with Steps 1 through 4 running in a single linear path before bifurcating after Step 4 into Pathway A on the left and Pathway B on the right. The two pathways converge at Step 7 and continue as a single sequence through to Step 10. It therefore provides a single overview of how assessment information moves from field observation to a reusable digital asset within a receiving project.

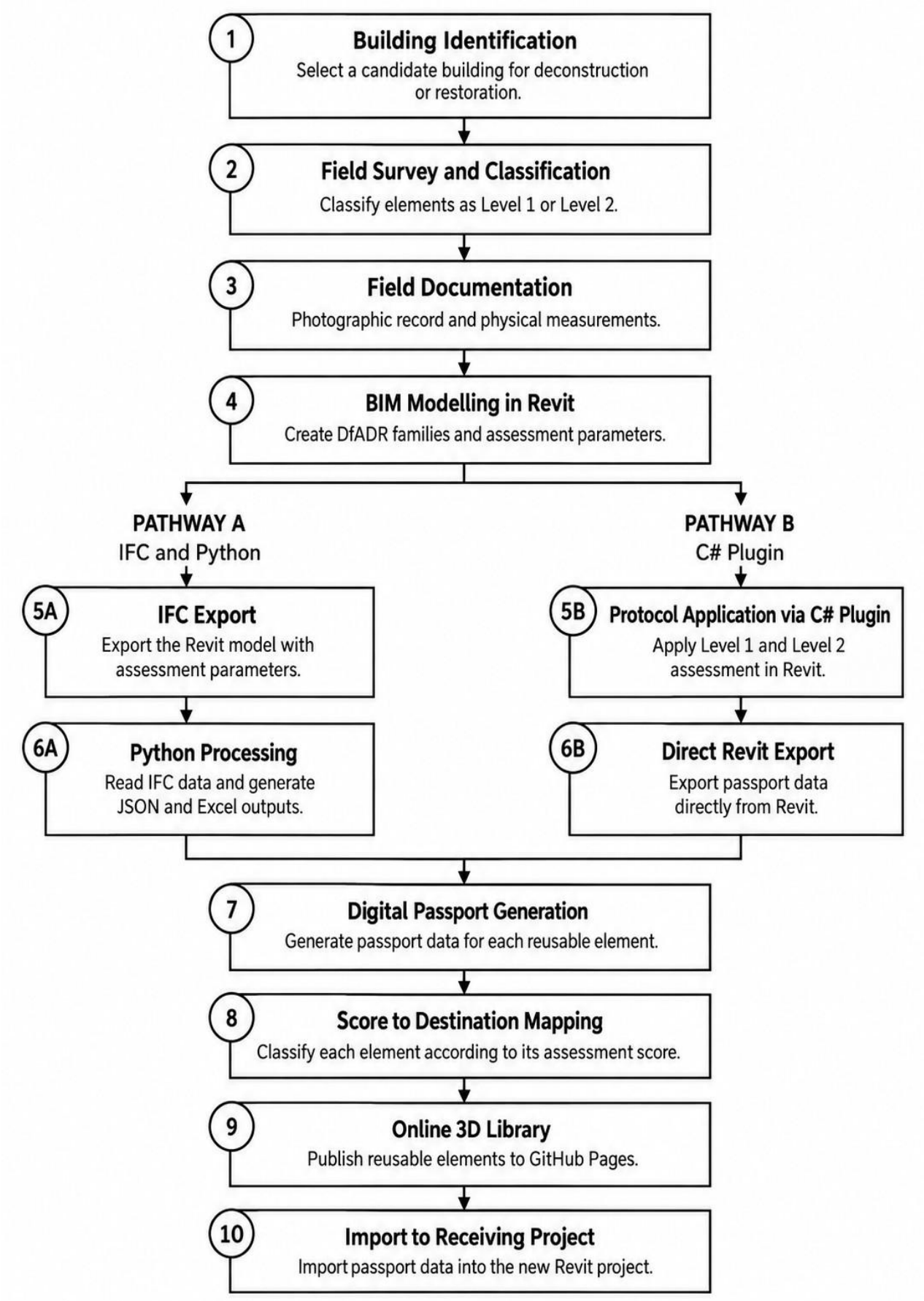


Figure 18 – Overall DfADR implementation workflow. Source: Author.

The numbered steps correspond directly to the sections that follow. Steps 1 through 4 are addressed in Sections 2.2 and 2.3. The bifurcation at Steps 5 and 6 corresponds to the technical pipeline described in Section 2.7 and implemented in Chapter 3. Steps 7 through 10 map onto Section 2.6, the online library in Section 3.6, and the import functionality in Section 3.5.2.

2.1.3. Integration with the two-level protocol

The bifurcation visible in Figure 18 has a technical explanation, but it also has a conceptual one. The two pathways exist because the framework serves two different user profiles. Pathway A, IFC export followed by Python post-processing, is suited to users comfortable working outside Revit who need to process large numbers of elements efficiently, extracting and transforming data in batch. Pathway B, the C# plugin, is designed for users who prefer to remain within Revit, assessing and documenting elements one by one through a structured interface. The outputs are equivalent. The experience of producing them is not.

What connects both pathways to the two-level protocol is a single shared parameter set. Every element in the BIM model carries the same parameter structure, regardless of which pathway processes it. Level 1 elements carry the four CT/CA/ID/GPE scores and the aggregate disassembly class. Level 2 elements carry the four criteria scores developed for that level and their aggregate recommendation. Both also carry the same identification and lifecycle fields, current location, current use, expected service life, installation date, reparability, and lifecycle history, that complete the parameter set's structure independently of assessment level. The parameter set is the common language. The two pathways are simply two ways of reading and writing it.

The classification decision made in Step 2 is therefore not just a field judgement. It is a data architecture decision. It determines which subset of the Pset parameters will be populated, which scoring logic will be applied, and which output fields will carry meaningful values in the final passport. An element incorrectly classified at Step 2, a monolithic adobe section routed to Level 1, will produce a technically complete but operationally empty passport: the CT/CA/ID/GPE scores will be assigned, but they will not reflect anything useful about the element's actual reuse potential. Getting Step 2 right is the most consequential decision in the entire workflow.

2.2. Two-level evaluation framework: rationale

The four-factor structure used throughout this chapter, Connection Typology (CT), Accessibility of Connections (CA), Independence of Disassembly (ID), and Geometry of Product Edge (GPE), follows the parameter set introduced by van Vliet, van Grinsven and Teunizen (2021) for the Dutch Green Building Council's Disassembly Potential Measurement Method, itself built directly on four of Durmisevic's (2006) determining factors and her Independence indicator (Section 1.2.1). The scoring bands within each factor (Tables 7–10) are reproduced from Durmisevic (2006) as cited by van Vliet et al. (2021), unaltered. What this dissertation proposes is the aggregation of the four factors into a five-class disassembly classification (Table 11), a synthesis neither Durmisevic (2006) nor van Vliet et al. (2021) define in this form.

The problem emerged during the development of the framework, in discussion with the dissertation supervisors. Applied to elements with defined geometry and discrete connections, the CT/CA/ID/GPE system works as intended. Applied to monolithic materials, it does not fail gracefully. It produces scores, but those scores carry no useful information about reuse potential. A continuous adobe wall receives the lowest Connection Typology score, not because it is poorly suited for reuse, but because the framework lacks a categorical structure for materials never assembled from discrete components. The score is technically correct and practically meaningless. That is a different kind of problem from a framework that underestimates or overestimates reuse potential. It is a framework that cannot see the material at all. Table 6 summarises how each element type is routed between Level 1 and Level 2, and why.

Table 6 – Element routing between Level 1 and Level 2.

Element Type	Examples	Level 1	Level 2	Rationale
Components with defined geometry	Doors, windows, timber beams, roof tiles, structural columns	Applicable: scores are informative and reflect genuine reuse potential	Not required: element characteristics are fully captured by CT/CA/ID/GPE scoring	Discrete connections, standardized geometry, and identifiable boundaries allow all four factors to be meaningfully assigned
Monolithic and irregular materials	Adobe walls, rammed earth sections, rubble stone masonry, lime renders	Technically applicable: scores can be assigned but carry no useful information about reuse potential	Applicable: scores reflect physically observable properties relevant to reuse	Absence of discrete connections and defined geometry renders DDF scores operationally empty; Level 2 criteria are calibrated to what can actually be observed and measured in the field
Hybrid or transitional elements	Timber-framed walls with earthen infill, mixed masonry sections	Partially applicable: framing components may be scored under Level 1	Partially applicable: infill materials assessed under Level 2	Element contains both discrete components and monolithic material; classification decision made at field survey stage determines which sub-elements are routed to which level

The discussions highlighted the need for a field-based assessment protocol designed around what can actually be observed and measured in monolithic materials. Not a replacement for the Decomposition Design Factor system, but a complement to it, operating where the existing system is blind. That

conversation was the origin of the TRACE Protocol: Tangible Reuse Assessment for Construction Elements. Its four criteria, physical integrity, recoverability, reuse feasibility and information confidence, were selected because they can be assessed on site without presupposing discrete components: the first two through direct observation of the material, the third through the receiving context, and the fourth through the documentation available at the time of survey.

The decision to maintain two distinct levels rather than merging them into a single unified protocol deserves a brief explanation, because the alternative was considered. A single protocol covering all element types would have the advantage of simplicity: one scoring sheet, one set of output fields, one classification logic. The disadvantage is that it would either force monolithic materials into a categorical structure built for components, reproducing exactly the problem the TRACE Protocol was designed to solve, or it would dilute the precision of the Decomposition Design Factor scoring for elements where that precision is both achievable and valuable. Doors, windows, structural columns, and timber beams can be assessed with considerably more granularity than a single unified protocol would allow. Keeping the two levels separate preserves that granularity where it is possible, and applies a different logic where it is not.

2.3. Level 1: Disassembly potential scoring (CT/CA/ID/GPE)

Level 1 applies to elements with defined geometry, discrete connections, and identifiable boundaries: doors, windows, timber beams, roof tiles, structural columns. The theoretical basis of the scoring system is established in Section 1.2.1. What this section documents are the scoring rules set out by van Vliet et al. (2021) for applying that system consistently, since criteria developed for industrialized construction typologies inevitably leave room for judgement when applied to building types they were not originally designed to assess. Chapter 4 applies these rules to the Fazenda Ribeiro case study. The technical implementation of the scoring interface is described in Chapter 3.

Connections that combine two connection types at once, most commonly a mechanical fixing bedded in mortar or a similar matrix, a configuration common wherever frames are set into masonry or earthen wall openings, are resolved through van Vliet et al.'s (2021, Section 04.01.01) equivalence principle: where an assembly is not well represented by a single category in Table 7, the assessor evaluates whether it disassembles at least as effectively as the closest reference category and assigns that category's score, provided the equivalence is explicitly substantiated. A mechanical fixing bedded in mortar that serves only a gap-filling function, for instance, may be scored as equivalent to a direct integral connection if removing the fixing does not require breaking the mortar bond. This equivalence is documented explicitly wherever it is applied, since it is the point at which two assessors are most likely to diverge. Table 7 lists the scoring bands applied for Connection Typology.

Table 7 - Connection Typology scoring bands. Source: van Vliet et al. (2021), based on Durmisevic (2006).

Connection type	Score
Dry connection (loose, click, velcro, magnetic)	1.00

Connection with added elements (bolt and nut, spring, corner, screw)	0.80
Direct integral connection (pin, nail)	0.60
Soft chemical connection (caulking, foam/PUR)	0.20
Hard chemical connection (adhesive, weld, cementitious, chemical anchors)	0.10

Accessibility of Connections is determined from the reverse construction sequence at the point of disassembly, following van Vliet et al. (2021, Section 04.02.01): for an element with the same expected lifespan as the building itself, accessibility is assessed against the sequence that would apply if the building were fully dismantled; for an element with a shorter lifespan, intended to be replaced during the building's life, accessibility is assessed against the sequence that applies to that replacement operation specifically, which is typically shorter and less disruptive. This distinction connects directly to Brand's (1994) layered lifespans introduced in Section 1.2: a structural element and a service component may share an identical physical connection, yet warrant different accessibility scores, because the disassembly operation each implies differs in scope. Table 8 lists the scoring bands applied for Accessibility of Connections.

Table 8 - Accessibility of Connections scoring bands. Source: van Vliet et al. (2021), based on Durmisevic (2006).

Connection accessibility	**Score**
Freely accessible without additional actions	1.00
Accessible with additional actions that do not cause damage	0.80
Accessible with additional actions with fully repairable damage	0.60
Accessible with additional actions with partially repairable damage	0.20
Not accessible, irreparable damage to the product or surrounding products	0.10

Independence of Disassembly follows two rules set out by van Vliet et al. (2021, Section 04.04.01). First, the rating is reciprocal: the element that creates a dependency and the element whose removal is constrained by it receive the same score, since independence is a property of the relationship between elements rather than of either element in isolation. Second, where an element is subject to more than one dependency, such as its original assembly plus later additions like fixtures, service conduits, or fittings, the lowest of the applicable ratings governs the element's score. An element that would otherwise qualify as fully independent, but has acquired a single later dependency, is scored according to that dependency, not according to its original design intent. Table 9 lists the scoring bands applied for Independence of Disassembly.

Table 9 - Independence of Disassembly scoring bands. Source: van Vliet et al. (2021), based on Durmisevic (2006).

Independency	Score
No independency, modular zoning of products/elements from different layers	1.00
Occasional independency of products/elements from different layers	0.40
Full integration of products/elements from different layers	0.10

Geometry of Product Edge is scored by counting the edges through which an element is enclosed by surrounding products, following the categorical definitions in van Vliet et al. (2021, Section 04.05.01): an element accessible from at least one side, with no enclosing edge, is scored as open; an element enclosed along exactly one edge is scored as overlapping; an element enclosed along two or more edges is scored as closed. Van Vliet et al. (2021) further specify that elements formed or poured in place, monolithic and without discrete boundaries, fall under the closed category regardless of edge count, a provision that does not bear directly on Level 1 elements but is relevant at the boundary between the two assessment levels, where an element's classification as Level 1 or Level 2 is itself a judgement call (Section 2.3.1). Table 10 lists the scoring bands applied for Geometry of Product Edge.

Table 10 - Geometry of Product Edge scoring bands. Source: van Vliet et al. (2021), based on Durmisevic (2006).

Geometry of product edge	Score
Open, no obstacle to the (interim) removal of products or elements	1.00
Overlapping, partial obstruction to the (interim) removal of products or elements	0.40
Closed, complete obstruction to the (interim) removal of products or elements	0.10

The four scores are combined through the harmonic mean, following van Vliet, van Grinsven and Teunizen (2021), rather than a simple average. The harmonic mean penalises a low score in any single factor more heavily than an arithmetic mean would: an element with excellent connection typology but a fully embedded, irreparable connection should not receive a moderate composite score, it should receive a low one, since that single condition may be enough to make disassembly impractical regardless of how favourable the other factors are.

The disassembly potential of the connection combines Connection Typology and Accessibility of Connections:

$$DPc_n = 2 / (1/CT_n + 1/CA_n) \quad (1)$$

The disassembly potential of the composition combines Independence and Geometry of Product Edge:

$$DPcp_n = 2 / (1/ID_n + 1/GPE_n) \quad (2)$$

The disassembly potential of the product or element, equivalent to DfD_DisassemblyScore in the Pset_DfD_LifeCycle parameter set, combines both:

$$DPp_n = 2 / (1/DPc_n + 1/DPcp_n) \quad (3)$$

which is algebraically equivalent to the direct four-factor harmonic mean:

$$DPp_n = 4 / (1/CT_n + 1/CA_n + 1/ID_n + 1/GPE_n) \quad (4)$$

Van Vliet et al. (2021) demonstrate that both formulations converge to the same result; this dissertation uses whichever form is more convenient at each stage of implementation. Table 11 presents the classification derived from this score.

In the Revit implementation, scores are entered through the plugin interface and the aggregate class (Table 11) is calculated automatically, removing manual calculation from the assessment process. This automated workflow also ensures that all assessed elements are evaluated consistently using the same predefined scoring logic, reducing the likelihood of user error and improving the repeatability of the assessment.

Table 11 - Level 1 disassembly class thresholds. Source: Author, based on the scoring bands of van Vliet et al. (2021).

Class	Aggregate Score	Reuse Suitability
A	≥ 0.75	High - direct reuse recommended
B	0.55 – 0.74	Good - reuse with minor intervention
C	0.35 – 0.54	Moderate - reuse with significant intervention
D	0.15 – 0.34	Low - recycling preferred
E	< 0.15	Very low - disassembly without destruction impractical

2.4. Level 2: TRACE protocol

Section 1.3.2 established this gap directly. The case for element-level reuse of materials outside classical DfD frameworks is empirically grounded in the SXL work, Brütting et al. (2019) and Devènes et al. (2024), which demonstrate that structured assessment and reuse are viable for structural components regardless of original design intent. The material category addressed by that work,

structural steel and reinforced concrete, is remote from earthen walls, rubble masonry, and other monolithic construction, and the investigation techniques involved do not transfer directly. The reasoning structure does: an audit of physical condition, combined with a context-specific judgement of reuse potential, is a transferable logic even where the material itself resists componentised assessment. What was missing was an assessment approach calibrated to what can actually be observed and measured in the field for that different material category, recovered through selective demolition rather than reversible disassembly. The Tangible Reuse Assessment for Construction Elements protocol (TRACE), presented in this section, is the response to that gap.

Level 2 applies to elements that fall outside the scope of conventional Design for Disassembly (DfD) assessment, namely building elements without discrete geometry, reversible connections, or clearly identifiable component boundaries, such as continuous adobe walls, rubble stone masonry, rammed earth, and lime-bonded earthen renders. Because these materials cannot be meaningfully evaluated using criteria developed for component-based systems, the TRACE Protocol introduces a field assessment specifically calibrated for monolithic construction. This assessment evaluates material characteristics, repair potential, and future adaptability, establishing a tailored approach for monolithic systems. It therefore expands circularity evaluation beyond conventional component-based criteria.

Rather than adapting existing DfD scoring systems, TRACE derives its assessment criteria from the broader literature on selective demolition, material reuse, building assessment, and material passports. Four aspects recur across that literature as determinants of whether a reclaimed monolithic element can realistically be reused: its physical condition, the feasibility of recovering it without excessive damage, the existence of a plausible reuse opportunity, and the availability of sufficient information to support decision making. No single source proposes these four as a set. Grouping them into a single protocol, and defining what each means for monolithic material, is a contribution of this dissertation.

While the assessment criteria are grounded in existing literature, the operationalization into a three-level field scoring system (0-2) is a methodological contribution of this dissertation, developed to provide a practical inspection tool for selective demolition of monolithic building elements. The three-level structure balances discriminatory capacity and field applicability: a binary system would collapse meaningful intermediate conditions, while a finer scale would introduce a precision that field observation cannot reliably support. Each criterion is scored uniformly, with 0 indicating conditions that preclude reuse, 2 indicating conditions that support direct reuse, and 1 covering intermediate conditions where reuse remains possible but requires further evaluation. The technical implementation of the protocol within the BIM workflow is presented in Chapter 3. Table 12 lists the four TRACE criteria together with the assessment focus of each and the literature that supports its inclusion.

Table 12 - TRACE Protocol assessment criteria and supporting literature.

Criterion	Assessment focus	Supporting literature	TRACE scoring
Physical Integrity	Degree to which the element remains physically intact after removal	Addis (2006); FCRBE (2020); Devènes et al. (2024)	Score 0-2 proposed by the author

Recoverability	Feasibility of extracting the element while preserving its reuse potential	Addis (2006); Akinade et al. (2015, 2017); FCRBE (2020)	Score 0–2 proposed by the author
Reuse Feasibility	Likelihood that the recovered element has a realistic receiving application	Sivers & Fivet (2025); Lambec et al. (2025)	Score 0–2 proposed by the author
Information Confidence	Availability and reliability of information supporting reuse decisions	Honic et al. (2021); Çetin et al. (2023); Tomczak et al. (2024)	Score 0–2 proposed by the author

Table 12 establishes what each criterion measures and grounds it in the literature, but it does not, on its own, tell an assessor what distinguishes a score of 0 from a score of 1 in the field. That gap matters more for TRACE than it would for a criterion borrowed from an established system, precisely because these four criteria are proposed here for the first time: there is no prior scoring practice for an assessor to fall back on if the definitions are left implicit. The same concern that motivated explicit scoring bands for CT, CA, ID, and GPE in Level 1 (Section 2.5) applies here, with less room for improvisation, since Level 1 inherits van Vliet et al.'s (2021) definitions while TRACE has none to inherit. Table 13 clarifies what each score level represents for the four criteria.

Table 13 - TRACE Protocol scoring rubric. Proposed by the author.

Criterion	**Score 0**	**Score 1**	**Score 2**
Physical Integrity	Severe damage or fragmentation; element is not structurally coherent	Moderate, repairable damage; reduced but recoverable integrity	Minimal damage; element remains structurally coherent
Recoverability	Extraction not feasible without destroying the element	Extraction possible with specialised technique or minor, repairable damage	Extraction feasible with standard manual technique, no damage
Reuse Feasibility	No plausible receiving context identified	A plausible receiving application exists in principle, no confirmed receptor	A specific receiving project or context has been identified
Information Confidence	Minimal or no documentation; assessment based on visual impression only	Partial documentation (photographic or visual record only)	Full documentation (photographic record, measurements, and material condition data)

The four criterion scores combine through a simple sum rather than a weighted or harmonic calculation:

$$TRACE_n = PI_n + R_n + RF_n + IC_n \quad (5)$$

yielding a total in the 0–8 range, which Section 2.7 maps onto the three destination classifications. Unlike the Level 1 aggregation (Section 2.5), which uses a harmonic mean to penalise a single weak factor disproportionately, the TRACE aggregation treats all four criteria as additive and independent. This reflects a substantive difference between the two protocols: Level 1 evaluates whether a specific joint prevents disassembly, a condition where one critical weakness can make the entire operation impractical regardless of the other factors, whereas the four TRACE criteria, physical condition, recoverability, receiving context, and information availability, address different stages of the reuse pathway, and a weakness in one does not by itself invalidate strength in another to the same degree.

The reviewed sources do not propose these four dimensions as a unified criterion set, nor do they define them specifically for monolithic materials. The grouping, definitions, and scoring structure are therefore contributions of this dissertation. The relevance of each dimension is established by the literature reviewed above, whereas the scoring structure is supported, at this stage, only by its performance in the evaluation context described in Chapter 4. The validation strategies outlined in Section 2.9 address this distinction directly.

2.5. Score-To-Destination mapping

Assessment scores are only useful if they translate into decisions. A Disassembly Potential score of 0.93 or a TRACE Score of 7 tells a practitioner something about an element's physical condition and reuse potential, but it does not, on its own, tell them what to do with it. The score-to-destination mapping closes that gap: it converts numerical scores into one of three operational classifications.

The three classifications are Direct Reuse, Conditional, and End of Life. Direct Reuse indicates that the element is suitable for reintegration into a new project without significant intervention. Conditional indicates that reuse is possible but requires either adaptation of the element, identification of a suitable receiving context, or both. End of Life indicates that the element's physical condition or contextual circumstances make reuse impractical. Table 14 presents how the three classifications map onto both assessment levels.

Table 14 - Score-to-destination mapping for the two-level assessment framework.

Classification	Level 1 (Desassembly Potential score)	Level 2 (TRACE protocol)
Direct Reuse	Class A or B (score ≥ 0.55)	TRACE Score 7 - 8
Conditional	Class C (score 0.35 - 0.54)	TRACE Score 4 - 6
End of Life	Class D or E (score < 0.35)	TRACE Score 0 - 3

The thresholds reflect a consistent underlying logic: elements in the upper tier have demonstrated sufficient physical integrity and contextual viability to warrant direct reuse; elements in the middle tier could support reuse under the right circumstances but require additional verification; elements in the lower tier present conditions that make reuse economically or technically unviable at the time of assessment.

Two aspects of this mapping deserve explicit mention. First, the classifications are not permanent, though the mechanism by which they change differs between the two levels. A Level 2 element classified as Conditional because no receiving project had been identified, for instance, can be reclassified as Direct Reuse once one is: reuse feasibility is one of the four TRACE criteria, so a change of this kind is captured by re-scoring the element and updating its resulting classification. A Level 1 element's classification, by contrast, follows only from its physical and geometric condition; it has no criterion sensitive to receptor availability, and would only be revised if reinspection produced different scores for connection type, accessibility, component independence, or the geometry of the product edge. Second, the mapping is applied independently for each element. There is no building-level aggregation that could mask the condition of individual components. An element that scores End of Life is classified as such regardless of how well the rest of the building performs.

2.6. Technical pipeline

The technical pipeline transforms assessment data entered into the BIM model into a structured digital passport accessible to receiving projects. It comprises three components: the Revit model with IFC export capability, a Python post-processing script, and a C# plugin operating natively within Revit. As established in Section 2.3, the pipeline bifurcates after the BIM modelling stage into two parallel pathways converging at the digital passport output.

Revit was selected because it is the platform on which the DfADR families and Pset were developed and because it is widely used in the professional contexts relevant to this study. IFC was chosen for Pathway A on grounds of interoperability: as an open, vendor-neutral standard, an IFC file carrying the assessment parameter set can be read by any compliant software without requiring a Revit licence. Python was chosen for post-processing because it requires no commercial licence, has mature libraries for IFC parsing and spreadsheet generation, and can run on any standard installation without specialist support. C# was selected because it provides direct access to the Revit API and therefore allowed the plugin to operate natively within the authoring environment. Both pathways operate within the IFC 4.3 schema established in Section 1.6.1, exporting and reading the same custom property set through the same definition regardless of which pathway generates it. This shared schema is what allows Step 7 to treat the two outputs as equivalent: a receiving system reading the resulting IFC file cannot determine whether the assessment was entered through the Python script or the C# plugin. The choice of pathway is therefore a matter of workflow convenience, not a factor that affects the resulting passport. Figure 19 summarises how these technologies are combined across the two implementation pathways, from the populated Revit model through IFC/Python processing or direct C# processing to the resulting passport data. The detailed architecture of each component is described in Chapter 3. This arrangement also allows the two pathways to be compared without changing the structure or content of the passport produced.

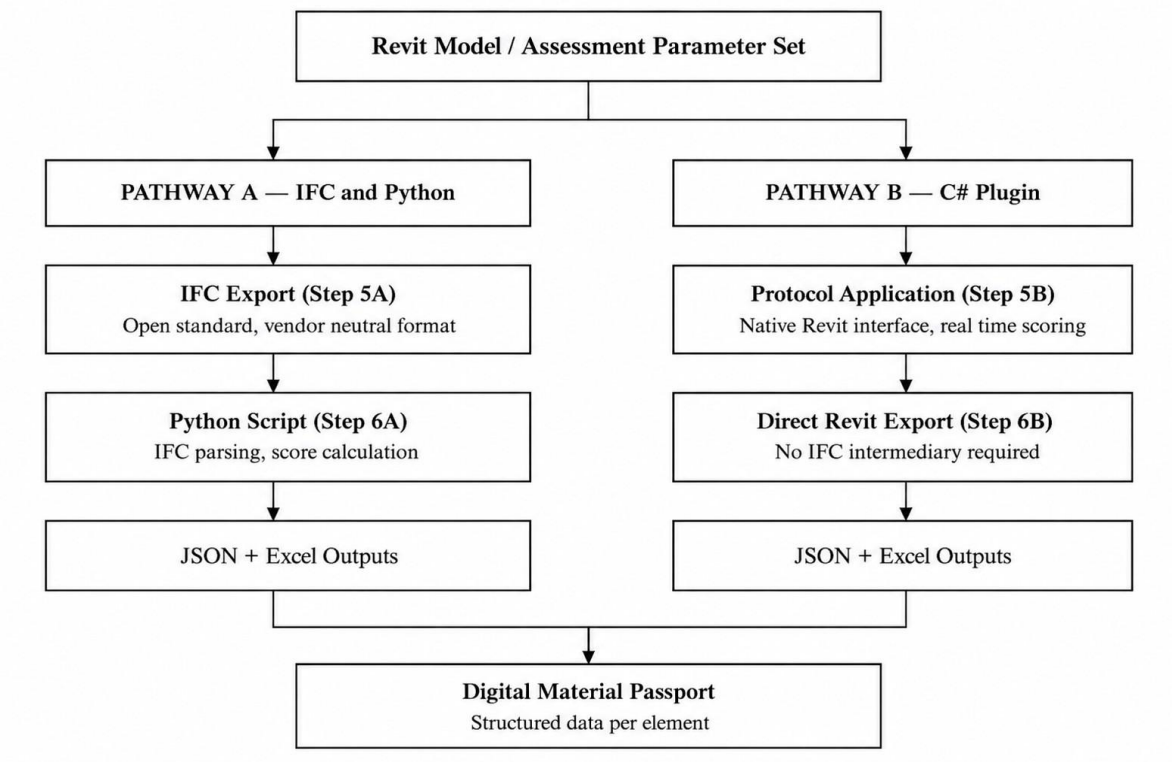


Figure 19 - Technical architecture of the two implementation pathways. Source: Author.

2.7. Framework evaluation strategy

The framework is evaluated through its application to a real building case study presented in Chapter 4. The purpose of this evaluation is to determine whether the proposed two-level structure can be applied consistently to both component-based and monolithic building elements, and whether the resulting assessment data can be recorded and maintained through the digital passport workflow.

Validation is based on three aspects. First, applicability is examined by applying the framework across the range of elements identified during the field survey and determining whether each can be routed and assessed through either Level 1 or Level 2. Second, internal consistency is considered by comparing the resulting scores and classifications with the physical conditions documented during the survey, including whether elements with similar construction and condition produce comparable outcomes. Third, digital continuity is tested by examining whether the assessment information remains associated with an element when its passport data are exported and transferred to another BIM project.

These three aspects correspond directly to the research questions set out above. Applicability speaks to whether the framework can be applied consistently across component-based and monolithic construction alike, the concern behind the first two research questions. Internal consistency speaks to whether the resulting scores are operationally meaningful rather than arbitrary, a condition both levels of the framework must satisfy if they are to support an actual reuse decision. Digital continuity speaks directly to the third research question, whether assessment information can be structured and carried forward in a form usable beyond the project in which it was first recorded. Chapter 4 reports the

results of this evaluation, and Chapter 5 returns to each of these three aspects in turn when discussing what the case study does, and does not, establish about the framework as a whole.

This evaluation should be understood as a case-study assessment of the framework within the conditions of the selected building. It does not establish inter-rater reliability, predictive accuracy, or general applicability across different building types and contexts.

3. DFADR BIM LIBRARY: IMPLEMENTATION

The two-level assessment framework described in Chapter 2 exists, at this point, as a set of scoring criteria and a decision logic. Neither is useful inside a professional workflow on its own. This chapter describes how that framework was embedded in software: the parameter set that carries assessment data inside Revit, the mechanism for attaching that parameter set to existing families and categories, the two processing pathways that turn a populated model into a digital passport, and the online library where reclaimed elements become discoverable.

These components were not developed independently of one another. Section 1.2.1, for instance, documents a case where an earlier naming decision in the parameter set later constrained how the output pathways described in Sections 1.4 and 1.5 could reference the TRACE criteria, and a mapping layer was added to resolve it once the protocol itself was restructured.

3.1. Library design principles

The implementation of the family library required a balance between geometric representation and information requirements. A Revit family is normally built to represent an object with reasonable geometric accuracy. What this project needed from a family was different: a container for assessment data that also carries enough geometry to be located, selected, and scheduled inside a model.

The DfADR families were not modelled with the level of geometric detail typical of manufacturer BIM content. This was a deliberate methodological choice: modelling a colonial-era adobe wall or a hand-adzed timber beam to survey-grade accuracy would have required substantial additional modelling effort without providing a corresponding benefit to the intended passport functions. A wall segment needs enough geometry to sit correctly in the model, to be measured for area and volume, and to be visually distinguishable in a viewer. Beyond this level, additional geometric fidelity provides limited value for the intended passport functions. By contrast, the parameter data attached to the object provides greater value for assessment and passport generation, and modelling effort throughout the project was directed accordingly.

A second principle followed directly from the two-level structure established in Section 2.4. The framework does not depend on a dedicated family type. The shared parameter set can be applied to existing Revit families and model elements without requiring a purpose-built DfADR family, provided that the shared parameters are added to the relevant category. In practice, this is handled through the Setup DfD Params function described in Section 3.5.2, which adds the shared parameters to the categories selected by the user. Classification into Level 1 or Level 2 is therefore not a property of the family itself; it is a value recorded in the parameter set once an element has been assessed in the field, following the survey procedure in Section 2.3.3. Reclassifying a hybrid element, such as a timber-framed wall with earthen infill found to behave more like a monolithic assembly than expected, means updating that field rather than remodelling the element under a different family. This was treated as a design requirement rather than a convenience: a framework that could only be applied to elements modelled inside a purpose-built family library would have limited practical value for existing

buildings, where the model, if one exists at all, was already built around whatever families the original project used, as Section 1.4.1 discusses.

Third, the library had to work outside Revit. This dissertation is built on a single BIM authoring platform for reasons that are practical rather than principled: availability, familiarity, and institutional support. The framework itself was not intended to depend on these platform-specific conditions. An assessed component should, at least in principle, remain interpretable by a receiving project team using a different software environment. That requirement is what turned IFC export, and by extension the entire Pathway A route described in Section 2.7, from an optional interoperability feature into a core requirement of the library design.

3.2. Pset_DfD_Lifecycle: formal proposal

A custom Pset requires clear documentation if it is to be consistently interpreted across applications and, eventually, registered as a shared reference. buildingSMART's Data Dictionary documentation specifies a name, code, and data type as core attributes of a registered property (buildingSMART International). This section documents Pset_DfD_LifeCycle using this structure as a reference, with the eventual buildingSMART Data Dictionary (bSDD) registration identified in Section 6.2 in mind, even though registration itself has not yet been attempted.

The Pset contains 27 shared parameters, organized into four named groups, addressing what the element is and where it came from, what has happened to it since assessment, how it scored under whichever protocol applied, and what its current lifecycle status is. Table 15 summarizes the four groups.

Table 15 - Parameter groups within Pset_DfD_LifeCycle.

Group	Function	Applies to	Example fields
DfD_ID	Element identification and provenance	All elements	Source building, assessment date, assessor, element GUID
DfD_LifeCycle	Lifecycle status, history, and extended DPP-oriented fields	All elements	Current destination, timestamped history log, time to reuse, receptor status, cost tier
DfD_DisassemblyPotential	Disassembly Potential scoring	Level 1 elements	CT, CA, ID, GPE, aggregate score, disassembly class
DfD_TRACE	TRACE Protocol scoring	Level 2 elements	Four criterion scores, aggregate score, TRACE-based destination

3.2.1. Parameter group and definitions

DfD_ID and DfD_LifeCycle apply uniformly, regardless of which assessment level a given element was routed to. DfD_Durmisevic and DfD_TRACE, by contrast, populate only for the level to which the element was assigned; the fields belonging to the other level remain present in the schema, for the reasons given in Section 1.1, but are left blank. The complete set of parameters and their allocation across these four groups is provided in Table 16.

Table 16 - Complete parameter list for Pset_DfD_LifeCycle.

Group	Parameter	Data Type	Applies to
DfD_ID	MaterialPassportID	Text	All elements
DfD_ID	OriginalCategory	Text	All elements
DfD_ID	AssessmentMethod	Text	All elements
DfD_ID	UseTraceProtocol	Yes/No	All elements
DfD_LifeCycle	CurrentLocation	Text	All elements
DfD_LifeCycle	CurrentProject	Text	All elements
DfD_LifeCycle	CurrentUse	Text	All elements
DfD_LifeCycle	ExpectedServiceLife	Text	All elements
DfD_LifeCycle	InstallationDate	Text	All elements
DfD_LifeCycle	IsRepairable	Yes/No	All elements
DfD_LifeCycle	IsReusable	Yes/No	All elements
DfD_LifeCycle	LifecycleHistory	Text	All elements
DfD_LifeCycle	LifeCycleState	Text	All elements
DfD_LifeCycle	ReassemblyCount	Text	All elements
DfD_DisassemblyPotential	CT_Score	Number	Level 1
DfD_DisassemblyPotential	CA_Score	Number	Level 1
DfD_DisassemblyPotential	ID_Score	Number	Level 1
DfD_DisassemblyPotential	GPE_Score	Number	Level 1

DfD_DisassemblyPotential	DisassemblyScore	Number	Level 1
DfD_DisassemblyPotential	DisassemblyClass	Text	Level 1
DfD_DisassemblyPotential	ConnectionType	Text	Level 1
DfD_TRACE	TRACE_PhysicalIntegrity	Integer	Level 2
DfD_TRACE	TRACE_Recoverability	Integer	Level 2
DfD_TRACE	TRACE_ReuseFeasibility	Integer	Level 2
DfD_TRACE	TRACE_InformationConfidence	Integer	Level 2
DfD_TRACE	TRACE_Score	Number	Level 2
DfD_TRACE	TRACE_Recommendation	Text	Level 2

Within DfD_ID, MaterialPassportID holds the element's unique passport identifier; OriginalCategory records the Revit or IFC category under which the element was originally modelled; AssessmentMethod indicates which protocol, Disassembly Potential or TRACE, was applied; and UseTraceProtocol is the boolean flag that routes the element to Level 2 assessment. (Figure 20)

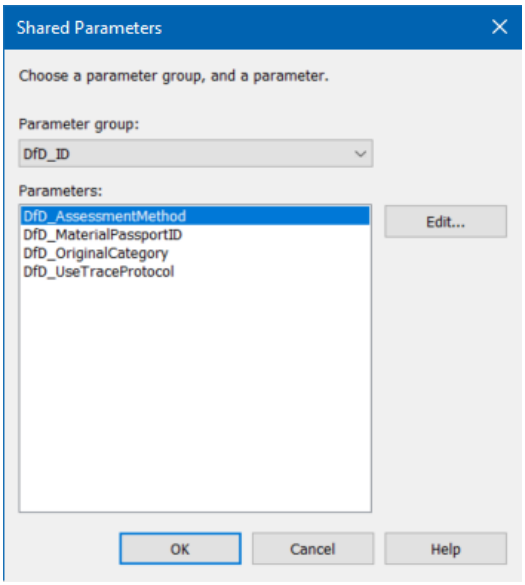


Figure 20 - DfD_ID parameter group in Revit. Source: Author.

DfD_LifeCycle carries the fields that track an element's status and history over time. CurrentLocation and CurrentProject record where the element is and which project it currently belongs to; CurrentUse describes how it is being used; ExpectedServiceLife and InstallationDate describe its anticipated remaining life and when it was installed; IsRepairable and IsReusable are boolean flags describing its condition; LifecycleHistory is a chronological log of recorded events; LifeCycleState describes its

present stage, such as in use, stored, or reused; and ReassemblyCount tracks how many times it has been reassembled into a project. (Figure 21)

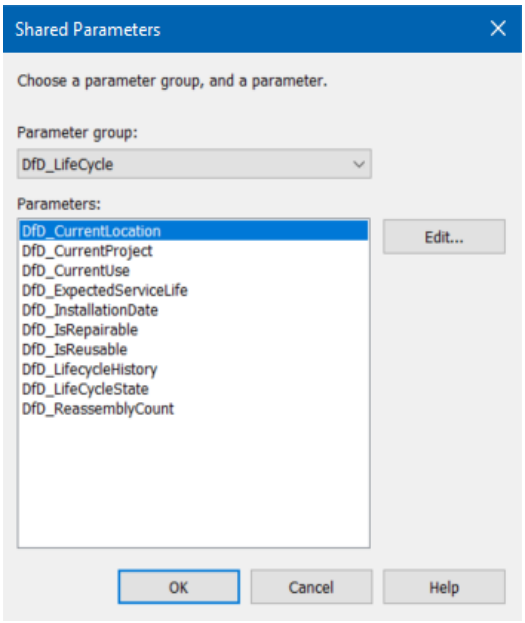


Figure 21 - DfD_LifeCycle parameter group in Revit. Source: Author.

DfD_DisassemblyPotential holds the Level 1 scoring fields. CT_Score, CA_Score, ID_Score, and GPE_Score record Connection Type, Connection Accessibility, Independence, and Geometry of Product Edge respectively; DfD_DisassemblyScore combines the four factor scores through the harmonic-mean calculation defined in Section 2.3; DfD_DisassemblyClass is the resulting classification from A to E; and DfD_ConnectionType describes the physical connection used to fix the element (Figure 22).

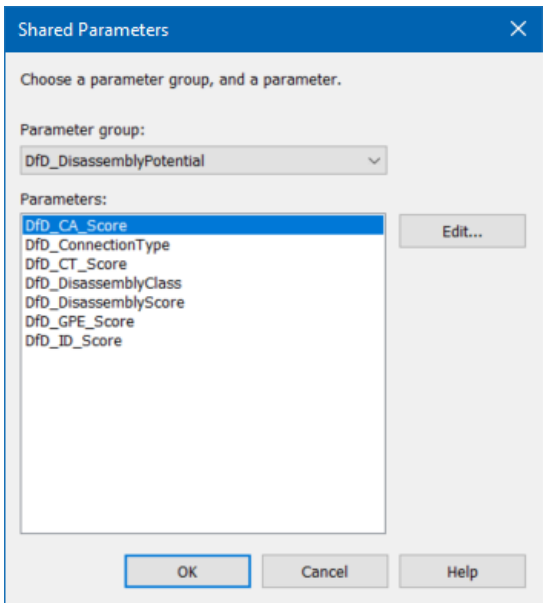


Figure 22 - DfD_DisassemblyPotential parameter group in Revit. Source: Author.

DfD_TRACE holds the Level 2 scoring fields. TRACE_PhysicalIntegrity, TRACE_Recoverability, TRACE_ReuseFeasibility, and TRACE_InformationConfidence are the four criterion scores, each 0 to 2; TRACE_Score is their sum, 0 to 8; and TRACE_Recommendation is the resulting destination classification, Direct Reuse, Conditional, or End of Life (Figure 23).

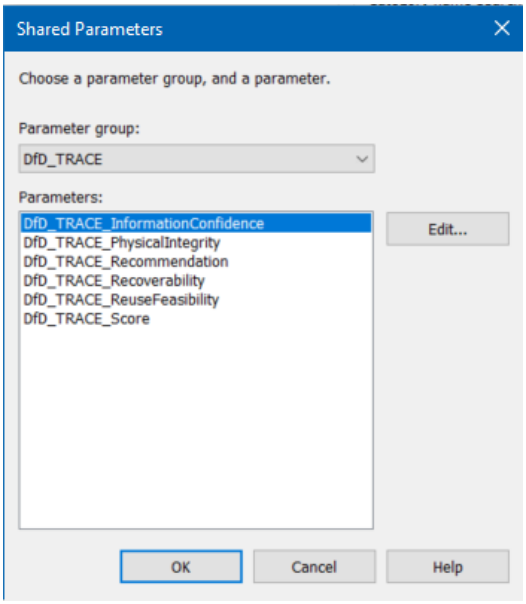


Figure 23 - DfD_TRACE parameter group in Revit. Source: Author.

Five of the 27 parameters are calculated rather than entered directly, using native Family Editor formulas rather than plugin logic. Each is described in turn below.

DfD_AssessmentMethod records which of the two protocols governs the element, read directly from the routing flag rather than entered separately:

$$\text{AssessmentMethod} = \text{if}(\text{UseTraceProtocol}, \text{"Trace_Protocol"}, \text{"DisassemblyPotential"}) \quad (6)$$

If DfD_UseTraceProtocol is checked, the element is treated as a Level 2 case and the field returns "Trace_Protocol"; if unchecked, it returns "DisassemblyPotential" for a Level 1 case. Because this field reads the flag rather than being set independently, the two can never fall out of agreement with one another.

DfD_DisassemblyScore aggregates the four Level 1 factors, CT_Score, CA_Score, ID_Score, and GPE_Score, using the harmonic mean formula adopted from van Vliet et al. (2021):

$$\text{DisassemblyScore} = \text{if}(\text{or}(\text{CT_Score} < 0.001, \text{CA_Score} < 0.001, \text{ID_Score} < 0.001, \text{GPE_Score} < 0.001), 0, 4 / (1/\text{CT_Score} + 1/\text{CA_Score} + 1/\text{ID_Score} + 1/\text{GPE_Score})) \quad (7)$$

The harmonic mean follows van Vliet et al. (2021). The guard clause returns 0 when any factor is unset, preventing the calculation from being performed on incomplete assessment data.

DfD_DisassemblyClass maps that score onto the five-class scale established in Section 2.4:

DisassemblyClass = if(not(DisassemblyScore < 0.75), "A", if(not(DisassemblyScore < 0.55), "B", if(not(DisassemblyScore < 0.35), "C", if(not(DisassemblyScore < 0.15), "D", "E")))) (8)

This nested structure evaluates the thresholds from the top down: a score of 0.75 or above returns Class A, and each subsequent condition is only reached if the score falls short of the one above it, down to Class E for any score below 0.15.

DfD_TRACE_Score sums the four TRACE criteria directly, since each is already expressed on the same 0 to 2 scale and no weighting or normalisation is required:

TRACE_Score = InformationConfidence + PhysicalIntegrity + Recoverability + ReuseFeasibility (9)

The result ranges from 0 to 8.

DfD_TRACE_Recommendation maps that sum onto the three destination classifications defined in Table 14:

TRACE_Recommendation = if(TRACE_Score < 4, "End of Life", if(TRACE_Score < 7, "Conditional", "Direct Reuse")) (10)

A score below 4 returns End of Life, a score from 4 to 6 returns Conditional, and a score of 7 or above returns Direct Reuse.

Figure 24 shows these formulas as implemented in the Family Types dialog, with all parameters at their default, unassessed values.

Parameter	Value	Formula
IFC Parameters		
DfD_AssessmentMethod (default)	Trace_Protocol	=if(DfD_UseTraceProtocol, "Trace_Protocol", "DisassemblyPotential")
DfD_MaterialPassportID (default)		=
DfD_OriginalCategory (default)		=
DfD_UseTraceProtocol (default)	☑	=
DfD_CurrentLocation (default)		=
DfD_CurrentProject (default)		=
DfD_CurrentUse (default)		=
DfD_ExpectedServiceLife (default)		=
DfD_InstallationDate (default)		=
DfD_IsRepairable (default)	☑	=
DfD_IsReusable (default)	☑	=
DfD_LifecycleHistory (default)		=
DfD_LifeCycleState (default)		=
DfD_ReassemblyCount (default)	0	=
DfD_CA_Score (default)	0.000000	=
DfD_CT_Score (default)	0.000000	=
DfD_ID_Score (default)	0.000000	=
DfD_GPE_Score (default)	0.000000	=
DfD_DisassemblyScore (default)	0.000000	=if(or(DfD_CT_Score < 0.001, DfD_CA_Score < 0.001, DfD_ID_Score < 0.001, DfD_GPE_Score < 0.001), 0, 4 / (1 / DfD_CT_Score + 1 / DfD_CA_Score + 1 / DfD_ID_Score + 1 / DfD_GPE_Score))
DfD_ConnectionType (default)		=
DfD_DisassemblyClass (default)	E	=if(not(DfD_DisassemblyScore < 0.75), "A", if(not(DfD_DisassemblyScore < 0.55), "B", if(not(DfD_DisassemblyScore < 0.35), "C", if(not(DfD_DisassemblyScore < 0.15), "D", "E"))))
DfD_TRACE_InformationConfidence (default)	0	=
DfD_TRACE_PhysicalIntegrity (default)	0	=
DfD_TRACE_Recoverability (default)	0	=
DfD_TRACE_ReuseFeasibility (default)	0	=
DfD_TRACE_Score (default)	0.000000	=DfD_TRACE_InformationConfidence + DfD_TRACE_PhysicalIntegrity + DfD_TRACE_Recoverability + DfD_TRACE_ReuseFeasibility
DfD_TRACE_Recommendation (default)	End of Life	=if(DfD_TRACE_Score < 4, "End of Life", if(DfD_TRACE_Score < 7, "Conditional", "Direct Reuse"))

Figure 24 - Calculated parameter formulas in the Family Types dialog, shown at default, unassessed values. Source: Author.

Every assessed element carries the full parameter set regardless of which group actually applies to it, so the schema itself does not depend on the assessment level used. How this operates in practice which

fields are populated and which remain blank depending on the routing decision is described in Section 3.2.2.

The DfD_ prefix used across the 27 parameters is an implementation-specific naming convention adopted to identify and group the parameters within Revit. It is not intended as part of a formal buildingSMART property-set definition and differs from buildingSMART's naming guidance for bSDD registration, which recommends avoiding prefixes that reduce the portability of definitions outside their originating context (buildingSMART International, n.d.-a). A future registration of the schema would therefore require reviewing this naming convention and potentially adopting prefix-free parameter names.

3.2.2. Field population: a Level 1 and Level 2 example

Populating the schema in practice differs across groups. DfD_ID and DfD_LifeCycle fields are entered directly by the assessor, while MaterialPassportID and LifecycleHistory are generated or updated automatically by the plugin during Write Passport. DfD_UseTraceProtocol is the decision point that determines which scoring group applies to an element. When checked, the element is treated as Level 2 and the DfD_TRACE_* fields are populated according to the field protocol described in Section 2.5. When unchecked, the element is treated as Level 1 and the CT_Score, CA_Score, ID_Score, and GPE_Score fields are populated instead. The flag therefore records the classification made during the field assessment; it does not make that decision itself described in Section 2.3.3. DfD_AssessmentMethod is derived from DfD_UseTraceProtocol and records the assessment method used, keeping the two fields consistent. The complete set of parameters and their allocation across these four groups is provided in Figure 25.

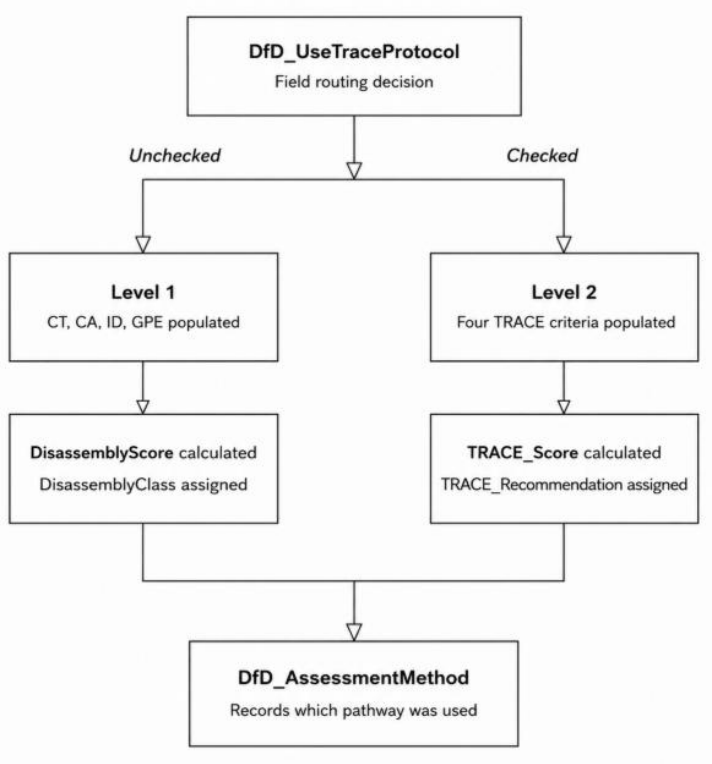


Figure 25 - Level 1 and Level 2 routing logic. Source: Author.

Populating the schema in practice is best shown by tracking generic elements across stages, rather than described in the abstract. This provides a clearer view of how field observations are progressively translated into structured parameters and how the resulting information is retained throughout the workflow.

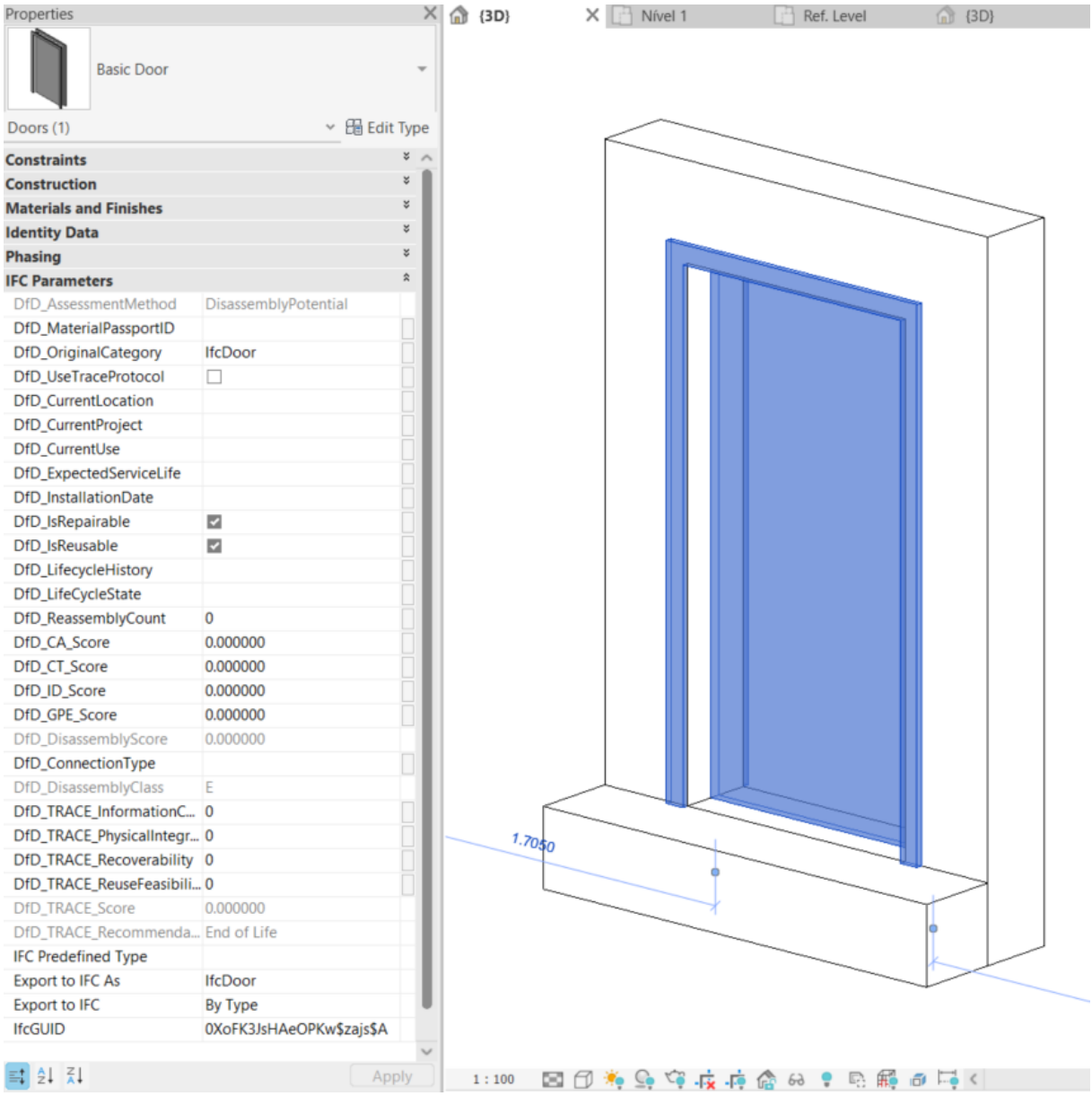


Figure 26 - Generic door before schema population. Source: Author.

Figure 26 shows a generic door instance immediately after field classification: DfD_UseTraceProtocol and DfD_AssessmentMethod are already set, but every other field remains at its default, unpopulated state. DfD_ID is populated next. MaterialPassportID is assigned as a unique identifier; OriginalCategory records the Revit or IFC category the element was originally modelled under. Figure 27 shows these fields populated on the same door instance, with MaterialPassportID set to MP-TEST-001 and OriginalCategory set to IfcDoor.

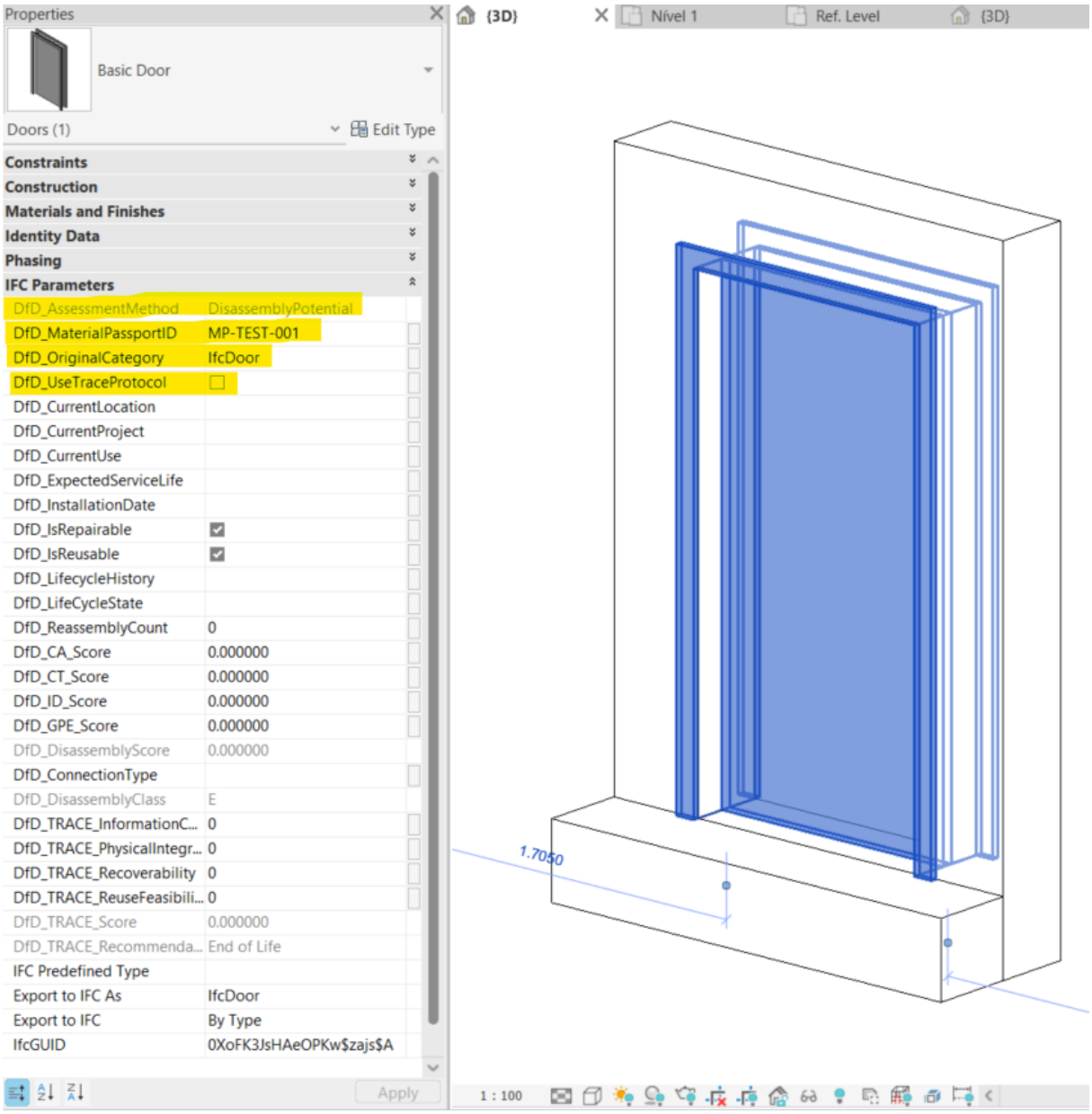


Figure 27 - DfD_ID populated on the generic door. Source: Author.

DfD_LifeCycle is populated next. CurrentLocation, CurrentProject, and CurrentUse describe where the element is, which project it belongs to, and how it is being used; ExpectedServiceLife and InstallationDate describe its anticipated remaining life and when it entered service; IsRepairable and IsReusable are boolean flags recording its condition; LifeCycleState describes its present stage. Some of these fields are designed to be revised as an element's circumstances change rather than fixed at first entry. LifeCycleState is the clearest case: an element can move from “In Use” to “Stored” and later to “Reused”, with each change appended to LifecycleHistory as a new, timestamped entry rather than overwriting the previous record. ReassemblyCount is updated in the same way, incrementing each time the element is reintegrated into a new project. Figure 29 shows DfD_LifeCycle populated on the same instance, with LifecycleHistory carrying two entries to illustrate this append-only behaviour.

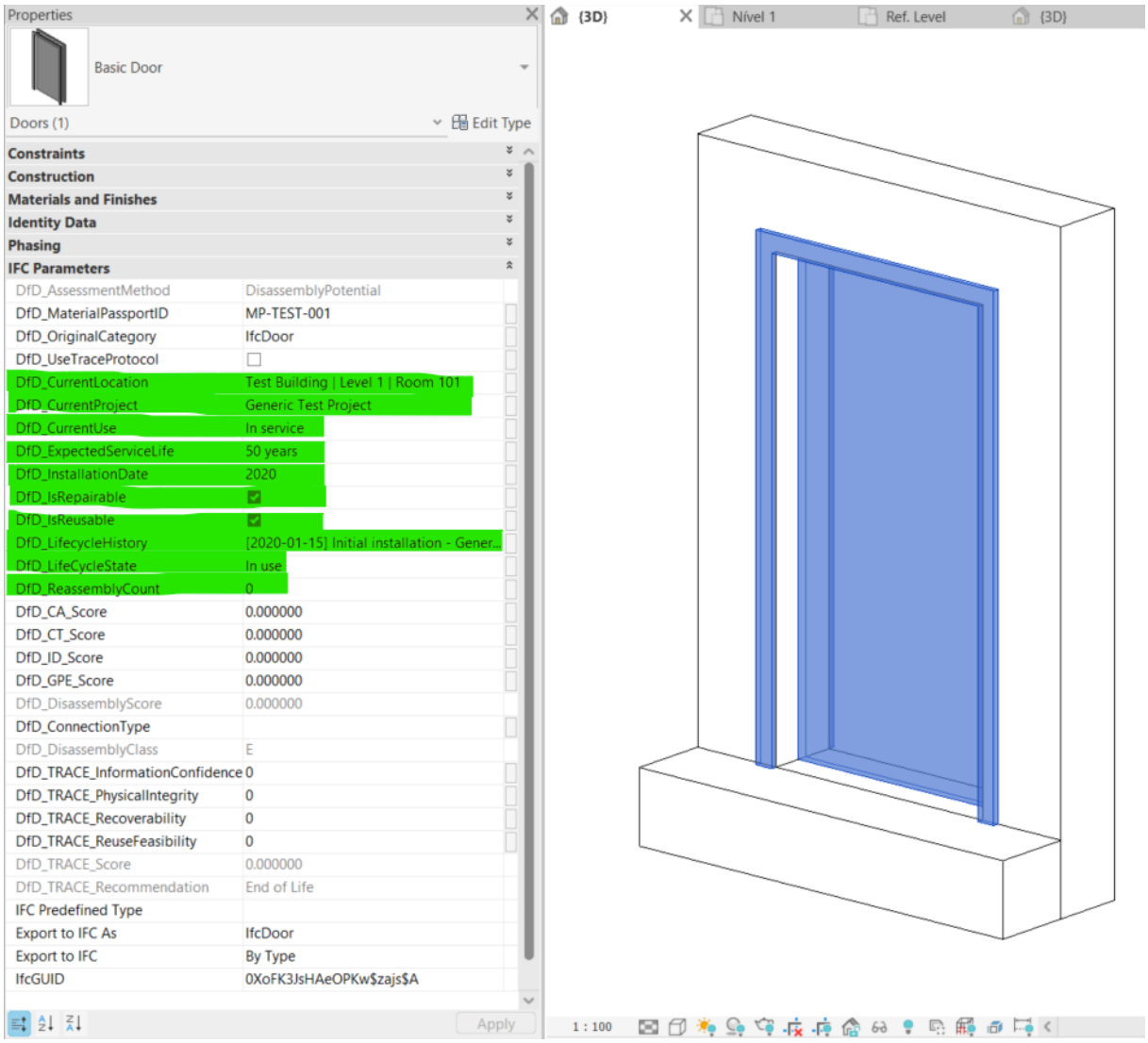


Figure 28 - DfD_LifeCycle populated on the generic door. Source: Author.

With identity and lifecycle status in place, the door is ready to be scored. The four Level 1 factors are not entered as raw numbers. Each one is selected from a predefined lookup table that links an observed field condition to its corresponding score: a bolted or screwed connection maps to a defined CT value, an element assessed as fully independent maps to a defined ID value, and so on. This keeps the inputs to DisassemblyScore consistent across assessments and avoids requiring the assessor to assign numerical values directly. Figure 29 shows the same door with CT_Score = 0.80, CA_Score = 1.00, ID_Score = 0.70, and GPE_Score = 1.00, aggregating to a DisassemblyScore of 0.855 and a Class A rating under the thresholds established in Section 2.4. Its DfD_TRACE fields, meanwhile, remain at their default. DfD_TRACE_Recommendation reads "End of Life" as a result, a value produced by running an unset score through the same mapping logic that applies to genuinely assessed Level 2 elements. Read in isolation, that field could be mistaken for a real recommendation against reusing the door, when it is in fact an artifact of the field never having been scored under that protocol. This distinction is important when interpreting the passport, since inactive assessment fields should not be treated as valid evidence of an element's reuse potential. In practice, the selected assessment level therefore determines which recommendation fields should be considered active and meaningful.

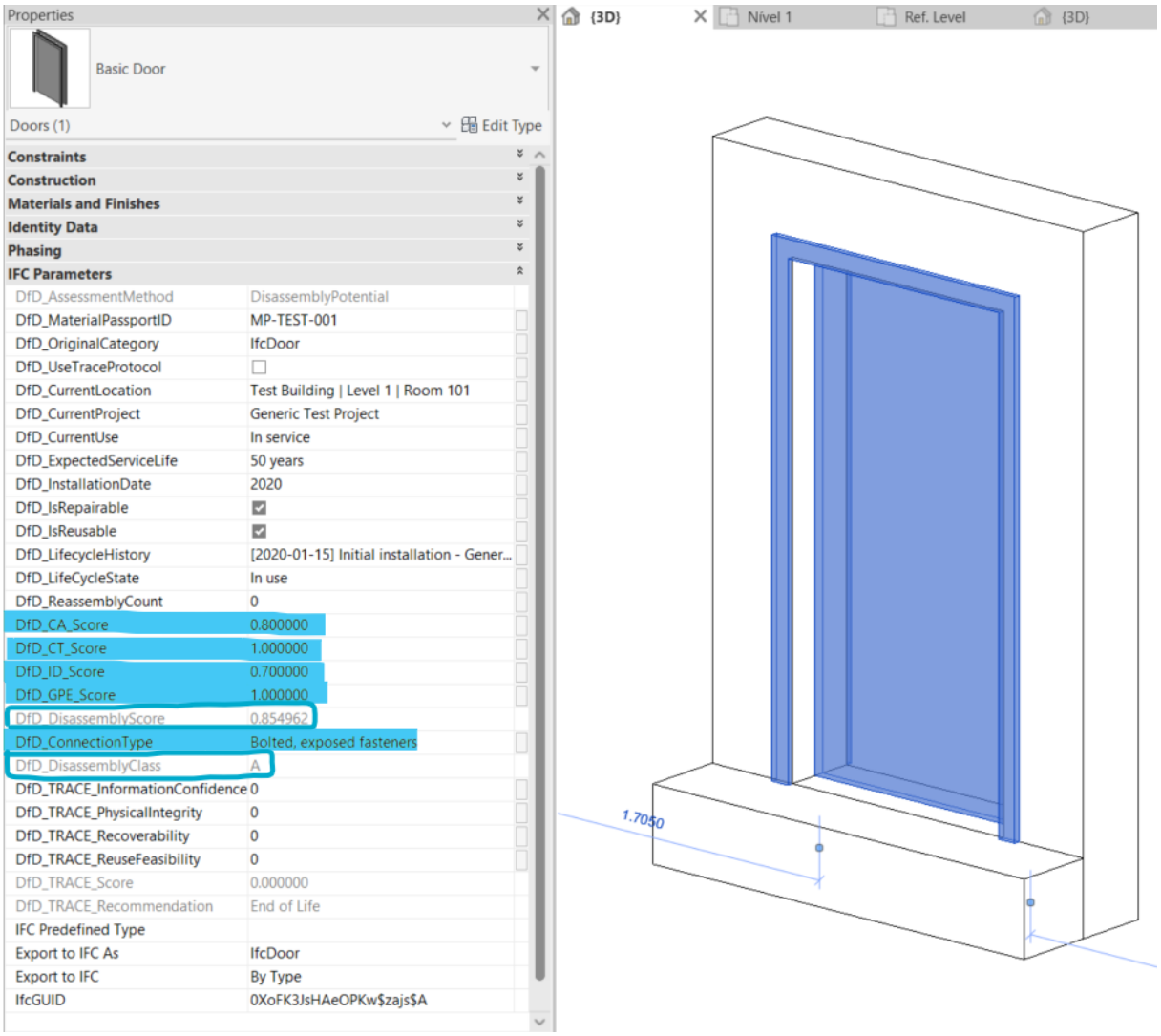


Figure 29 - Disassembly Potential scored, TRACE at default. Source: Author.

The same situation occurs in the opposite direction for a Level 2 element. A generic wall was chosen for this example precisely because it lacks the discrete, separable components that Level 1 assumes, the same reasoning that motivated the TRACE Protocol in the first place. The four TRACE criteria, in contrast to the Level 1 factors, are entered directly as integer scores from 0 to 2, following the definitions in Table 12. Figure 30 shows a generic wall instance assessed under TRACE (DfD_AssessmentMethod = Trace_Protocol, DfD_UseTraceProtocol checked), with its four TRACE criteria populated with field scores, aggregating to a TRACE_Score and a destination classification following Table 14. Its DfD_DisassemblyPotential fields remain at their default of zero, and DfD_DisassemblyClass reads "E," the lowest possible rating, produced the same way: by running an unset score through the Level 1 mapping logic. DfD_AssessmentMethod is what resolves the ambiguity in both directions: it is what tells a reader which of the two result sets, Disassembly Potential or TRACE, actually applies to a given element, and, by implication, which of the two default values to disregard. This explicit routing logic prevents default values from being interpreted as valid assessment outcomes and ensures that each element is evaluated only through the protocol appropriate to its physical characteristics. It also makes the two-level framework readable within a single shared parameter structure without requiring separate datasets for Level 1 and Level 2 elements.

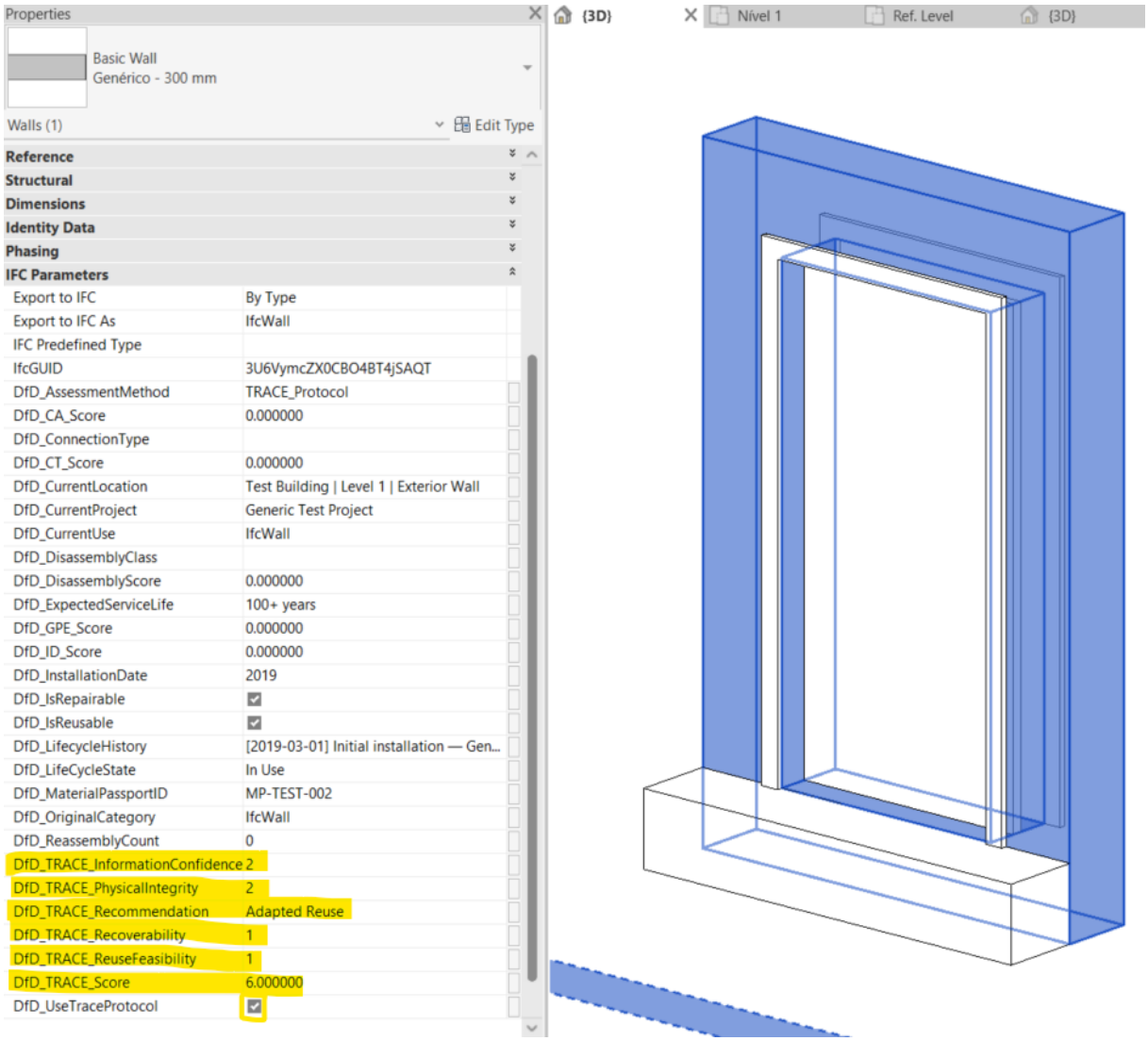


Figure 30 - TRACE scored, Disassembly Potential at default. Source: Author.

The door and the wall together illustrate the same underlying principle from two directions: identity and lifecycle status apply uniformly, but scoring is protocol-specific, and DfD_AssessmentMethod is what tells a reader which set of results to trust and which to disregard. This is not a limitation of the schema so much as a consequence of accommodating two structurally different assessment logics within a single, uniform passport structure. The remaining sections of this chapter describe how this schema is exported, read, and reintegrated across the two implementation pathways.

3.3. Pathway A: python script

Pathway A moves an assessed element from the Revit model to a receiving-ready passport, and back into a new BIM environment, through a fixed sequence of steps: IFC export, property set recovery, routing determination, score recalculation, geometry extraction, output generation, and reintegration into a receiving project. Figure 31 summarises this sequence as a closed loop, since the passport generated at one project's end of life is precisely the input a receiving project needs at the start of its own assessment cycle. The sections that follow examine each step in turn, together with the fallback

mechanisms built into the three steps most exposed to the export behaviour described in Section 3.3.1; reintegration itself is addressed separately in Section 3.3.3.

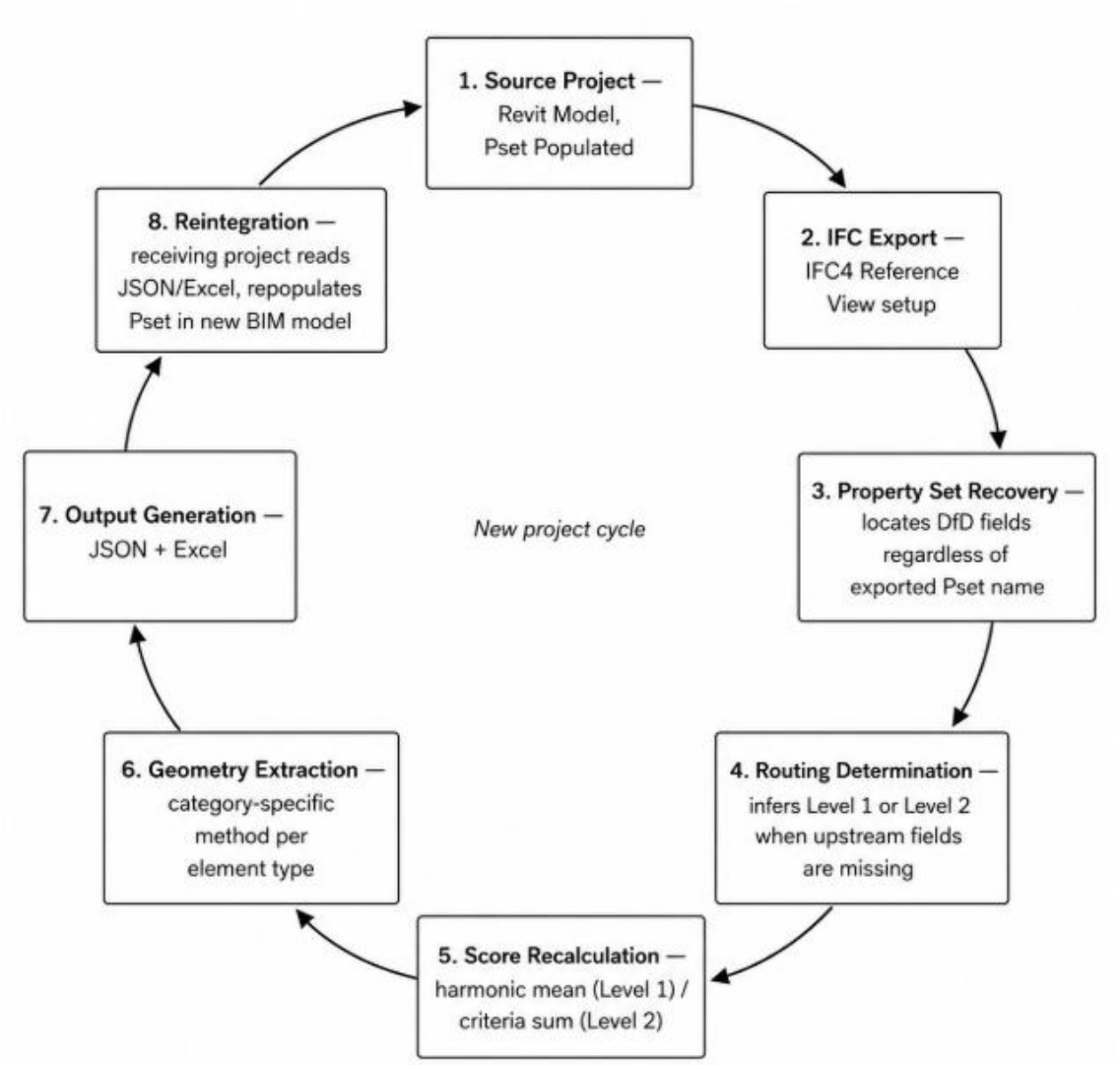


Figure 31 - Pathway A as a closed loop: from IFC export to reintegration in a receiving project. Source: Author.

3.3.1. IFC export and post-processing

The export step uses Revit's native IFC exporter, configured through a custom setup based on the IFC4 Reference View with an Architectural Reference Exchange model, Property Mapping set to IFC4, and Level of Detail set to Medium.

Two settings are particularly relevant to the export. First, "Export parts as building elements" is enabled so that composite elements are exported as identifiable building elements rather than as undifferentiated geometry. Second, "Store the IFC GUID in an element parameter after export" is enabled to preserve the correspondence between the Revit element and its IFC GUID across subsequent exports, addressing the GUID persistence limitation discussed in Section 1.6.1. As shown in Figure 15.

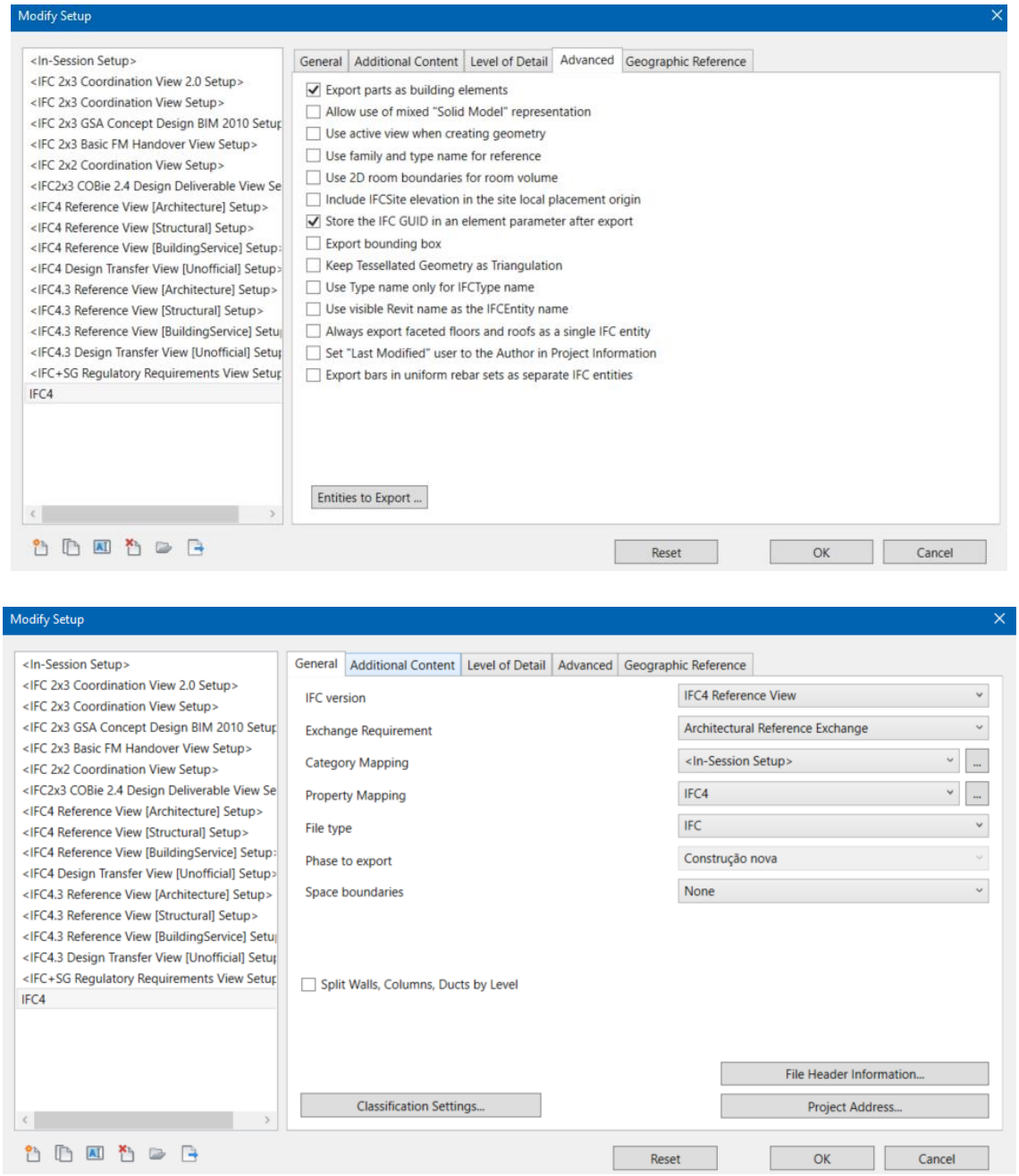


Figure 32 - IFC export setup: general and advanced configuration. Source: Author.

Inspection of the exported IFC shows that the 27 shared parameters are all present, grouped under a single IfcPropertySet named "IFC Parameters" rather than as a separately named Pset_DfD_LifeCycle. The four groups defined in Section 3.2.1, DfD_ID, DfD_LifeCycle, DfD_DisassemblyPotential, and DfD_TRACE, remain defined in the Revit model and in the shared parameter file, and each individual parameter name is retained in the export exactly as defined. In the raw IFC file, this property set appears as a single STEP entity referencing each of its 27 properties by number:

```
#115=IFCPROPERTYSET('0lB9fluBbFUlwi5Xi99OQ0',#6,'IFC Parameters',$,(#81,#82,#83,#84,#85,#86,#87,#88,#89,#90,#91,#92,#93,
#94,#95,#96,#97,#98,#99,#100,#101,#102,#103,#104,#105,#106,#107));
```

(11)

Read on its own, this line confirms only that the property set is named "IFC Parameters" and contains 27 properties; the numbers in parentheses are references to separate entities elsewhere in the file, each holding the actual property name and value, and are not meaningful without resolving them.

Reading the file with ifcopenshell resolves these references directly. Figure 33 shows the result of querying the property sets attached to a door element: "IFC Parameters" is returned alongside the model's other standard property sets, and every one of the 27 DfD_ fields defined in Section 3.2.1 is present and readable by name within it, confirming that the schema survives the export intact, even though its four-group structure is flattened into a single named set.

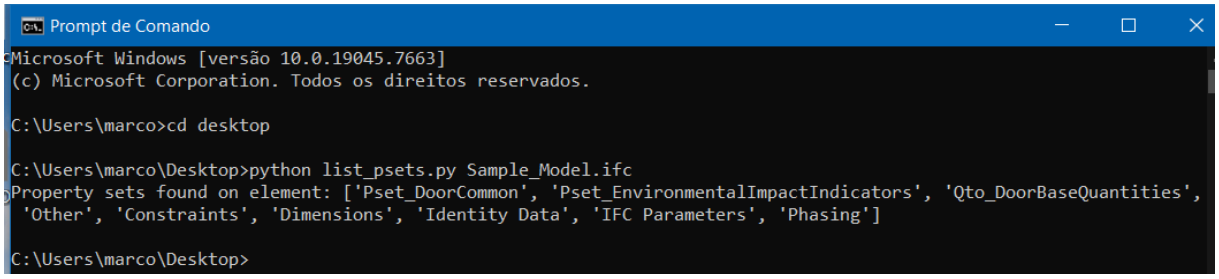


Figure 33 - Door element with exported IFC parameters. Source: Author.

The Python post-processing script handles this when reading the IFC. It first searches for a property set named Pset_DfD_LifeCycle. If this is not found, it searches the property sets attached to each element and collects properties whose names match the known DfD_ fields, regardless of the property set in which they were exported. The intended schema can therefore be reconstructed from the exported parameters without modifying the Revit-side configuration.

The fallback logic is implemented directly in the get_pset() function shown in Figure 34. The function first searches for the expected Pset_DfD_LifeCycle property set and, when it is not found, searches the available property sets for the known DfD_ parameters. This allows the script to retrieve the assessment data despite the different property set name produced by the IFC export.

```
229  def get_pset(elem, name):
230      """Read named Pset; if Pset_DfD_LifeCycle not found by name,
231      scan all Psets for DfD parameters (Revit exports them inside 'IFC Parameters')."""
232      fallback = {}
233      for rel in getattr(elem, "IsDefinedBy", []):
234          if not rel.is_a("IfcRelDefinesByProperties"): continue
235          ps = rel.RelatingPropertyDefinition
236          ps_name = getattr(ps, "Name", "")
237          props = {}
238          for p in getattr(ps, "HasProperties", []):
239              v = getattr(p, "NominalValue", None)
240              if v is not None: props[p.Name] = v.wrappedValue
241          if ps_name == name:
242              return props
243          for k, v in props.items():
244              if k in DFD_PARAM_NAMES:
245                  fallback[k] = v
246      if name == "Pset_DfD_LifeCycle" and fallback:
247          return fallback
248      return {}
```

Figure 34 - get_pset() fallback logic for DfD parameters. Source: Author.

The script also includes a fallback for determining the assessment level. Each element is expected to contain DfD_UseTraceProtocol and DfD_AssessmentMethod, which identify whether Level 1 or Level 2 was applied. The script checks DfD_UseTraceProtocol first. If the field is unavailable, it checks DfD_AssessmentMethod for a recognised value. If neither is available, the populated score fields are used instead. An element with populated TRACE fields and no populated Disassembly Potential fields is treated as Level 2, while the opposite pattern is treated as Level 1. As illustrated in Figure 35, this fallback was included because these fields may also be affected by the IFC export behaviour described above.

```
193  def _is_trace_route(data):
194      """Decide if an element should be routed through the TRACE protocol
195      instead of Disassembly Potential (Level 1). Tries DfD_UseTraceProtocol /
196      DfD_AssessmentMethod
197      first; if both are missing/empty (e.g. not yet added to the IFC export
198      Pset mapping), falls back to inferring the route from which fields are
199      actually filled in."""
200      use_trace = data.get("DfD_UseTraceProtocol")
201      if isinstance(use_trace, str):
202          use_trace = use_trace.strip().lower() in ("yes", "true", "1")
203      if use_trace:
204          return True
205
206      method = str(data.get("DfD_AssessmentMethod", "")).strip().lower()
207      if "trace" in method:
208          return True
209      if "durmisevic" in method or "ddf" in method or "disassembly" in method:
210          return False
211
212      # ┼ Fallback: DfD_AssessmentMethod / DfD_UseTraceProtocol came back
213      # empty (commonly because they're missing from the IFC export Pset
214      # mapping). Infer the route from which score fields are filled.
215      trace_signal = any(_is_filled(data.get(k)) for k in
216                         ("DfD_TRACE_Score", "DfD_TRACE_PhysicalIntegrity",
217                          "DfD_TRACE_Recoverability", "DfD_TRACE_ReuseFeasibility",
218                          "DfD_TRACE_InformationConfidence", "DfD_TRACE_Recommendation"))
219      l1_signal = any(_is_filled(data.get(k)) for k in
220                              ("DfD_DisassemblyScore", "DfD_ConnectionType",
221                               "DfD_CT_Score", "DfD_CA_Score",
222                               "DfD_ID_Score", "DfD_GPE_Score"))
223
224      if trace_signal and not l1_signal:
225          return True
226      return False
```

Figure 35 - _is_trace_route() fallback logic for Level 1/Level 2 routing. Source: Author.

Score calculation follows the same logic used by the Revit-side formulas described in Section 3.2.1. DisassemblyScore is recalculated from the four Level 1 factors using the harmonic mean, with a check for unset factors to avoid undefined results. As shown in Figure 36, the calc() function implements this calculation together with the corresponding zero-guard clause. DfD_DisassemblyClass is read directly from the IFC when available and is independently calculated only when it is not. TRACE_Score is recalculated as the sum of the four TRACE criteria when all four values are available. Otherwise, the recorded value is used. The harmonic mean implemented in the Python script is the same as the one used in the Revit formulas, so both processing pathways produce the same numerical result for the same assessed element, as described in Section 2.7.

```python
def calc(ct, ca, id_, gpe):
    # Harmonic mean of the four Design Determining Factors. A harmonic mean is
    # dominated by its smallest input, so a single weak factor (e.g. a welded
    # connection) pulls the whole score down instead of being diluted by the
    # other three — unlike an arithmetic mean, where one bad factor can be
    # masked by three good ones.
    vals = [ct, ca, id_, gpe]
    if any(v <= 0 for v in vals):
        # Any factor at 0 (missing/unassessed data) makes the true harmonic
        # mean undefined (division by zero); mathematically the harmonic
        # mean collapses toward 0 as any input approaches 0, so 0.0 is the
        # correct limiting value here, not a crash.
        return 0.0
```

Figure 36 - calc() function: harmonic mean aggregation with zero-guard clause. Source: Author.

Geometry is extracted according to element category, because the IFC representation is not identical across building element types. Doors and windows provide OverallWidth and OverallHeight directly, or through Pset_DoorCommon and Pset_WindowCommon. Walls and slabs expose their dimensions through IfcElementQuantity sets, using Width, Length, and Height, while columns and beams use different quantity structures. The script therefore selects the appropriate extraction method for each category instead of applying a single method to all elements. As shown in Figure 37, the script therefore selects the appropriate extraction method for each category instead of applying a single method to all elements.

```python
def get_geometry(elem):
    geom = {"width_mm": None, "height_mm": None, "thickness_mm": None, "source": "not found"}
    ow = getattr(elem, "OverallWidth", None)
    oh = getattr(elem, "OverallHeight", None)
    if ow is not None or oh is not None:
        geom["width_mm"]  = _to_mm(ow)
        geom["height_mm"] = _to_mm(oh)
        geom["source"]    = "IfcDoor/IfcWindow direct attributes"

    pset_common = get_pset(elem, "Pset_DoorCommon") or get_pset(elem, "Pset_WindowCommon")
    if pset_common:
        if "Width"     in pset_common: geom["width_mm"]     = _to_mm(pset_common["Width"]);     geom["source"] = "Pset_DoorCommon/WindowCommon"
        if "Height"    in pset_common: geom["height_mm"]    = _to_mm(pset_common["Height"])
        if "Thickness" in pset_common: geom["thickness_mm"] = _to_mm(pset_common["Thickness"])

    for rel in getattr(elem, "IsDefinedBy", []):
        if not rel.is_a("IfcRelDefinesByProperties"): continue
        qs = rel.RelatingPropertyDefinition
        if not qs.is_a("IfcElementQuantity"): continue
        qs_name = getattr(qs, "Name", "")
        if qs_name in ("Qto_DoorBaseQuantities", "Qto_WindowBaseQuantities", "BaseQuantities"):
            for q in getattr(qs, "Quantities", []):
                v = getattr(q, "LengthValue", None)
                if q.Name == "Width"  and v: geom["width_mm"]     = _to_mm(v); geom["source"] = qs_name
                if q.Name == "Height" and v: geom["height_mm"]    = _to_mm(v)
                if q.Name == "Depth"  and v: geom["thickness_mm"] = _to_mm(v)
        # Walls/Slabs typically expose Width/Length/Area instead of Width/Height
        if qs_name in ("Qto_WallBaseQuantities", "Qto_SlabBaseQuantities"):
            for q in getattr(qs, "Quantities", []):
                v = getattr(q, "LengthValue", None)
                if q.Name in ("Width",) and v: geom["thickness_mm"] = _to_mm(v); geom["source"] = qs_name
                if q.Name in ("Length",) and v: geom["width_mm"]    = _to_mm(v)
                if q.Name in ("Height",) and v: geom["height_mm"]   = _to_mm(v)
        # Columns/Beams typically expose Length (along axis) + cross-section
        if qs_name in ("Qto_ColumnBaseQuantities", "Qto_BeamBaseQuantities"):
            for q in getattr(qs, "Quantities", []):
                v = getattr(q, "LengthValue", None)
                if q.Name in ("Length",)    and v: geom["height_mm"]    = _to_mm(v); geom["source"] = qs_name
                if q.Name in ("CrossSectionArea",): pass  # area, not a length — skip
                if q.Name in ("Width",)     and v: geom["width_mm"]     = _to_mm(v)
                if q.Name in ("Depth",)     and v: geom["thickness_mm"] = _to_mm(v)
    return geom
```

Figure 37 - get_geometry() function: category-specific geometry extraction. Source: Author.

Together, these mechanisms mean that Pathway A does not depend on the exported IFC preserving Revit's internal naming or structure exactly. Property set names, routing fields, and score values are all recovered through explicit fallback logic rather than assumed, and the resulting passport data is identical regardless of which of these paths a given element actually took to reach it. None of this needs to be verified element by element: the script is invoked from the command line, taking the exported IFC file as its single argument, and reports the outcome of this fallback logic directly once processing is complete. Figure 38 shows the console output of a typical run, confirming the level breakdown and the two files generated in the target folder. Section 3.3.2 describes the JSON and Excel outputs this process produces.

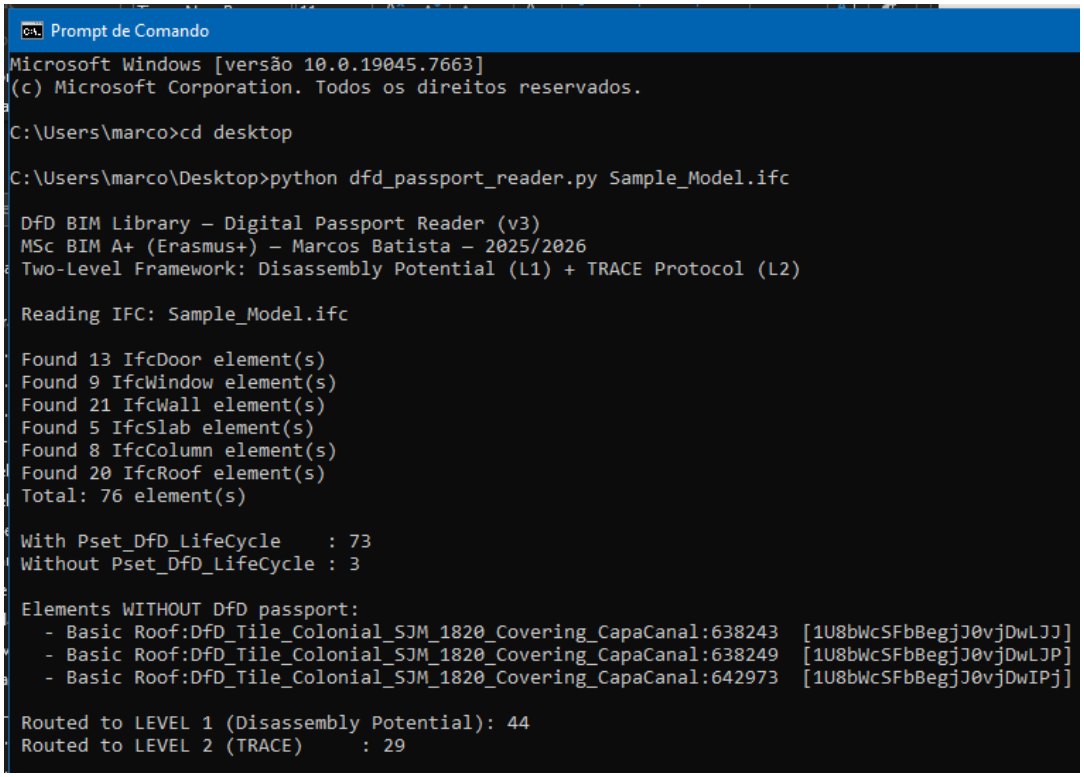


Figure 38 - Console output of a typical script run, confirming the level breakdown and the files generated. Source: Author.

3.3.2. JSON and Excel outputs

The script produces two output formats from the same ordered data: a single JSON file and a single Excel workbook, both named dfd_passport_library with the appropriate extension.

The JSON output nests elements under two top-level groups, level_1_disassembly_potential and level_2_trace, each reporting a count, a breakdown by IFC class, and the ordered element list itself. As illustrated in Figure 39, within each element, fields appear in a fixed sequence, identification (element name, IFC GUID, IFC class, assessment level), common lifecycle fields shared across both levels, the level-specific score fields, and finally geometry. Only populated fields are included; a field left at its default, unassessed state is omitted rather than exported as an empty value. Where DfD_AssessmentMethod itself was not recovered from the IFC, it is reconstructed from the routing inferred in Section 3.3.1, so this field is never missing from the output.

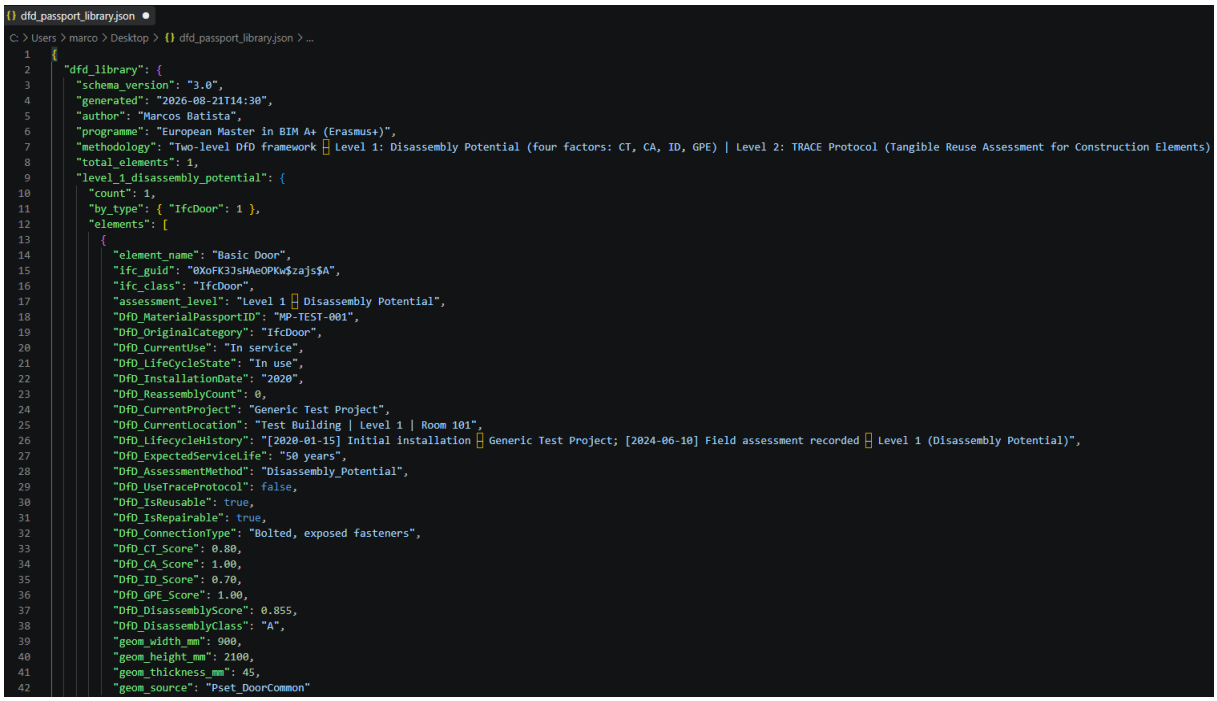


Figure 39 - JSON output structure for a Level 1 element. Source: Author.

The Excel workbook mirrors this separation as a sheet structure rather than a nested object. Level 1 elements are written first, followed by Level 2 elements, with a separate sheet generated for each IFC class present within a level; sheet names are truncated to Excel's 31-character limit where necessary. As illustrated in Table 17 and 18, the two levels use different column sets, reflecting their different score fields, Connection Type and the four Disassembly Potential factors for Level 1, the four TRACE criteria and the resulting recommendation for Level 2, alongside a shared set of identification, lifecycle, and geometry columns common to both.

Table 17 - Excel sheet for the Level 1 (Disassembly Potential) example element. Source: Author.

DfD BIM Library — Level 1 — Disassembly Potential — Doors | Generic Test Building | 1 element(s)

Passport ID	IFC Class	IFC Category	Current Use	Lifecycle State	Assessment Method	Location
MP-TEST-001	IfcDoor	IfcDoor	In service	In use	Disassembly_Potential	Test Building | Level 1 | Room 101

Project	Installed	Reuse Count	Connection Type	CT Score	CA Score	ID Score	GPE Score
Generic Test Project	2020	0	Bolted, exposed fasteners	0,8	1	0,7	1

Disassembly Score	Class	Reusable	Repairable	Service Life	Width (mm)	Height (mm)	Thickness (mm)
0,855	A	Yes	Yes	50 years	900	2100	45

Geometry Source	IFC GUID	Element Name
Pset_DoorCommon	0XoFK3JsHAeOPKw$zajs$A	Basic Door

Table 18 - Excel sheet for the Level 2 (TRACE) example element. Source: Author.

DfD BIM Library — Level 2 — TRACE Protocol — Walls | Generic Test Building | 1 element(s)

Passport ID	IFC Class	IFC Category	Current Use	Lifecycle State	Assessment Method	Location
MP-TEST-002	IfcWall	IfcWall	In service	In use	Trace_Protocol	Test Building | Level 1 | Exterior Wall

Project	Installed	Reuse Count	Physical Integrity (0-2)	Recoverability (0-2)	Reuse Feasibility (0-2)	Information Confidence (0-2)
Generic Test Project	2019	0	2	1	1	2

TRACE Score (0-8)	Recommendation	Reusable	Repairable	Service Life	Width (mm)	Height (mm)
6	Conditional	Yes	Yes	100+ years	4000	3000

Thickness (mm)	Geometry Source	IFC GUID	Element Name
300	Qto_WallBaseQuantities	1YpGK4KtIBfPLx$abcs$B	Generic Wall

The JSON and Excel outputs are two representations of the same ordered data, chosen for different purposes: the JSON preserves the nested, filtered structure needed for machine reading by a receiving project's own tools, while the Excel workbook lays the same data out for direct human review, split by level and by element type.

3.3.3. Reintegration into a receiving project

Reintegration closes the loop of Pathway A introduced in Figure 31. A passport generated at the end of one project's life can be used as the starting record when the element is introduced into a receiving project. Since Pathway A does not depend on the plugin described in Section 3.4, this reintegration is carried out manually.

The receiving team first consults the JSON or Excel output described in Section 3.3.2 to identify the element and retrieve its recorded values. If the receiving Revit model does not already contain the DfD parameter set, the same shared parameter file described in Section 3.1 is loaded through Revit's native Manage > Shared Parameters dialog and the required parameters are added to the relevant category. The values stored in the passport are then entered into their corresponding fields. This includes the calculated results, such as DisassemblyScore and DisassemblyClass for Level 1 elements, or TRACE_Score and TRACE_Recommendation for Level 2 elements. These results are transferred directly rather than recalculated in the receiving model.

Keeping this step manual is consistent with the interoperability requirement established in Section 2.7. A team using Pathway A can recover the assessment information using the exported files, the shared parameter file, and Revit, without requiring the plugin introduced in Section 3.4. The manual reintegration workflow presented in Figure 40 follows this process from the exported passport to the receiving Revit model. Transferring the calculated results also avoids having to reproduce the

formulas in another project, where differences in their implementation could lead to a different result. In Pathway B, this transfer is handled by the plugin within the BIM environment; in Pathway A, the information is transferred manually.

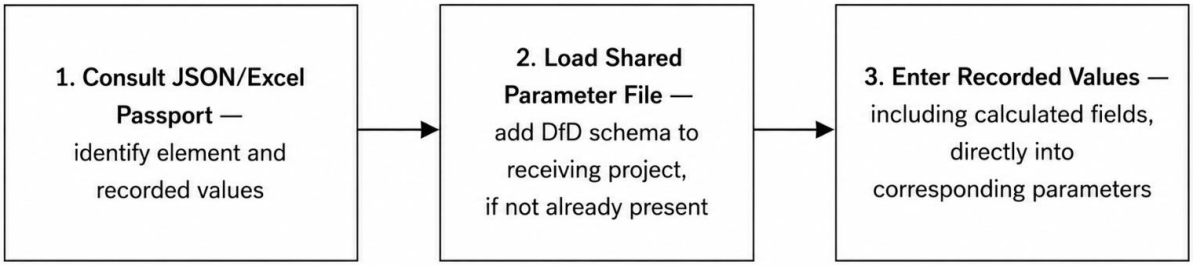


Figure 40 - Pathway A manual reintegration workflow. Source: Author.

This completes Pathway A, from the assessment of the existing element to the generation and subsequent reintegration of its digital record. The workflow maintains the assessment data across the different stages without relying on a dedicated software environment beyond the tools used to create and read the passport. This provides the baseline against which the more integrated workflow developed in Pathway B can be compared.

3.4. Pathway B: C# plugin

Pathway B reaches the same outcome as Pathway A, an assessed element that can be scored, exported, and reintegrated into a receiving project, but entirely from within Revit's native interface, through four commands added to a dedicated ribbon tab: Setup DfD Params, Write Passport, Export Passport, and Import to New Project. Because every step operates directly on Revit's own parameter objects, rather than reconstructing them from an intermediate file format, none of the fallback mechanisms documented in Section 3.3.1, property set name recovery, level routing inference, are required here: the plugin always knows, unambiguously, which parameter it is reading or writing.

This distinction matters because it changes where the burden of correctness sits. In Pathway A, correctness depends on the script correctly interpreting whatever the IFC exporter happened to produce, which is why so much of Section 3.3.1 is devoted to fallback logic in the first place. In Pathway B, correctness depends instead on the plugin being installed and maintained on every machine used to assess or receive an element, a different kind of dependency, closer to a shared tool than a shared file format. Neither dependency is eliminated by choosing one pathway over the other; each simply trades one point of failure for another, which is why both are offered rather than one being treated as a replacement for the other.

Figure 41 summarises this sequence as a closed loop, mirroring Figure 31: setup binds the schema to a project, writing records an assessment through a form that calculates scores in real time, export generates the same JSON and Excel outputs described in Section 3.3.2, and import reads that same output back into a new element in a receiving project, closing the cycle that Pathway A completes manually in Section 3.3.3.

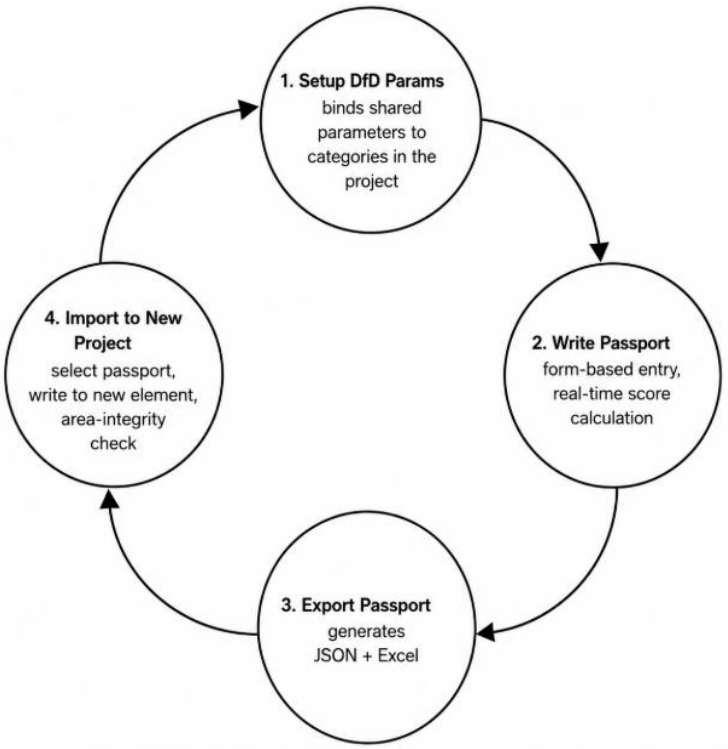


Figure 41 - Pathway B as a closed loop: from parameter setup to reintegration in a receiving project. Source: Author.

3.4.1. Plugin architecture and interface

The plugin is a native Revit Add-In developed in C# using the Revit API, without an intermediate visual programming layer such as Dynamo. When Revit starts, the plugin registers a dedicated ribbon tab, "DfD BIM," with a "Digital Passport" panel. Four commands are available from this panel: Setup DfD Params, Write Passport, Export Passport, and Import to New Project. Each button is linked to a separate command class implementing the Revit IExternalCommand interface, shows in Figure 42.

```
26      public Result OnStartup(UIControlledApplication app)
27      {
28          string tab = "DfD BIM";
29          try { app.CreateRibbonTab(tab); } catch { }
30          RibbonPanel panel = app.CreateRibbonPanel(tab, "Digital Passport");
31
32          panel.AddItem(new PushButtonData(
33              "DfDSetup", "Setup\nDfD Params",
34              typeof(App).Assembly.Location,
35              "DfD_RevitPlugin.CmdSetupParameters"));
36
37          panel.AddItem(new PushButtonData(
38              "DfDWrite", "Write\nPassport",
39              typeof(App).Assembly.Location,
40              "DfD_RevitPlugin.CmdWritePassport"));
41
42          panel.AddItem(new PushButtonData(
43              "DfDExport", "Export\nPassport",
44              typeof(App).Assembly.Location,
45              "DfD_RevitPlugin.CmdExportPassport"));
46
47          panel.AddItem(new PushButtonData(
48              "DfDImport", "Import to\nNew Project",
49              typeof(App).Assembly.Location,
50              "DfD_RevitPlugin.CmdImportPassport"));
51
52          return Result.Succeeded;
53      }
```

Figure 42 - App.OnStartup(): ribbon tab and command registration. Source: Author.

Across these commands, parameters are accessed using Element.LookupParameter. Instead of relying on category-specific built-in identifiers, the plugin searches for parameters by name. For example, it can request "DfD_CT_Score" or "DfD_TRACE_Recommendation" from the selected element and check whether that parameter is available. The same approach is used for doors, windows, walls, floors, columns, and structural framing, avoiding separate parameter access routines for each category. Figure 43 shows this pattern as implemented in the parameter-writing routine shared across commands. Setup, Write, and Import modify the Revit model and therefore run inside a Revit Transaction; Export only reads the stored information and does not require one.

```
477         static void WriteParams(Element elem, List<string> paramNames, Dictionary<string, string> values)
478         {
479             foreach (string p in paramNames)
480             {
481                 Parameter param = elem.LookupParameter(p);
482                 if (param == null || param.IsReadOnly) continue;
483                 string val = values.ContainsKey(p) ? values[p] : "";
484                 SetParamValue(param, val);
```

Figure 43 - WriteParams() function: generic parameter access by name, shared across all element categories. Source: Author.

Score calculation is implemented independently of the Python reader described in Section 3.3.1, but follows the identical harmonic mean formula, shown in Figure 44. This duplication is deliberate rather than accidental: each pathway needs its own working copy of the calculation, and keeping both implementations aligned is what allows Section 2.7's claim of numerical equivalence between the two pathways to hold in practice, rather than by assumption.

```
1611        static double HarmonicMean(double ct, double ca, double id_, double gpe)
1612        {
1613            double[] vals = { ct, ca, id_, gpe };
1614            foreach (double v in vals) if (v <= 0) return 0.0;
1615            double sumRecip = 0;
1616            foreach (double v in vals) sumRecip += 1.0 / v;
1617            return Math.Round(4.0 / sumRecip, 3);
1618        }
1619
```

Figure 44 - HarmonicMean() function in the C# plugin, matching the formula used in Section 3.3.1. Source: Author.

Data entry is handled through WinForms dialogs. For the assessment fields, the dropdowns are connected to SelectedIndexChanged events so that the score is recalculated while the form is being filled in, shown in Figure 45. If "screwed" is selected as the connection type for CT, for example, the displayed DisassemblyScore and class are updated immediately. This immediate feedback is deliberate: an assessor who selects an implausible combination of factors sees the resulting score right away, before the form is even submitted, rather than discovering the mismatch later when the passport is exported. The displayed score and class are read-only labels, recalculated on every dropdown change rather than editable fields in their own right, so what the assessor sees on screen and what the plugin ultimately records can never fall out of agreement within a single session. At this stage the values have not yet been written to the Revit element; this only happens after the form is submitted.

```
2052            cb.SelectedIndex = selectedIdx;
2053            cb.SelectedIndexChanged += (s, e) => UpdateScore();
2054            p.Controls.Add(cb); comboBoxes[scoreKey] = cb;
2055
2056            if (!string.IsNullOrEmpty(labelKey))
2057            {
2058                WinForms.TextBox hidden = new WinForms.TextBox();
2059                hidden.Visible = false;
2060                hidden.Text = current.ContainsKey(labelKey) ? current[labelKey] : options[0, 0];
2061                p.Controls.Add(hidden); textBoxes[labelKey] = hidden;
2062                cb.SelectedIndexChanged += (s, e) => {
2063                    int i2 = cb.SelectedIndex;
2064                    if (i2 >= 0 && i2 < options.GetLength(0)) hidden.Text = options[i2, 0];
2065                };
2066            }
2067            return y + 28;
2068        }
```

Figure 45 - Event handler wiring real-time score recalculation to dropdown selection. Source: Author.

Write Passport also checks the number of selected elements before opening the assessment form. With one element selected, the form is opened for that element only. Multiple selected elements open the bulk form, where common and level-specific values can be assigned to the full selection. Passport IDs are still generated individually and sequentially, grouped by category.

The four commands and their use within the assessment and passport workflow are described individually in Section 3.4.2.

3.4.2. Four-button workflow

Four commands are available from the Digital Passport panel: Setup DfD Params, Write Passport, Export Passport, and Import to New Project. They correspond to the main stages of the workflow developed in the previous sections. Setup uses the parameter structure described in Section 3.1, Write applies the assessment methods developed in Sections 2.4 and 2.5, and Export and Import cover the information exchange and reintegration stages presented for Pathway A in Sections 3.3.2 and 3.3.3. Figure 46 shows the four commands available to the user.

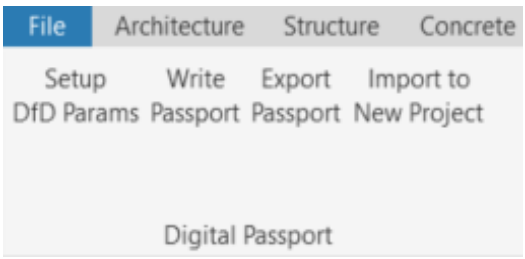


Figure 46 - The four plugin commands on the Digital Passport panel. Source: Author.

Setup DfD Params opens a dialog containing the categories available in the current model. The user selects one or more categories and the command binds the 27 shared parameters defined in Section 3.2.1 to them. It uses the same shared parameter file introduced in Section 3.1, so the process does not require families developed specifically for the plugin. Once the command is completed, the resulting parameter binding is reported to the user through the confirmation dialog presented in Figure 47.

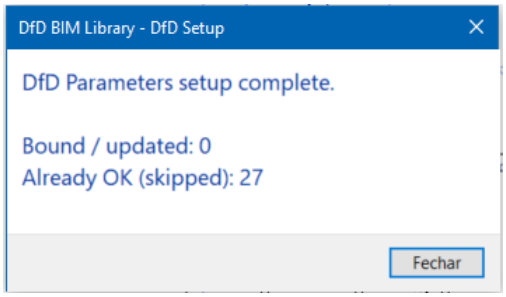


Figure 47 - Setup DfD Params confirmation, reporting bound versus already-configured parameters. Source: Author.

The command also reports how many parameters were added and how many were already present. In the example in Figure 47, all 27 parameters had already been configured, so no new parameters were bound. This allows Setup to be run again when required without duplicating parameters that are already available in the model.

Write Passport opens either the single-element or bulk assessment form described in Section 3.4.1. Figure 48 shows the form for a newly configured element before the assessment begins. At this point, the identification, location, lifecycle, and assessment fields remain in their default state.



Figure 48 - Write Passport form on a freshly categorised element, before any values are entered. Source: Author.

The identification, location, and lifecycle information is entered first. These fields correspond to the DfD_ID and DfD_LifeCycle groups documented in Section 3.2.1 and include the passport ID, current use and lifecycle state, project and physical location, and lifecycle history. Figure 49 shows these fields after completion. The information is the same as that entered directly through the Revit Properties palette in Pathway A, but here it is collected in a single form.

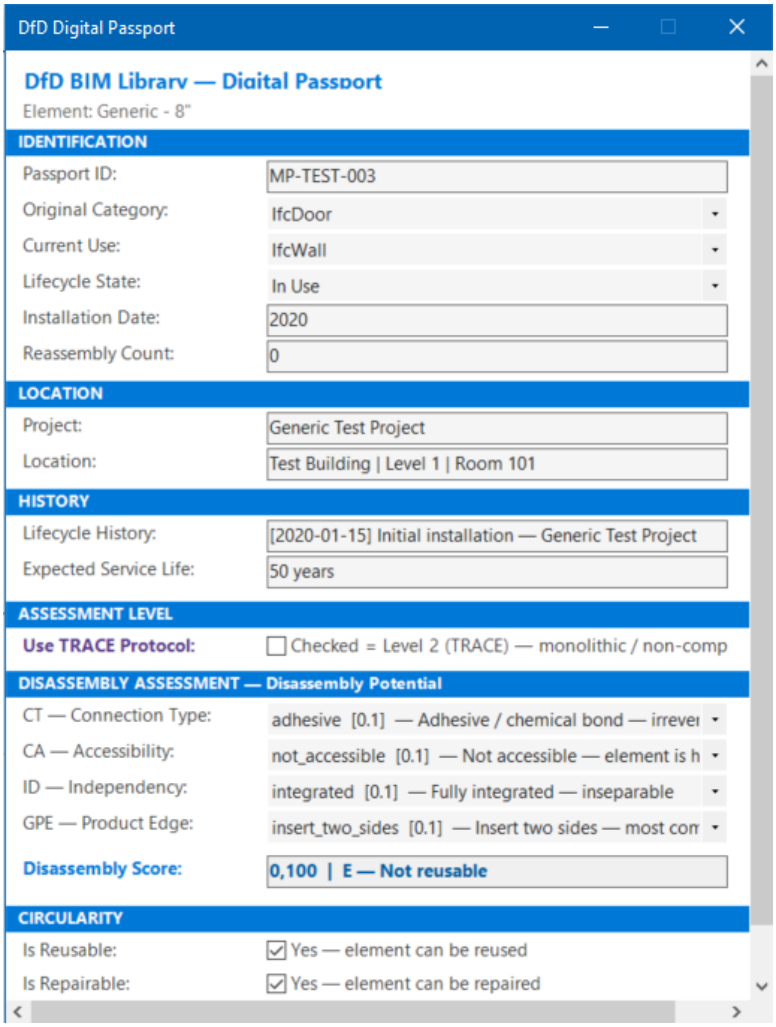


Figure 49 - Write Passport form with identification, location, and lifecycle fields completed. Source: Author.

For Level 1, the "Use TRACE Protocol" checkbox must be left unchecked, routing the element to the Disassembly Potential fields rather than the TRACE fields, the same DfD_UseTraceProtocol flag whose routing logic was established in Section 3.2.2. The four Disassembly Potential factors are then selected from the available dropdowns. Rather than typing a numerical value directly, the assessor chooses the qualitative field condition that matches what was observed, connection type, accessibility, independence, and product edge geometry, and the plugin maps that selection to its corresponding score internally, the same lookup logic already described in Section 3.3.2 for the standalone assessment panel. The score and class update as these selections are made, using the harmonic mean calculation described in Section 3.4.1. In the example in Figure 50, the connection type, accessibility, independence, and edge geometry options selected correspond to CT 0.80, CA 1.00, ID 0.70, and GPE

1.00 respectively. These are the same values used for the Pathway A example in Section 3.3 and result in a DisassemblyScore of 0.855 and Class A.

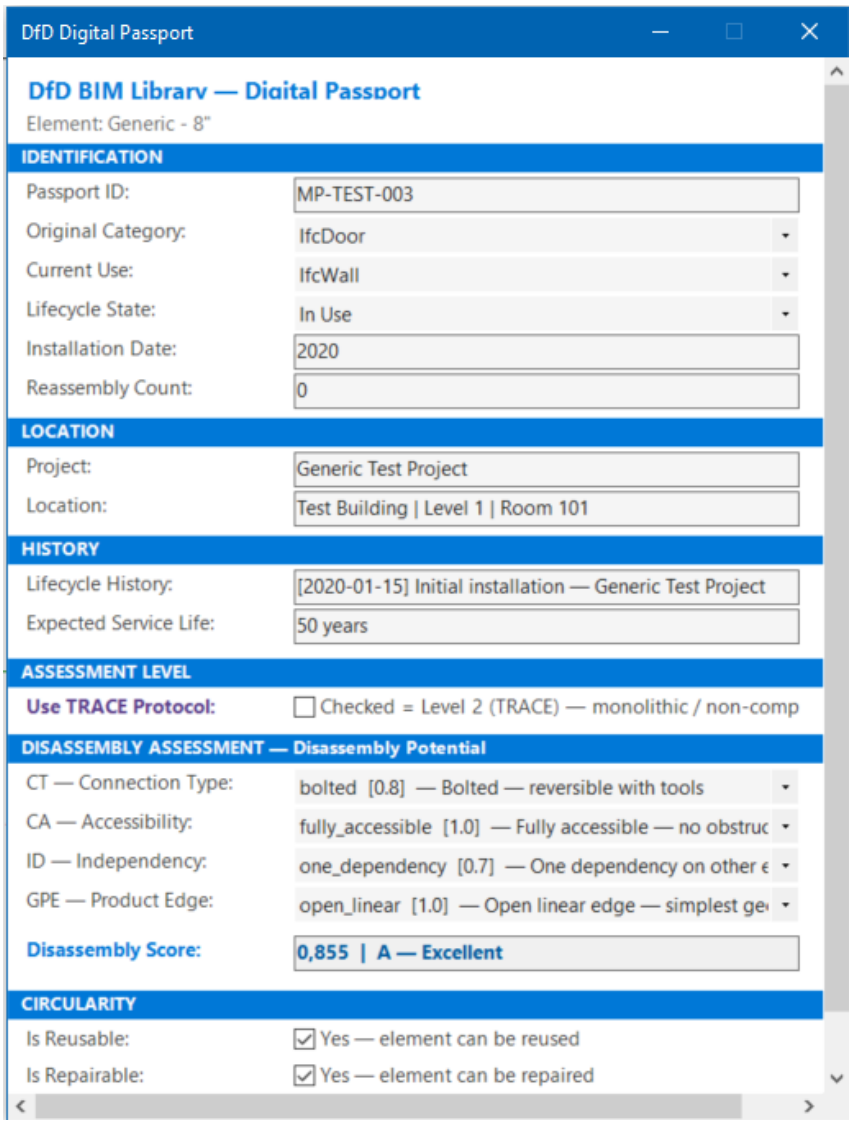


Figure 50 - Write Passport form for Disassembly Potential assessment. Source: Author.

Level 2 requires the "Use TRACE Protocol" checkbox to be checked, routing the element to the TRACE fields instead of the Disassembly Potential ones, the same DfD_UseTraceProtocol flag described above for Level 1, now in its other position. The four TRACE criteria defined in Table 12 are then selected from their own dropdowns, following the same qualitative-to-score mapping already described for CT, CA, ID, and GPE: rather than typing "2" or "1" directly, the assessor picks the field condition that best matches what was observed, physical integrity, recoverability, reuse feasibility, and information confidence, and the plugin resolves that selection to the corresponding point value. TRACE_Score and the resulting recommendation are calculated the same way, updating as each selection is made. The example in Figure 51 uses the same values as the wall assessed through Pathway A, a score of 6 and a Conditional recommendation, keeping this second example consistent with everything already established about that element's assessment elsewhere in this chapter.

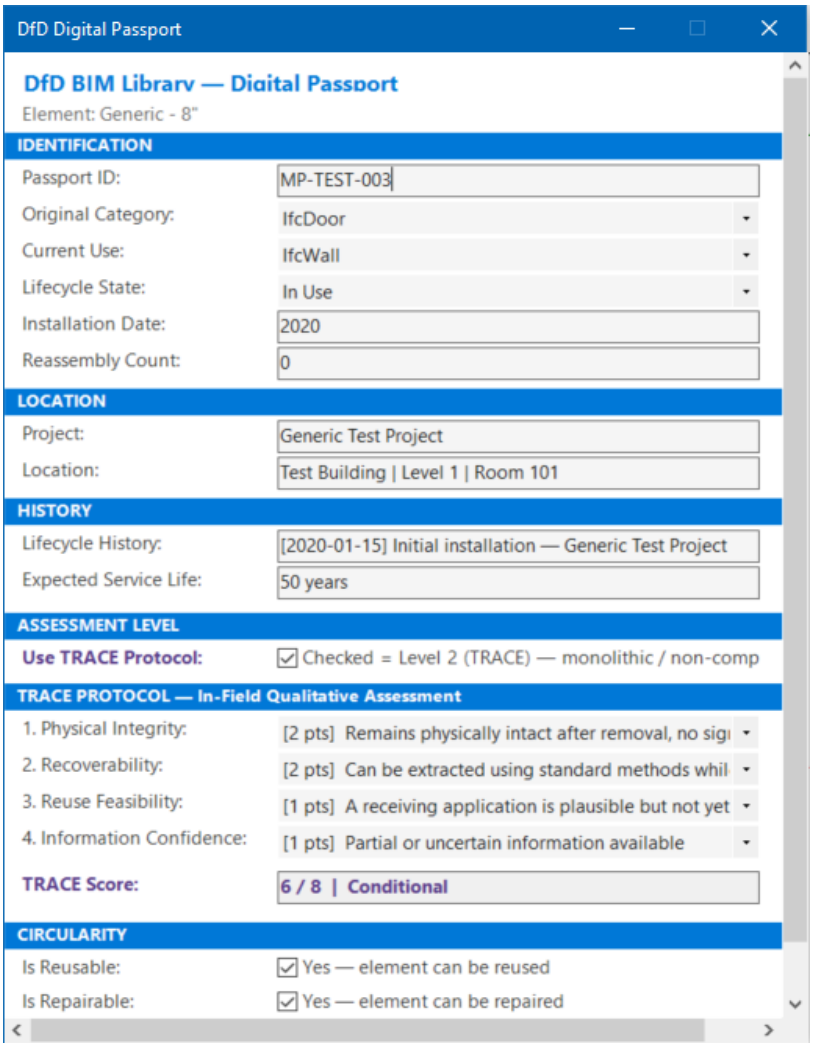


Figure 51 - Write Passport form for TRACE assessment. Source: Author.

Confirming either form triggers a short acknowledgment rather than a silent write: Figure 52 shows the plugin naming the element the values were just committed to and the level under which it was assessed, closing the loop on whichever of the two forms, Level 1 or Level 2, was just completed.

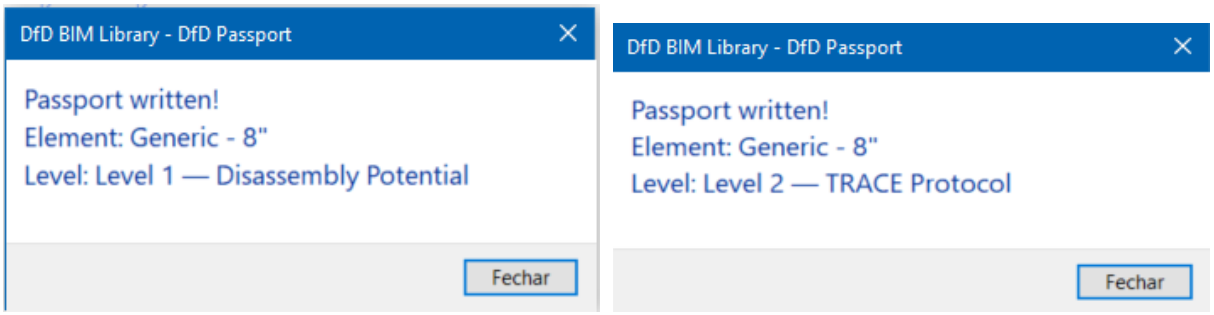


Figure 52 - Write Passport confirmation, naming the assessed element and its level. Source: Author.

Once the form is confirmed, the entered and calculated values are written to the selected element within a Revit transaction.

Export Passport reads the stored parameters from the DfD-tagged elements and exports the information to a folder selected by the user (Figure 53). This is the plugin equivalent of the manual export process used in Pathway A, where the IFC file is processed through the Python script described in Section 3.3.2 to generate the same passport outputs. Here, the same operation is carried out directly from Revit without requiring the intermediate IFC processing step.

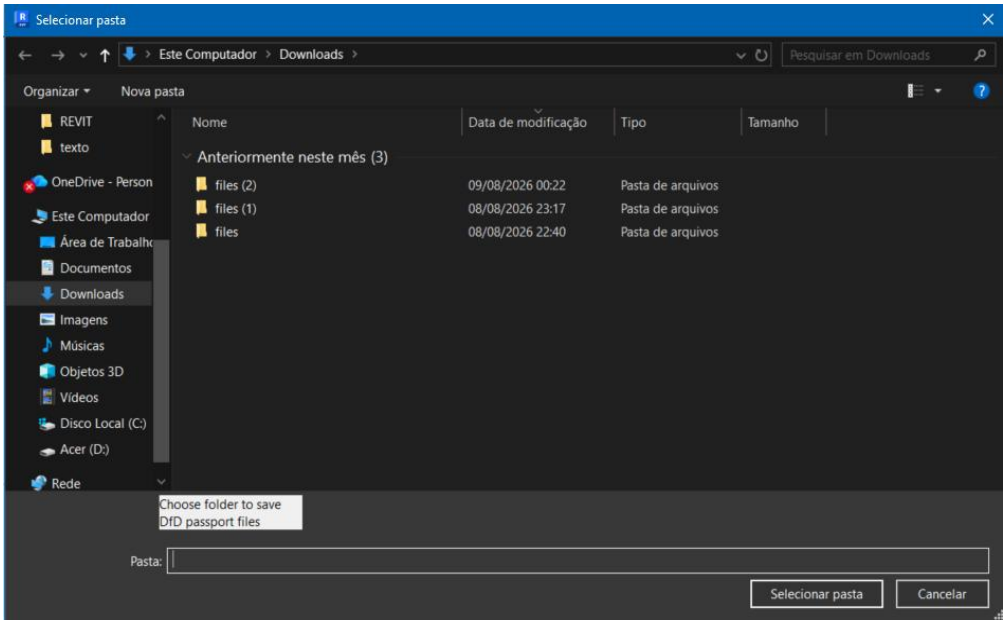


Figure 53 - Export Passport folder selection dialog. Source: Author.

The command generates both JSON and Excel outputs, and reports the outcome explicitly rather than completing silently: Figure 54 confirms the mode of the export (a full model export or, as here, a selection of specific elements), the count of elements written to each level, and the destination folder and file names. This same confirmation pattern, an explicit report rather than a silent write, mirrors the one already shown for Write Passport in Figure 52: neither command lets an action complete without telling the user exactly what it did. The field ordering and organisation of the two files follow the structure described in Section 3.3.2, allowing the outputs produced through the two pathways to retain the same passport structure.

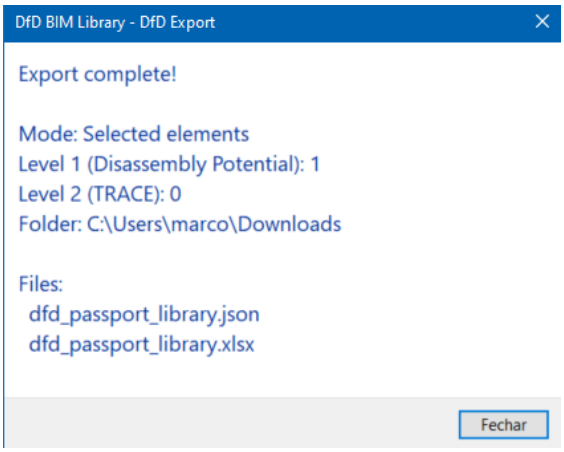


Figure 54 - Export Passport confirmation and summary. Source: Author.

Import to New Project performs the reintegration stage described manually for Pathway A in Section 3.3.3. Instead of reading the passport and entering its values manually, the user selects the exported Excel workbook through the dialog shown in Figure 55.

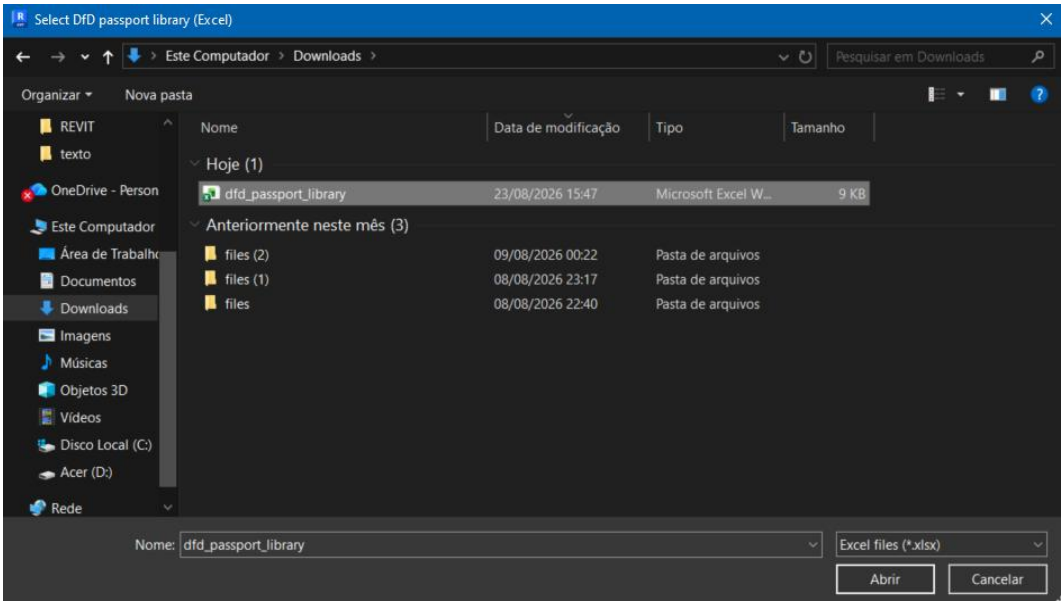


Figure 55 - Locating the exported passport library for import. Source: Author.

The passports contained in the workbook are then listed by ID, source category, and GUID. The required record can be selected from this list before it is assigned to the receiving element (Figure 56).

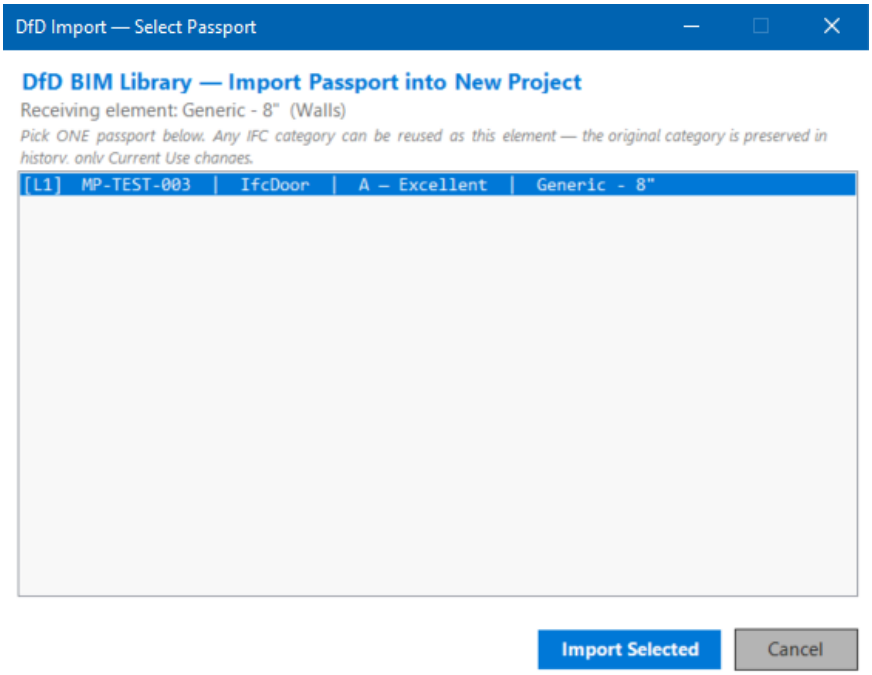


Figure 56 - Selecting which recorded passport to apply to the receiving element. Source: Author.

Before the values are written, the command compares the area recorded at export with the area of the receiving element. A difference greater than 10% generates the warning shown in Figure 57.

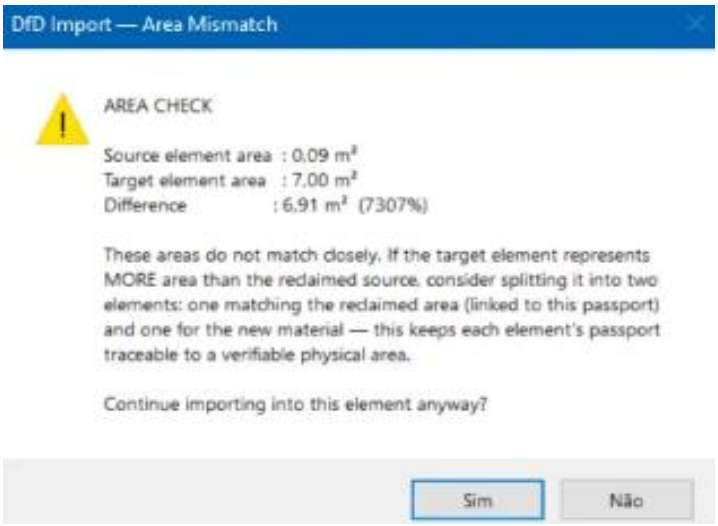


Figure 57 - Area-integrity check triggered by a mismatch between source and receiving element geometry. Source: Author.

The check provides an additional control before a passport is assigned to an element with different geometry. The user can still confirm the import after the warning. When the import is completed, the passport values are written to the receiving element and DfD_ReassemblyCount is incremented, confirmed in Figure 58. This records the new reintegration using the parameter defined in Section 3.2.1.

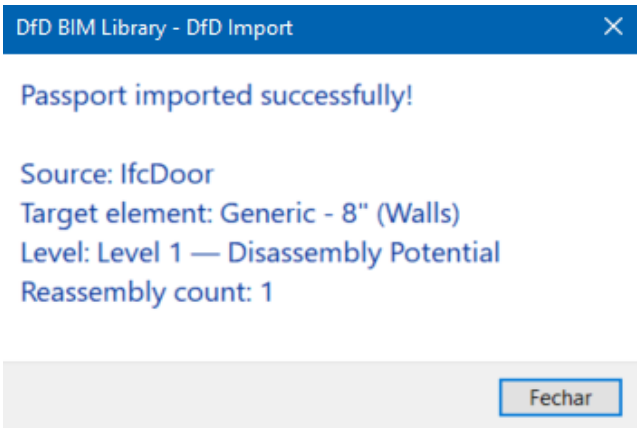


Figure 58 - Passport import confirmation. Source: Author.

The four commands therefore cover the complete Pathway B workflow inside Revit: parameter setup, assessment, passport export, and reintegration. The resulting information follows the same structure used in Pathway A, while the plugin handles the data entry and transfer directly within the BIM environment.

The two pathways do not need to be used independently. An element assessed through Pathway B can later be exported and reintegrated manually by a team without access to the plugin, following the process described in Section 3.3.3. Similarly, an element previously processed through Pathway A can later be used by a team working directly in Revit through the plugin. This is possible because both pathways rely on the same Pset defined in Section 3.2. Pathway A accesses this information through

IFC and the Python script, while Pathway B works with the parameters directly in Revit. The passport therefore remains independent of the pathway used to create or update it.

3.5. Online component library

The online component library closes the loop opened by both pathways: any passport, whether generated through Pathway A's JSON export or Pathway B's Export Passport command, becomes searchable, browsable, and visually locatable through a single web interface. The library is a static, client-side application with no backend of its own: on load, it fetches the same dfd_passport_library.json file documented in Sections 3.3.2 and 3.4.2 directly in the browser, parses it, and renders it as a filterable catalogue. Selecting an element does more than display its recorded fields: it sends that element's Passport ID to an embedded 3D viewer, which locates the corresponding named node within an exported model of the building, highlights it, and dims every other element to near-transparency, so that a receiving team can see not only the element's identity and recorded attributes, but exactly where it sits within the structure it came from.. Figure 59 summarises this flow, from a passport generated by either pathway to an element discoverable, filtered, and located in three dimensions by a receiving project. Section 3.5.1 describes the platform's architecture and hosting; Section 3.5.2 describes the filtering logic and visual interface in detail.

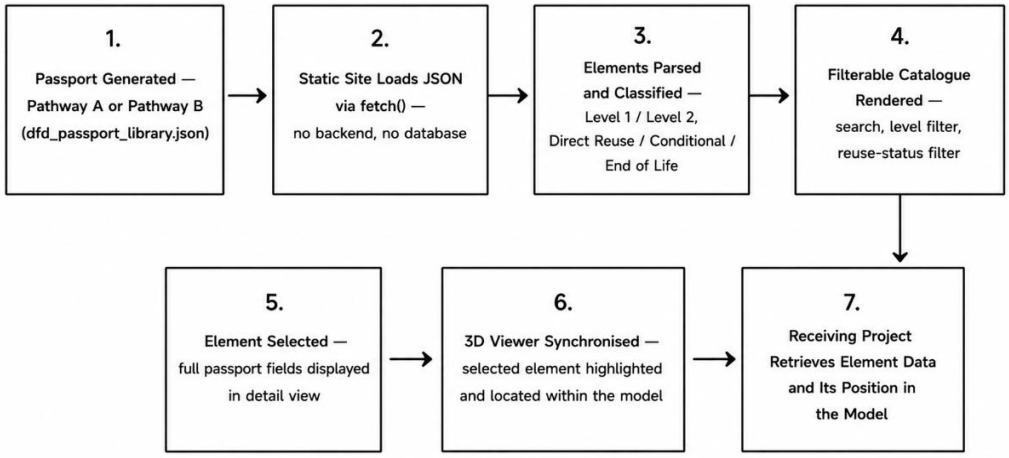


Figure 59 - Data flow from passport generation to element discovery and 3D location within the online component library. Source: Author.

3.5.1. Platform architecture - GitHub pages

The library is hosted on GitHub Pages, which serves the files directly from the repository without server-side processing. As with Pathway A in Section 3.3.1, this keeps the implementation relatively simple and avoids the need for additional infrastructure. The repository contains five files: index.html, which provides the catalogue interface described in Section 3.5.2; viewer.html, used for the 3D viewer; dfd_passport_library.json, containing the passport data described in Sections 3.3.2 and 3.4.2; the .glb model used to display the building geometry in the browser; and the source .ifc model, kept in the repository for reference but not itself loaded by the site, as presented in Figure 60. The .glb was converted from the IFC model described in Section 3.3.1.

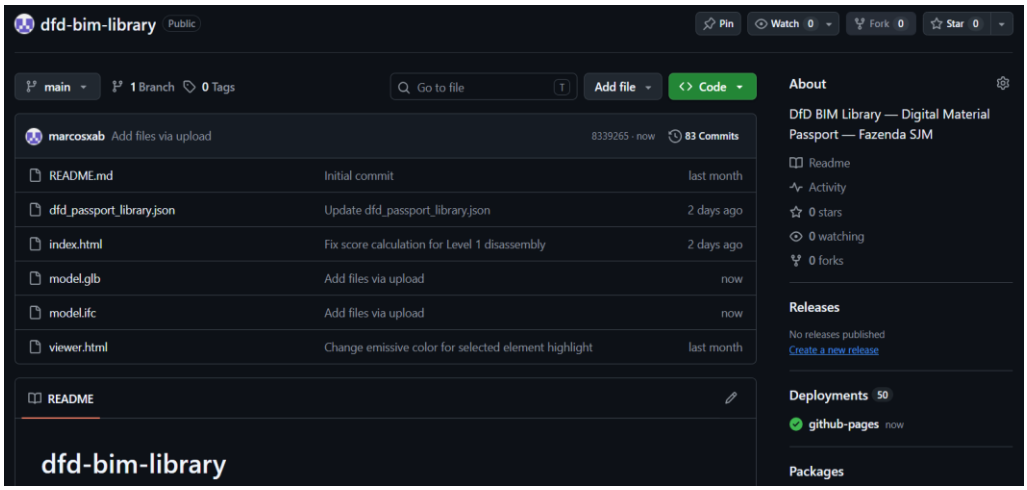


Figure 60 - Repository structure for the GitHub Pages deployment. Source: Author.

The .glb file is produced by a separate conversion script, run once the IFC model is finalised, following the process presented in Figure 61, since browsers cannot read IFC geometry directly. Using ifcopenshell to iterate over the model's geometry, the script extracts each element's mesh data and assigns it a colour and a layer name based on its IFC class, the same eight layer names used as toggle buttons in the viewer. Each mesh's node is named using the element's DfD_MaterialPassportID, read directly from the same IFC property set that dfd_passport_reader.py reads to generate the JSON and Excel outputs described in Section 3.3.2. The Passport ID used for highlighting in the viewer is therefore not assigned separately during conversion; it is the same identifier traced back to its source in the IFC file. Elements without exportable geometry are skipped.

```
CATEGORY_COLORS = {
    "IfcWall":          ([0.58, 0.58, 0.58, 1.0], "Walls"),
    "IfcSlab":          ([0.48, 0.48, 0.48, 1.0], "Floors"),
    "IfcRoof":          ([0.10, 0.50, 0.10, 1.0], "Roof"),
    "IfcDoor":          ([0.45, 0.28, 0.12, 1.0], "Doors"),
    "IfcWindow":        ([0.45, 0.28, 0.12, 1.0], "Windows"),
    "IfcColumn":        ([0.55, 0.55, 0.55, 1.0], "Structure"),
    "IfcStair":         ([0.52, 0.52, 0.52, 1.0], "Stairs"),
    "IfcOpeningElement": (None, "skip"),
}
DEFAULT = ([0.55, 0.55, 0.55, 1.0], "Other")

def get_cat(cls):
    for k, v in CATEGORY_COLORS.items():
        if cls.startswith(k): return v
    return DEFAULT

def get_passport_id(elem):
    """Read DfD_MaterialPassportID from any IFC property set."""
    try:
        for rel in getattr(elem, 'IsDefinedBy', []) or []:
            if not rel.is_a('IfcRelDefinesByProperties'): continue
            pset = rel.RelatingPropertyDefinition
            for prop in getattr(pset, 'HasProperties', []) or []:
                if prop.Name == 'DfD_MaterialPassportID':
                    val = getattr(prop, 'NominalValue', None)
                    if val and str(val.wrappedValue).strip():
                        return str(val.wrappedValue).strip()
    except Exception:
        pass
```

Figure 61 - IFC-to-GLB conversion. Source: Author.

When the page is opened, index.html loads dfd_passport_library.json using fetch() and uses its content to populate the catalogue. Figure 62 presents this loading step, which takes place directly in the browser without requiring a backend or database.

```
document.addEventListener('DOMContentLoaded', () => {
  fetch('./dfd_passport_library.json')
    .then(r=>r.json()).then(d=>load(d)).catch(()=>load(FALLBACK));
  document.getElementById('search').addEventListener('input', e=>{
    fSearch=e.target.value.toLowerCase(); render();
  });
});

function load(d) {
  const l1 = (d?.dfd_library?.level_1_disassembly_potential?.elements||[]).map(e=>({...e,_level:'L1'}));
  const l2 = (d?.dfd_library?.level_2_trace?.elements||[]).map(e=>({...e,_level:'L2'}));
  DATA = [...l1,...l2];
  render();
}
```

Figure 62 - Passport library loading in the browser. Source: Author.

The 3D viewer is kept in a separate viewer.html file and embedded in the catalogue through an iframe. Communication between the catalogue and the viewer uses the browser's postMessage mechanism. The model itself is loaded with Three.js from the .glb file, while GLTFLoader and OrbitControls provide the model loading and navigation functions. This loading configuration is presented in Figure 63. The libraries are referenced from a public CDN rather than stored in the repository.

```
<script src="https://cdn.jsdelivr.net/npm/three@0.134.0/build/three.min.js"></script>
<script src="https://cdn.jsdelivr.net/npm/three@0.134.0/examples/js/controls/OrbitControls.js"></script>
<script src="https://cdn.jsdelivr.net/npm/three@0.134.0/examples/js/loaders/GLTFLoader.js"></script>
```

Figure 63 - Three.js libraries and .glb model loading. Source: Author.

The model is also divided into groups such as Roof, Walls, Doors, and Windows, which are used as layers in the viewer. Each group can be switched on or off independently. Element selection works through the Passport ID: when an element is selected in the catalogue, its ID is sent to the viewer using postMessage. The viewer searches the model for the object with the corresponding identifier and highlights it. Figure 64 presents this layer grouping and matching process. For this reason, the objects in the .glb model must retain the same Passport IDs used in the JSON library.

```
function nodeMatchesId(obj, id) {
  // Walk up the parent chain looking for a node named with the passport ID
  var current = obj;
  while (current) {
    if (current.name === id) return true;
    current = current.parent;
  }
  return false;
}

function highlightElement(passportId) {
  if (!sceneRef || !passportId) return;
  var found = 0;
  sceneRef.traverse(function(obj) {
    if (obj.isMesh && nodeMatchesId(obj, passportId)) found++;
  });
  console.log('[DfD Viewer] highlight:', passportId, '| meshes found:', found);
  sceneRef.traverse(function(obj) {
    if (!obj.isMesh) return;
    var orig = origMats.get(obj.uuid);
    if (!orig) return;
    var mat = orig.clone();
    if (nodeMatchesId(obj, passportId)) {
      // This element is selected — full highlight
      mat.emissive          = new THREE.Color(0.0, 0.3, 0.8);
      mat.emissiveIntensity = 1.0;
      mat.transparent       = false;
      mat.opacity           = 1.0;
    } else {
      // All others dimmed
      mat.transparent = true;
      mat.opacity     = 0.08;
      mat.emissive    = new THREE.Color(0, 0, 0);
    }
    obj.material = mat;
  });
}
```

Figure 64 - Layer grouping and highlight-matching logic in the 3D viewer. Source: Author.

Together, these components provide the connection between the passport data and the 3D model used by the online library. The JSON file contains the assessment and lifecycle information, while the .glb model provides the corresponding geometry. The Passport ID links the two, allowing the catalogue and the viewer to refer to the same element without requiring a database or additional server-side processing. This structure also keeps the geometry and passport data as separate files, while maintaining their relationship through a common identifier. As a result, either file can be updated independently as long as the Passport IDs remain consistent.

3.5.2. Reusability filtering and visual interface

The interface presents the parsed library as a single-page catalogue, with its overall structure presented in Figure 65. It is organised around three elements established in Section 3.5.1: a statistics header, a colour-coded legend, and a combination of level and reuse-status filters. All of these operate on data already loaded client-side, so interactions happen immediately without further requests to the server.

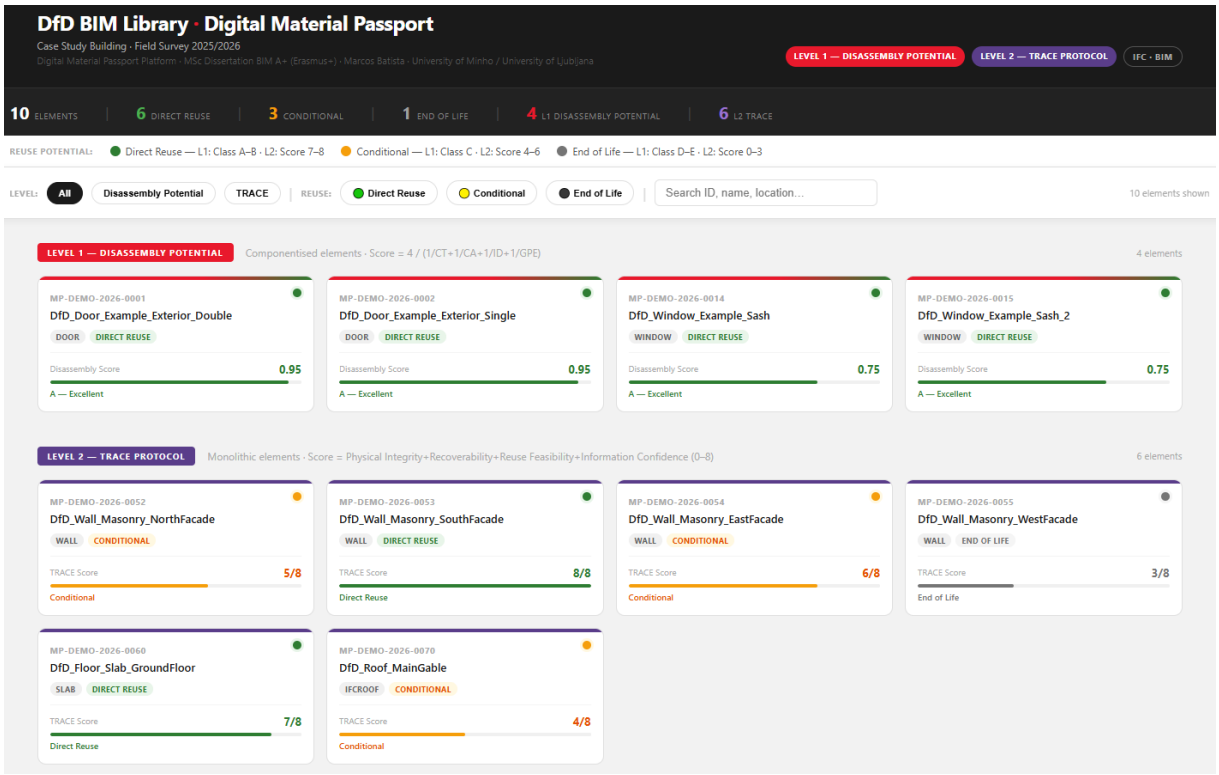


Figure 65 - Full catalogue interface, showing the statistics header, reuse-status legend, filters bar, and the element grid organised by level. Source: Author.

Filtering combines two independent dimensions rather than a single dropdown: a Level filter (All, Disassembly Potential, TRACE) and a Reuse-status filter (Direct Reuse, Conditional, End of Life), applied together with a free-text search across Passport ID, element name, category, location, and project. Because filtering runs entirely in JavaScript against the data already loaded, as described in Section 3.5.1, combining filters narrows the visible grid immediately, with the count of matching elements updated in the same instant. Figure 66 presents the catalogue after combining the Level and Reuse-status filters.

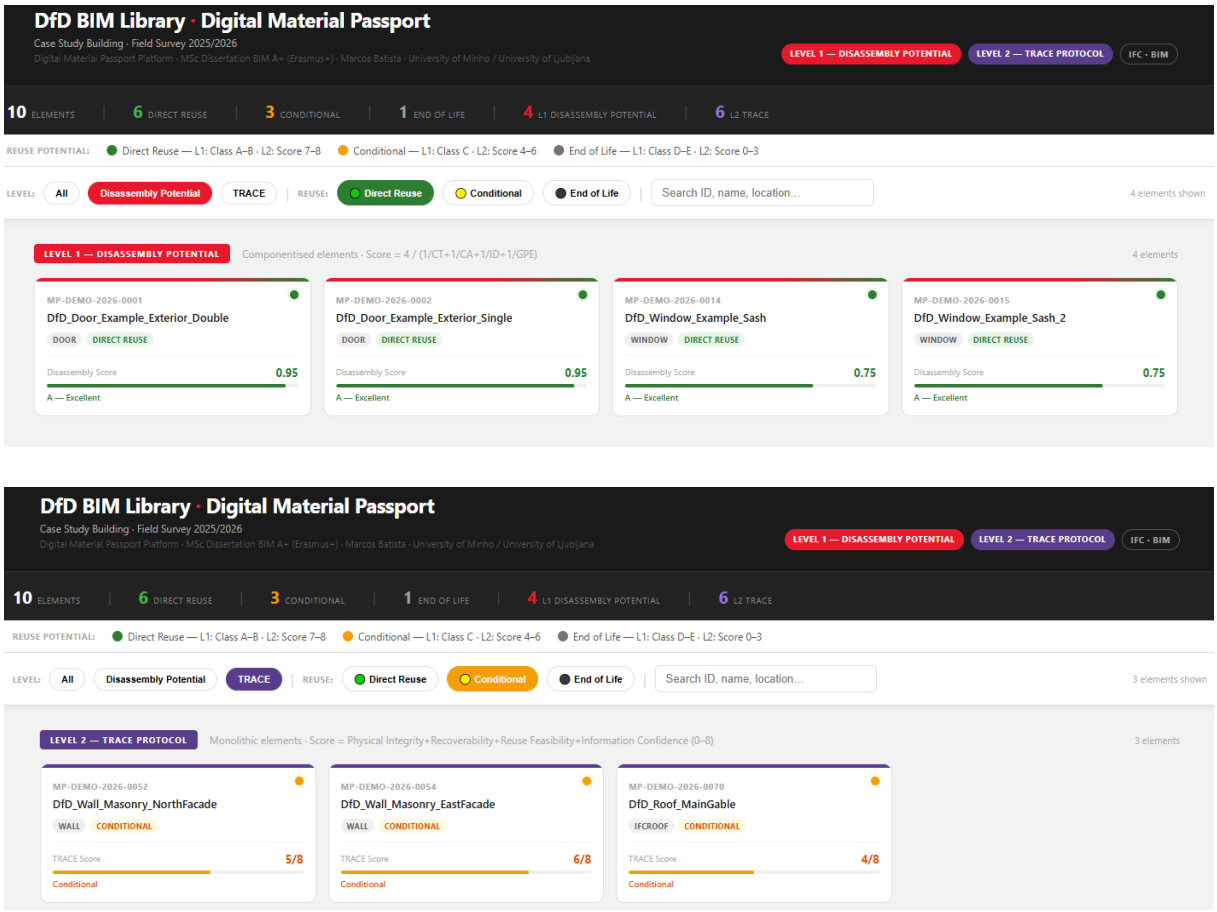


Figure 66 - Level and reuse-status filters applied together, narrowing the catalogue to a specific subset. Source: Author.

Each element in the grid is represented by a card summarising just enough to decide whether it is worth opening: its Passport ID, element name, category, a reuse-status tag using the same colour convention as the legend, and its score, shown both as a numeric value and as a proportional bar. Figure 67 presents how this information is arranged within an individual element card. Level 1 and Level 2 elements are visually distinguished this way without requiring separate pages or views.

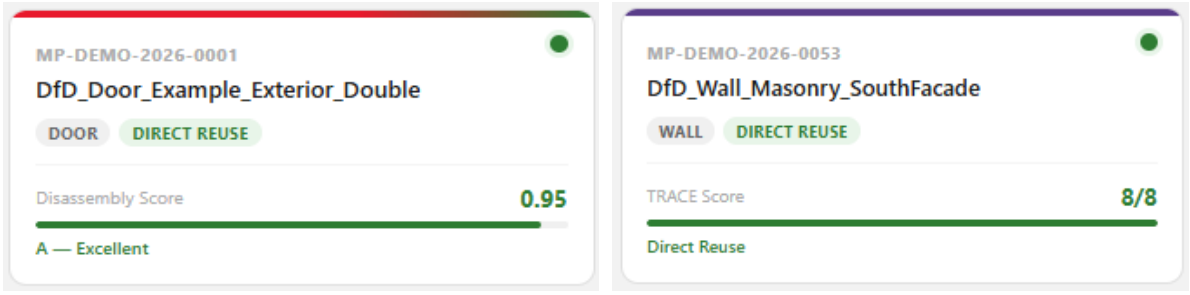


Figure 67 - Element cards, showing identification, category, reuse status, and score. Source: Author.

Selecting a Level 1 element opens its full record: identification and lifecycle fields as documented in Section 3.2.1, followed by the Disassembly Potential group, connection type, the four CT/CA/ID/GPE scores, and the resulting score and class. Figure 68 presents this complete Level 1 record together with

the 3D viewer described in Section 3.5.1. The selected element is highlighted in the model, while the remaining elements are dimmed to make its location easier to identify. This allows the assessment information and the physical location of the element to be consulted within the same view.

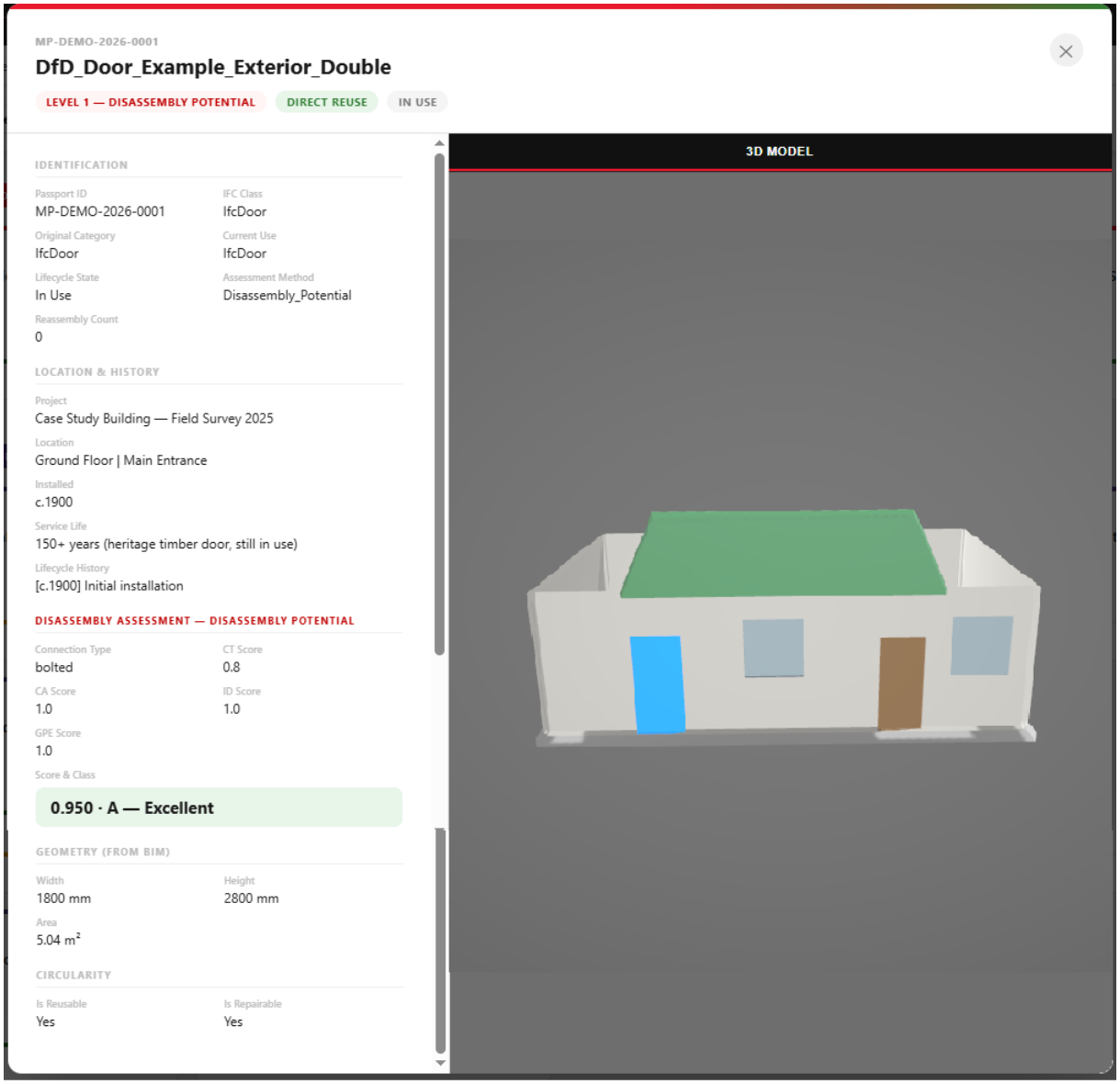


Figure 68 - Detail view for a Level 1 door element, with populated fields and the 3D viewer showing it highlighted. Source: Author.

Selecting a Level 2 element instead surfaces the TRACE group in place of the Disassembly Potential one, with the four criteria scores and the resulting recommendation. Figure 69 shows this Level 2 configuration for a wall element, while the remaining identification, location, lifecycle, geometry, and circularity fields are populated in the same way regardless of the assessment level. The 3D viewer behaves identically here: the same highlighting and dimming mechanism applies to a wall as it does to a door, since both are ultimately named nodes in the same model. This keeps the catalogue structure consistent across both assessment levels and avoids creating separate interfaces for different element types. The distinction between Level 1 and Level 2 therefore remains in the assessment data, while the interaction with the element and its geometry stays unchanged.

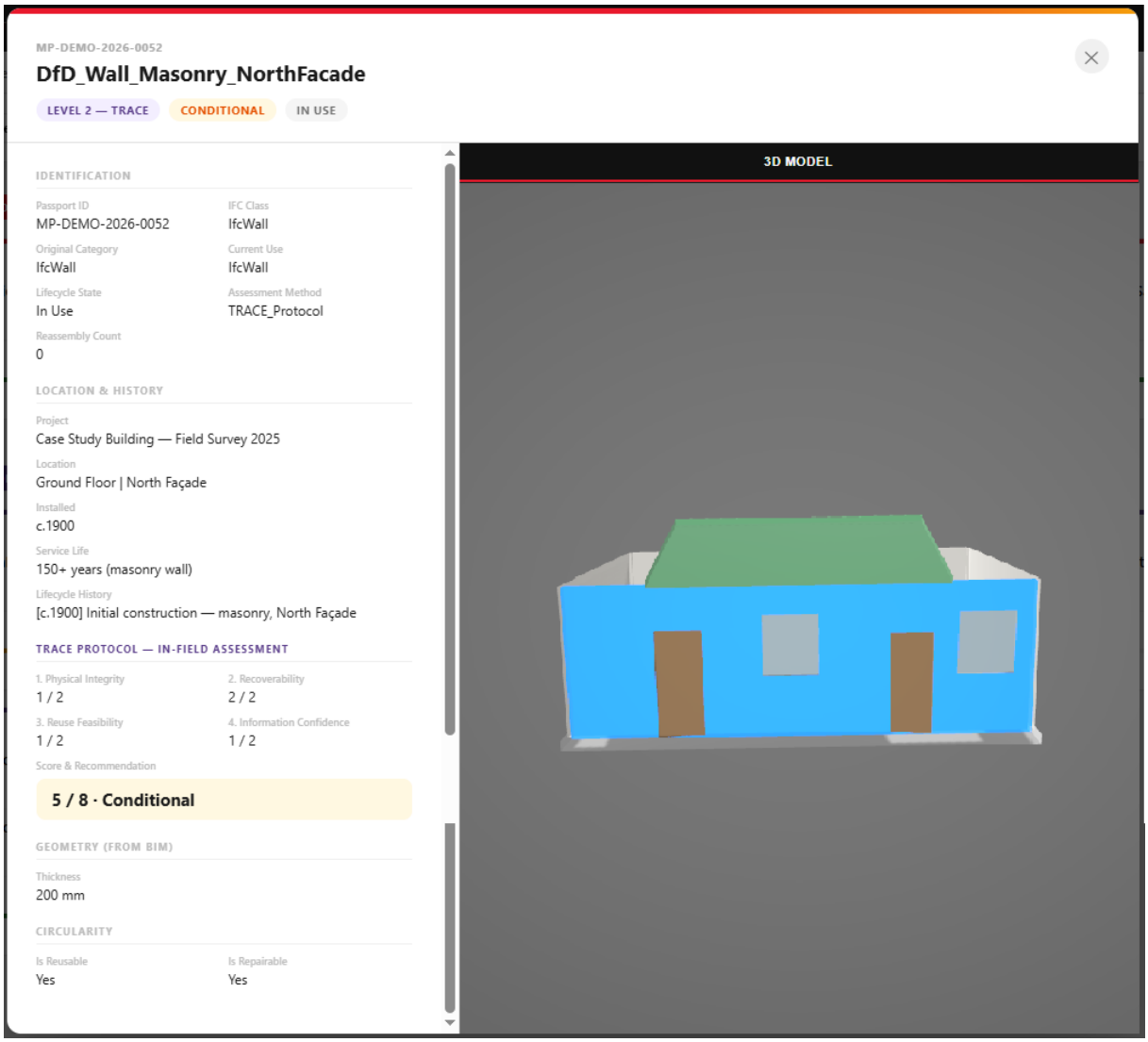


Figure 69 - Detail view for a Level 2 wall element, with populated fields and the 3D viewer showing it highlighted. Source: Author.

Taken together, the catalogue, the filters, and the linked 3D viewer complete the cycle summarised in Figure 59: an element assessed and exported through either pathway becomes not just a record a receiving team can read, but one they can find among others like it, and see located within the building it came from.

3.6. Tool validation

The validation described here concerns the technical implementation itself, whether the software does what Chapter 3 claims it does, rather than the validity of the assessment criteria, which Section 2.9 already addresses as a separate question deferred to future work. Three checks were carried out, each targeting a specific claim made earlier in this chapter.

The first concerns numerical equivalence between the two pathways, claimed in Section 2.7. The same generic door (CT 0.80, CA 1.00, ID 0.70, GPE 1.00) was assessed independently through the Revit-native formula documented in Section 3.2.1, through the Python script's own recalculation described in

Section 3.3.1, and through the plugin's HarmonicMean() function described in Section 3.4.1. All three produced the same DisassemblyScore, 0.855, and the same class, A. This is not a single test but a by-product of the corrections made throughout this chapter: the harmonic mean formula was implemented independently three times, and bringing all three into agreement, rather than assuming they already were, is what this check confirms.

The second concerns schema integrity across the IFC export step described in Section 3.3.1. Querying the property sets attached to a test element via ifcopenshell, as shown in Figure 32, confirmed that all 27 DfD_ parameters survive the export intact, recoverable by name regardless of the property set grouping the exporter happened to produce. No field was found missing or renamed across the elements checked this way.

The third concerns the area-integrity check performed by Import to New Project, described in Section 3.4.2. Two scenarios were tested: a receiving element whose area matched the source passport closely, which imported without a warning, and a deliberate mismatch, a 0.09 m² source area against a 7.00 m² target, which triggered the warning shown in Figure 57. Both outcomes matched what the command is designed to do in each case. The results of this check, together with the other technical validation tests, are summarised in Table 19.

Table 19 - Summary of technical validation checks.

Check	What was tested	Result
Cross-pathway score equivalence	Same input values (CT 0.80, CA 1.00, ID 0.70, GPE 1.00) scored independently via Revit formula, Python script, and C# plugin	All three: DisassemblyScore 0.855, Class A
IFC schema integrity	All 27 DfD_ parameters queried by name on a test element after IFC export	All 27 fields present and readable
Area-integrity check (Import)	Matching-area scenario and deliberate 7307% mismatch scenario	Matching case imports without warning; mismatch triggers the warning correctly

Together, these checks confirm that the implemented workflow behaves consistently across its main technical stages, from assessment and IFC export to passport import. The tested outputs therefore support the technical reliability of the implementation presented in this chapter.

4. CASE STUDY: FAZENDA RIBEIRO (C.1820)

The two-level assessment framework and its supporting digital infrastructure, developed in Chapters 2 and 3, are tested in this chapter through a real case study. Fazenda Ribeiro, a rural estate in São José de Mipibu, Rio Grande do Norte, Brazil, was selected because its main house represents the type of existing building the framework was designed to address. Built predominantly in adobe and rammed earth, with additional timber and stone elements, it combines monolithic and discrete construction within the same building. Its vernacular character, lack of original digital documentation, and direct accessibility for field survey also made it particularly suitable for testing both assessment levels in practice.

This chapter presents the full application of the framework, from field survey to final assessment results. Section 4.1 introduces the historical background of Fazenda Ribeiro and the architectural organisation of the surviving house. Section 4.2 examines the building through its different construction phases, distinguishing original nineteenth-century fabric from later interventions. Section 4.3 describes the development of the BIM model through the C# plugin (Pathway B). Section 4.4 explains how the surveyed elements were classified between Level 1, based on Disassembly Potential, and Level 2, based on the TRACE Protocol. Section 4.5 presents the assessment results and discusses what they reveal about the building's reuse potential.

4.1. Historical and architectural context

São José de Mipibu, located roughly 30 kilometres from Natal, was an important sugar-producing municipality in Rio Grande do Norte during the eighteenth and nineteenth centuries. Local historical accounts indicate that more than thirty engenhos were active in the region by the mid-nineteenth century, including Boa Vista, Olho D'Água, Lagoa do Fumo, Pituba, and Mipibu (Chão Potyguar, 2010). Some of the casas-grandes associated with these estates are still standing and have been documented in regional sources. The casa-grande of Fazenda Olho D'Água, for example, was rebuilt in 1851, replacing an earlier structure founded in 1773 (Tribuna do Norte, 2013). The casa-grande of Engenho Lagoa do Fumo, a single-storey brick building with its original two-slope roof, dates from approximately 1810 (RioGrandeDoNorte.net, n.d.). These examples place much of the surviving rural architecture of the region within the period of sugar production between the late eighteenth and nineteenth centuries. The location of Fazenda Ribeiro and regional context is identified in Figure 70.



Figure 70 - Fazenda Ribeiro location in São José de Mipibu-RN, Brazil. Source: Author.

Fazenda Ribeiro developed within this same context. According to local historical research, its first casa-grande was built by the agriculturalist Francisco Sales e Silva, patriarch of the Ribeiro Dantas e Duarte family, sometime between the late eighteenth and early nineteenth centuries. The property also included a colonial baroque chapel dedicated to São João and a rudimentary animal-powered sugar mill (Emerenciano, as cited in Medeiros, 2023). The estate was reportedly involved in the Pernambucan Revolution of 1817, with meetings in support of Brazilian independence taking place in the main house (Medeiros, 2023). The headquarters was later rebuilt by Horácio Cândido Sales e Silva (1838–1903), grandson of Francisco Sales e Silva, who also replaced the animal-powered mill with a steam-driven one imported from Europe. However, the exact date of this reconstruction remains unknown, including in the local historical account used here (Medeiros, 2023). No primary archival source consulted for this dissertation provides an exact construction date for the surviving buildings. For this reason, c.1820 is adopted as an approximate working date throughout the study. It corresponds to the estate's earliest documented period of activity and is consistent with the dates of other rural estates in the region, but should not be understood as a confirmed construction date. The main façade of Fazenda Ribeiro is shown in Figure 71.



Figure 71 - Fazenda Ribeiro main façade (2026). Source: Author.

The casas-grandes of Brazil's colonial sugar estates followed a recognizable architectural logic, shaped less by formal design intent than by the productive relations of the engenho complex itself. Rural residences of the period were typically organized in direct relation to their surrounding service and production structures, with the main house's floor plan reflecting a division between areas of family life and areas of household labour, all built with the earthen or masonry techniques and construction systems locally available (Diniz, 2008). Single-storey construction with verandas (alpendres) bordering the main façades was a common response to the region's hot, humid climate, providing

shade and a transitional social space between the interior and the surrounding grounds. Fazenda Ribeiro's surviving casa-grande follows this general pattern as shown in Figure 72.



Figure 72 - Fazenda Ribeiro's verandas (2026). Source: Author.

The surviving dwelling examined in this case study is a single-storey building with verandas along the front and lateral façades, as shown in Figure 73. Covering approximately 485 m², its floor plan is organised into two main areas. The rear portion of the house accommodates the dining room, the kitchen, and a bathroom, while the front portion accommodates four bedrooms, a living room, a library, and a tea room. A chapel and the remains of the estate's engenho also survive elsewhere on the property, but these structures fall outside the scope of the present study, which focuses exclusively on the main house.

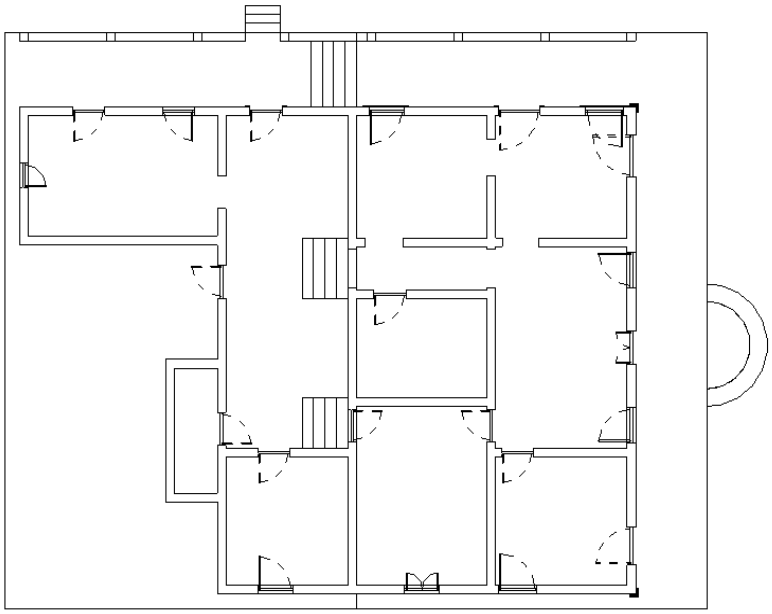


Figure 73 - Floor plan of Fazenda Ribeiro casa-grande. Source: Author.

The house documented here therefore combines a colonial spatial organisation, built originally in earthen construction, with a layout that has been adapted over time to accommodate later domestic needs. This combination of an inherited constructive logic and successive practical interventions is examined in detail in the following section, which analyses the building through its distinct temporal layers of construction.

4.2. Constructive analysis by temporal layers

The construction history of the Fazenda Ribeiro casa-grande can be read through three distinct temporal layers, identified during the field survey conducted for this dissertation. The first and most extensive layer corresponds to the original nineteenth-century construction. With the exception of the rear bathroom and the pillars and railing of the lateral veranda, all of the house's walls belong to this original phase, built in adobe and rammed earth. The roof structure also largely belongs to this layer: the tile covering and the primary timber framing, comprising props, rafters, and purlins, are all original and were retained through subsequent interventions. The doors throughout the house are likewise original to their respective periods of construction.

A second layer, no longer physically present, corresponds to a service annex that once adjoined the kitchen. This annex comprised a senzala, a corridor extending to the rear of the kitchen, and a bathroom accessed through that corridor. All three elements were demolished together; the opening once connecting the kitchen to this annex is now a door leading directly to an external area. This annex is indicated in yellow in Figure 74: the area corresponds to the former senzala, corridor, and bathroom, all demolished in 2010.

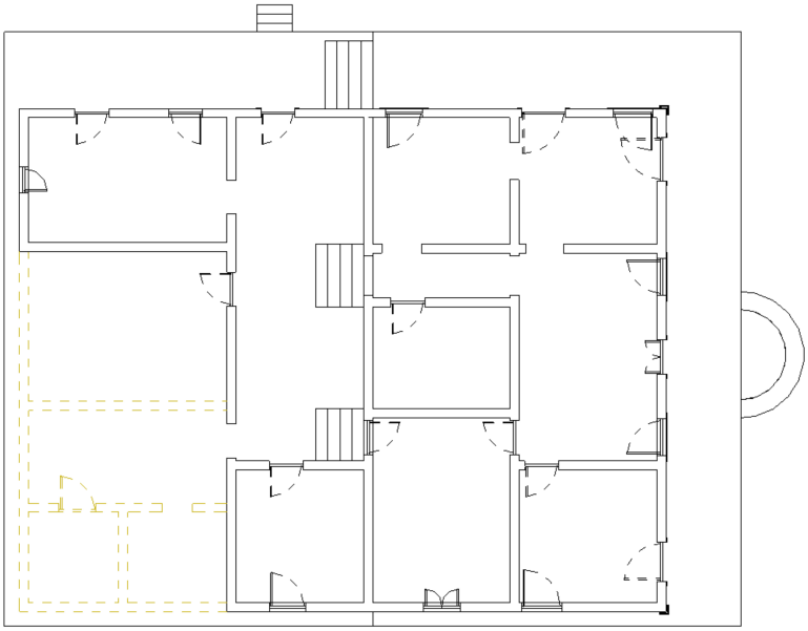


Figure 74 - Fazenda Ribeiro casa-grande, demolition plan. Source: Author.

The third layer corresponds to a renovation campaign carried out in 2010. This intervention replaced the demolished annex with a new bathroom, added new pillars and a new railing to the lateral veranda, and replaced the roof's laths, which had deteriorated, while keeping the original tile covering, props,

rafters, and purlins in place. These additions are indicated in red in Figure 75: the smaller area corresponds to the new bathroom, occupying part of the footprint of the demolished annex, while the highlighted line along the veranda corresponds to its new pillars and railing. With the exception of these interventions, the remainder of the house's fabric survives from its original period of construction.

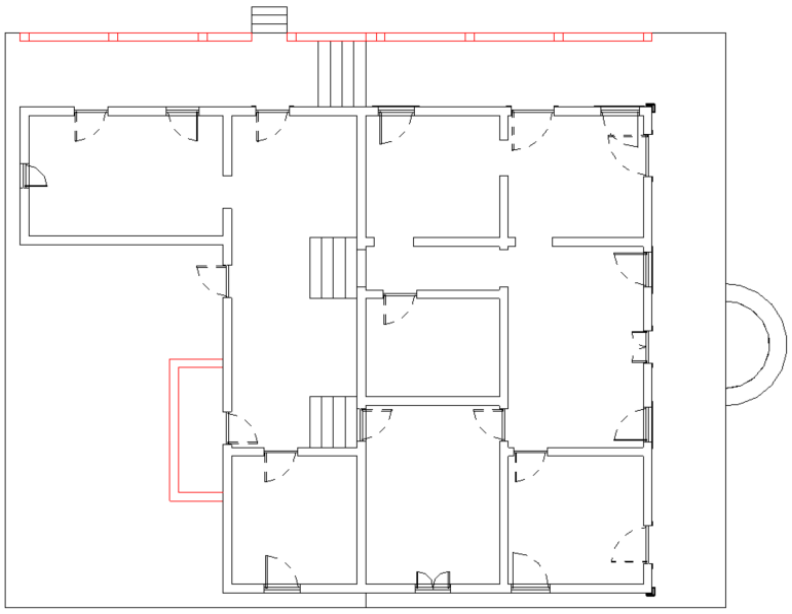


Figure 75 - Fazenda Ribeiro casa-grande, as-built plan. Source: Author.

The house's surface materials reflect the same combination of original fabric and later repair evident in its structure. The exterior walls are finished in a lime or cement render, painted white, with door and window surrounds picked out in a deep blue that follows the region's colonial vernacular convention, as shown in Figure 76.



Figure 76 - Veranda stairs. Source: Author.

Doors throughout the house are solid timber, painted in the same blue, set within arched masonry openings with plastered reveals (Figure 77):



Figure 77 - Two frontal doors. Source: Author.

Window shutters follow the same joinery and finish as the doors (Figure 78):



Figure 78 - Two windows. Source: Author.

The veranda ceiling exposes the timber roof structure directly, with rafters and battens visible beneath the clay tile covering, supported by timber pillars, as illustrated in Figure 79.



Figure 79 - Verandas and exposed timber roof structure. Source: Author.

Elsewhere in the house, the roof structure follows the same rafter and tile system, though the battens here retain a woven (Figure 80), crossed-lath pattern distinct from the straight battens visible over the veranda.



Figure 80 - Interior views of the timber roof structure at Fazenda Ribeiro. Source: Author.

A comparison between two deterioration cases documented in the building illustrates that material age alone does not determine a component's vulnerability to decay. The base of one of the veranda's pillars, a rendered fired-brick element added during the 2010 renovation and therefore less than two decades old, already shows advanced deterioration, with render and masonry both eroding at the point of ground contact (Figure 81). A comparable pattern of decay appears on one of the original

nineteenth-century walls, where a section of render has detached to expose the adobe masonry beneath, itself marked by biological growth and moisture staining across the surrounding surface (Figure 81). Despite the near two-century difference in age and the contrast in constructive material, fired brick against unfired earthen block, both elements exhibit a similar failure pattern concentrated at points of sustained moisture exposure. This suggests that the building's principal vulnerability lies less in the intrinsic durability of either material than in the adequacy of moisture management at ground level and at wall bases, a condition affecting both the original fabric and its later additions alike.



Figure 81 - Exposed wall damage and moisture-related deterioration. Source: Author.

Two paving materials were documented at ground level: fired clay brick, laid in running bond, inside the house, and a stained tile paving in the uncovered outdoor areas. Unlike the concrete paving found elsewhere on the property, brick flooring is a technique consistent with the building's original construction period, suggesting this interior paving may itself be original rather than a later addition, though this could not be confirmed during the field survey, as illustrate in Figure 82.



Figure 82 - Existing floor finishes. Source: Author.

Taken together, the evidence collected at Fazenda Ribeiro indicates that most of the building fabric is original, while later interventions are limited to a small number of identifiable elements. These include the rear bathroom, the veranda pillars and railing, and the roof battens, all associated with the 2010 renovation, as well as the removal of the former service annex. The observed deterioration does not appear to depend only on the age of the materials. In particular, the comparison between the newer pillar and the original adobe wall points to moisture at ground level as a recurring source of damage. Distinguishing between original elements, removed parts, and later additions is important for the next stage of the study, where the building is modelled and assessed element by element.

4.3. BIM model development

The Fazenda Ribeiro model was developed directly in Revit 2027. Field geometry was captured using a measuring tape and a laser distance meter, complemented by hand sketches recording room dimensions, wall thicknesses, and opening positions; these field sketches were not preserved beyond the modelling stage. The resulting model translates these measurements directly into Revit geometry, following the spatial organisation described in Section 4.1. The completed model is presented in Figure 83.

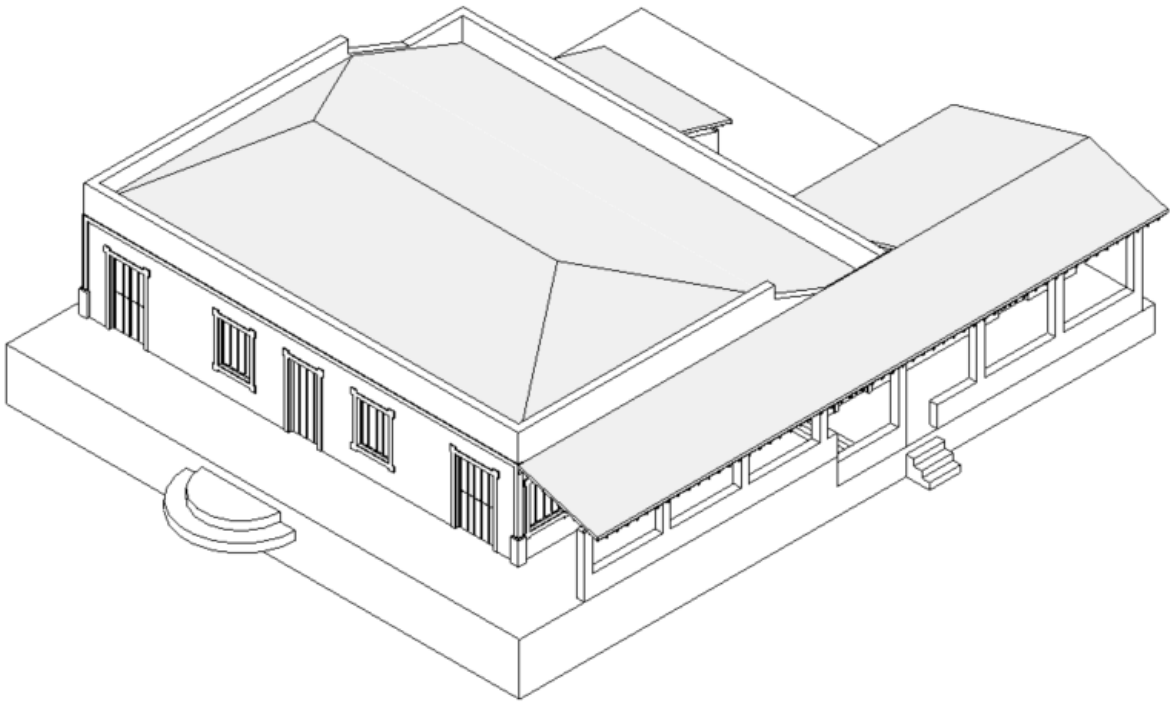


Figure 83 - Fazenda Ribeiro casa-grande, completed Revit model. Source: Author.

Building elements were modelled using the same naming convention across all structural and architectural categories: doors, windows, the roof's timber components, and the primary wall, floor, and column types were each named according to DfD_[Category]_[Construction style]_[Site code]_[Period]_[Position]_[Configuration], for example DfD_Door_Colonial_SJM_1820_Exterior_Double and DfD_Wall_Colonial_SJM_1820_Structural_Solid. Secondary type variants that do not represent the

house's principal constructive system, such as lightweight metal-stud partition walls added in later interventions, retained Revit's default type designations. This naming convention was adopted for this case study to keep the model itself legible and organised; it is not a requirement of the underlying DfD protocol, which identifies and tracks each element through its individual DfD_MaterialPassportID, assigned independently of the family or type name. Figure 84 provides an example of this naming structure as applied to the door families in the Project Browser.

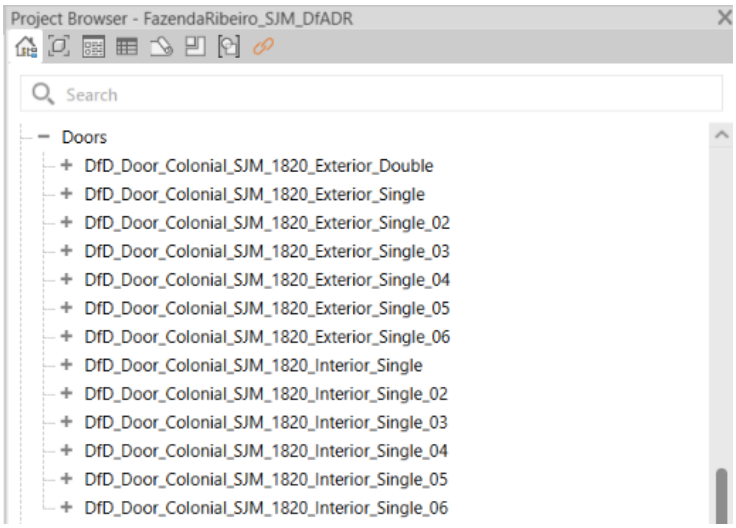


Figure 84 - Project Browser showing custom DfD family naming for Doors. Source: Author.

The roof was modelled as a complete assembly reflecting each of its original constructive layers, rather than as a single generic roof element: the tile covering, battens, rafters, and the purlin, wall plate, and ridge beam components were each built as distinct families, corresponding to the constructive layers identified in Section 4.2. This layered organisation can be seen in the exploded roof view in Figure 85.

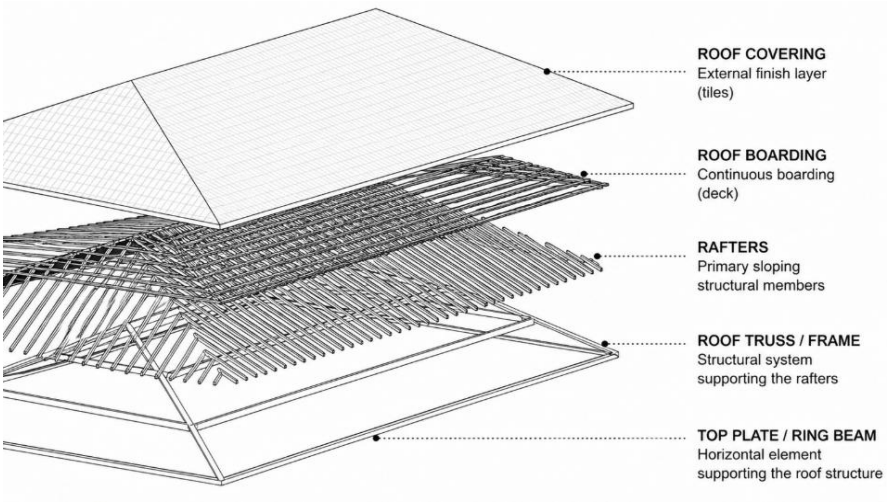


Figure 85 - Exploded view of the roof assembly and structural layers. Source: Author.

Doors and windows were built as nested families, in which the frame, hinges, and leaves were modelled as separate sub-families and combined within a single host family. For the purposes of this

case study, each door or window is assessed as a whole at the level of its host family, rather than at the level of its individual nested components; the framework nonetheless supports assessment at this finer level of decomposition where a more detailed disassembly analysis is required. Figure 86 illustrates the anatomy of this nested structure using one of the surveyed doors as an example, distinguishing its frame, hinges, upper leaf, and lower leaf.

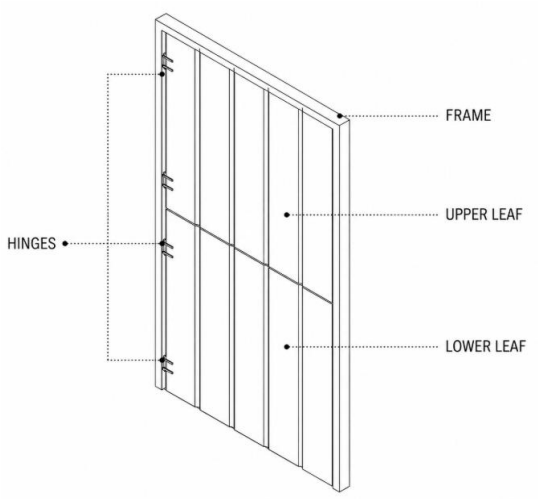


Figure 86 - Anatomy of a nested door family (frame, hinges, and leaves). Source: Author.

Within the Revit model itself, these components exist as separate loadable families nested inside the host family and visible as such in the Family Editor, as shown in Figure 87.

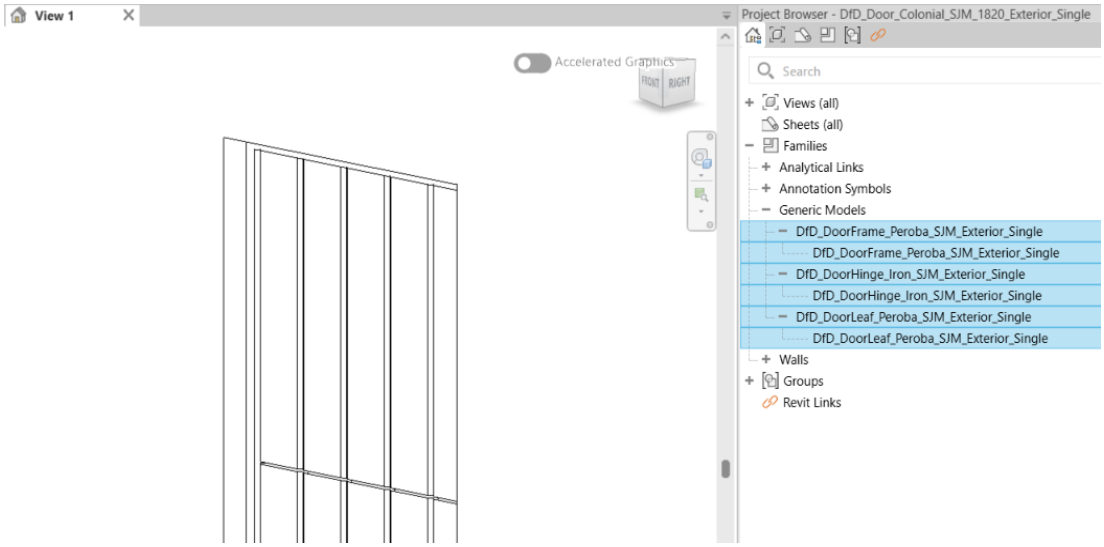


Figure 87 - Family Editor view of a door family and nested sub-families. Source: Author.

With the model's geometry complete, each element category was prepared to receive the assessment data described in the following section. This was done through the plugin's Setup DfD Params function, which writes the Pset_DfD_LifeCycle shared parameters directly onto the selected family or category. As the framework is family-agnostic, this step applies uniformly across both custom loadable families and native system families, regardless of the naming strategy used for each.

4.4. Element classification: level 1 and level 2

Each surveyed element was assigned to one of the framework's two assessment levels according to its constructive logic. Elements that are mechanically fixed and constitute discrete, individually removable components, such as doors and windows, were classified under Level 1 and assessed through the Disassembly Potential criteria (Connection Type, Connection Accessibility, Independence, and Geometry/Product Edge). Elements built through monolithic or earthen construction, where no discrete mechanical connection exists between the element and its surrounding fabric, such as the house's adobe walls, were classified under Level 2 and assessed through the TRACE Protocol (Physical Integrity, Recoverability, Reuse Feasibility, and Information Confidence).

This classification was applied through an on-site field survey, in which each element was assessed in person using the field assessment sheets described in the preceding section, one version structured around the Level 1 criteria and one around the Level 2 criteria. Two of the surveyed elements, door D-01 and wall W-01, are used below to illustrate the process, from field observation to its digital record within the BIM model, one assessed under each level.

Door D-01 (Level 1). The first section of the sheet records the element's identification and location within the building: its reference code, room or zone, and a brief description, alongside a photograph of the element in situ. The second section records its physical condition as observed on site: primary material, approximate dimensions, current use, and visible condition, together with a preliminary judgement of whether the element appeared repairable or reusable by visual inspection alone:

Level 1 Field Assessment Sheet

In-situ building survey

1. Survey and Element Identification			
Survey date	24/06/2026	**Assessor**	Author
Building / case study	Fazenda Ribeiro	**Element reference**	D-01
Level / storey	Ground floor	**Room / zone / grid**	Exterior veranda / façade
Element category	Door	**Element type / description**	Painted timber plank door in arched opening

2. In-situ Physical Information			
Primary material	Timber	**Finish / secondary material**	Blue painted finish; metal hardware
Approx. dimensions	L: 1.45 W: 0.05 H/T: 2.50	**Units**	[ ] mm [ ] cm [X] m
Current use / function	External access / enclosure	**Current state**	[X] In use [ ] Unused [X] Damaged [ ] Other
Visible condition	[ ] Good [X] Fair [ ] Poor	**Visible defects**	Longitudinal cracks and splits; local loss at lower edge; paint wear/flaking; gaps between boards; weathering near base.
Repairable on visual inspection?	[X] Yes [ ] No [ ] Uncertain	**Reusable on visual inspection?**	[X] Yes [ ] No [ ] Uncertain

Figure 88 - Field assessment sheet, Section 1 and Section 2, door D-01. Source: Author.

The sheet's third section structures the assessment itself. Each of the four Level 1 criteria was scored against the tickable conditions provided on the sheet: a mechanically fixed connection through hinges and fasteners (Connection Type, 0.80), fixings reachable but complicated by paint and ageing at the frame interface (Connection Accessibility, 0.60), a component removable without dismantling

adjoining elements (Independence, 1.00), and a leaf partially bounded by its surrounding frame (Geometry/Product Edge, 0.40), as shown in Figure 89.

3. Level 1 Assessment — Observed Disassembly Conditions			
Connection description	Timber door/frame mechanically fixed within rendered adobe wall opening; fixings concealed by frame/render.		
Connection location	Frame perimeter at jambs/head; leaf-to-frame hardware at side jamb.		
Criterion	**Points to check (tick all that apply)**	**Score**	**Field observation / justification**
Connection Type (CT)	**[X] Fixed with mechanical fasteners (screws, bolts, nails, clips, hinges)** [ ] Fixed with wet/adhesive methods (mortar, glue, chemical sealant) [ ] Cast-in-place or monolithically bonded to adjoining material [ ] More than one connection type present	**Score: 0.80** *0.00–1.00*	Timber door connected through mechanical fixing elements, most likely hinges and screws/fasteners. No evidence that the door leaf itself is chemically bonded to the surrounding construction.
Connection Accessibility (CA)	[ ] Fixings are exposed and visible **[X] Fixings are concealed behind finishes, render, or other components** **[X] Standard hand tools are sufficient to access the connection** [ ] Specialised equipment or scaffolding would be required **[X] Accessing the connection would likely damage adjoining finishes**	**Score: 0.60** *0.00–1.00*	Connections appear reachable, although paint layers, ageing and the existing interface with the frame may require additional actions and may cause minor repairable damage during removal.
Independence (ID)	**[X] Element can be removed without dismantling neighbouring elements** [ ] Element shares a structural or load path with adjoining components [ ] Removal is sequence-dependent on other elements being removed first	**Score: 1.00** *0.00–1.00*	The door can reasonably be removed as an individual component without requiring the dismantling of major adjoining building elements.
Geometry / Product Edge (GPE)	**[X] Element is bounded by a discrete frame or opening** [ ] Element is fully embedded, with no exposed edge [ ] Extraction would require cutting or breaking adjoining material	**Score: 0.40** *0.00–1.00*	The component is bounded by the surrounding frame, creating some obstruction, but it is not fully embedded or geometrically inseparable from the building fabric.

Figure 89 - Field assessment sheet, Section 3, door D-01. Source: Author.

The fourth section records recovery and reuse observations in qualitative form: constraints likely to affect removal, a plausible reuse context, and any adjoining materials or interfaces relevant to the element's disassembly. For D-01, this included the risk of damage to the cracked lower boards during extraction and the possibility of reuse in a compatible opening after repair (Figure 90).

4. Reuse / Recovery Observations			
Observed recovery constraints	Hidden fixings; risk of damage during extraction; cracked/split timber at lower edge; non-standard opening and geometry.	**Possible reuse context**	Heritage repair/restoration or adaptive reuse in a compatible opening after timber repair and hardware inspection.
Interfaces / adjoining materials	Timber frame; rendered adobe wall; mortar/plaster bedding; metal hardware.	**Other relevant observations (qualitative notes only — no calculated scores)**	Repair splits and damaged lower boards; renew finish as needed. Confirm dimensions, operation and concealed fixings before removal.

Figure 90 - Field assessment sheet, Section 4, door D-01. Source: Author.

Wall W-01 (Level 2). The same two opening sections were completed for wall W-01: its identification, location, and description, together with its observed physical condition, a rendered adobe wall section in fair condition, with extensive render loss, surface cracking, and vegetation at its base (Figure 91).

Level 2 Field Assessment Sheet

In-situ building survey

1. Survey and Element Identification			
Survey date	24/06/2026	**Assessor**	Author
Building / case study	Fazenda Ribeiro	**Element reference**	W-01
Level / storey	Ground floor	**Room / zone / grid**	Exterior façade / wall section
Element category	Wall	**Element type / description**	Rendered adobe wall section with external door opening

2. In-situ Physical Information			
Primary material	Adobe / earthen masonry	**Finish / secondary material**	Painted render/plaster; local repair patches
Approx. dimensions	—	**Units**	—
Current use / function	External enclosure / load-bearing wall	**Current state**	[X] In use [ ] Unused [X] Damaged [ ] Other
Visible condition	[ ] Good [X] Fair [ ] Poor	**Visible defects**	Extensive render loss and detachment; surface cracking; exposed substrate; weathering and dark staining; vegetation at base.
Repairable on visual inspection?	[X] Yes [ ] No [ ] Uncertain	**Reusable on visual inspection?**	[ ] Yes [ ] No [X] Uncertain

Figure 91 - Field assessment sheet, Section 1 and Section 2, wall W-01. Source: Author.

For this element, the sheet's third section structured the assessment around the four Level 2 criteria instead. Physical Integrity, Recoverability, Reuse Feasibility, and Information Confidence were each scored 1 out of 2, reflecting a monolithic element in fair condition whose material could plausibly be recovered only through careful, selective dismantling, with a plausible but unconfirmed route for its reuse (Figure 92).

3. Level 2 Assessment — In-situ Criteria (TRACE Protocol)			
Criterion	**Points to check (tick all that apply)**	**Score**	**Field observation / justification**
Physical Integrity	[ ] Material/element is structurally coherent and intact **[X] Visible cracks, losses, or structural weaknesses are present** [ ] Element would likely survive removal without collapse or major loss	**Score: 1** *0 / 1 / 2*	Wall remains standing and generally coherent, but visible render loss, cracking and local exposure indicate moderate, potentially repairable deterioration.
Recoverability	[ ] Element/material can be recovered in whole or usable units [ ] Removal is likely to be controlled rather than destructive **[X] Monolithic or composite construction limits clean separation** **[X] Fragmentation or material loss is expected during removal**	**Score: 1** *0 / 1 / 2*	Selective recovery appears possible only through careful/manual dismantling. Whole-section removal would likely cause fragmentation or minor material loss.
Reuse Feasibility	**[X] A plausible reuse route exists for the recovered material** [ ] A specific receiving project or use is already confirmed [ ] Recovered material would require processing or treatment before reuse	**Score: 1** *0 / 1 / 2*	A plausible reuse route exists for recovered adobe blocks/fragments or compatible earthen repair material, but no specific receiving project is confirmed.
Information Confidence	**[X] Photographic and visual documentation is available** [ ] Dimensions and material data are recorded [ ] Material testing or detailed condition survey has been carried out **[X] Further investigation would be needed before a confident classification**	**Score: 1** *0 / 1 / 2*	Photographic and visual evidence is available, but dimensions, material testing and detailed condition measurements for this wall section are not recorded here.

Figure 92 - Field assessment sheet, Section 3, wall W-01. Source: Author.

The fourth section recorded the same type of qualitative observations for W-01: the risk of fragmentation during removal, and the possibility of reusing recovered adobe units in compatible earthen repair work (Figure 93).

4. Reuse / Recovery Observations			
Observed recovery constraints	Monolithic construction; risk of fragmentation during removal; weathered/exposed areas; uncertain hidden condition; vegetation and surface deterioration at base.	**Possible reuse context**	Heritage repair, reconstruction or adaptive reuse using recovered adobe units/fragments or compatible earthen material.
Interfaces / adjoining materials	Rendered adobe wall; door opening/frame; plaster/render layers; adjoining wall and roof/parapet construction.	**Other relevant observations (qualitative notes only — no calculated scores)**	Local repair is visually feasible. Removal should be preceded by measurement and material-condition verification.

Figure 93 - Field assessment sheet, Section 4, wall W-01. Source: Author.

Once recorded on the field sheets, each element's data was transferred into the BIM model through the plugin's Write Passport interface. For each element, the assessor selects the corresponding family instance in Revit, opens the passport form, and enters the field-recorded values into their respective Pset_DfD_LifeCycle parameters, CT, CA, ID, and GPE for Level 1 elements, or the four TRACE criteria for Level 2 elements. The plugin then calculates the corresponding Disassembly Score and Class, or TRACE Score and Recommendation, directly within the model, without requiring this calculation to be performed manually on site (Figure 94).

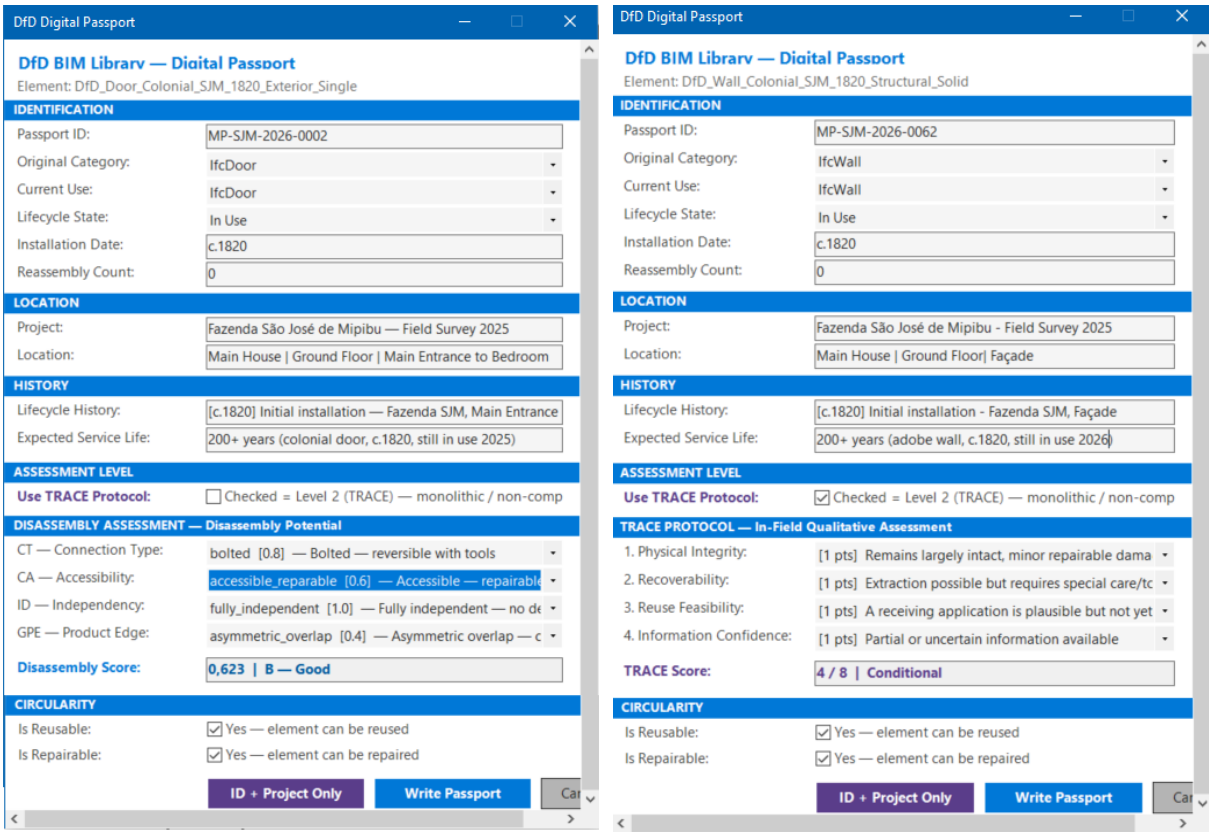


Figure 94 - Write Passport interface to Level 1 and Level 2 elements. Source: Author.

Each element's digital passport is uniquely identified through the DfD_MaterialPassportID parameter, visible at the top of the plugin's interface. The numeric suffix of this identifier is generated automatically by the plugin rather than tracked manually: the assessor defines a fixed prefix once, and the plugin assigns and increments the running count for each new passport created under that prefix. For this case study, the adopted prefix follows the pattern MP-SJM-YYYY, where MP stands for Material Passport, SJM identifies the site (São José de Mipibu), and YYYY records the year of assessment, as in MP-SJM-2026-0002 for a door and MP-SJM-2026-0062 for a wall. This scheme keeps each identifier legible at a glance, tracing a passport to its site and assessment year, while removing the need to manually assign or check for duplicate numbers across a growing set of elements.

With each surveyed element's data entered, the model's elements were isolated by assessment level using a Revit view filter based on the DfD_AssessmentMethod parameter. Elements classified under Level 1, comprising the roof's timber framing and tile covering, together with the house's doors and windows, are highlighted in Figure 95.

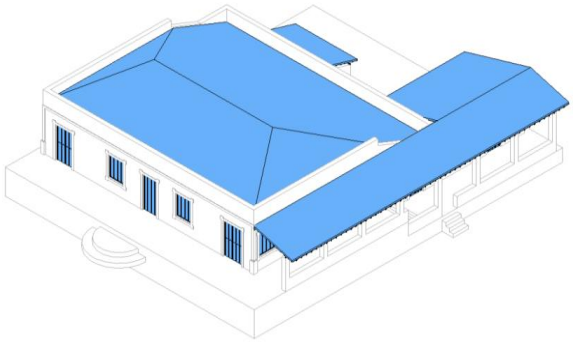


Figure 95 - Revit 3D view, elements classified under Level 1. Source: Author.

Elements classified under Level 2, comprising the house's adobe walls and its brick, the floor paving and stairs, are highlighted in Figure 96.

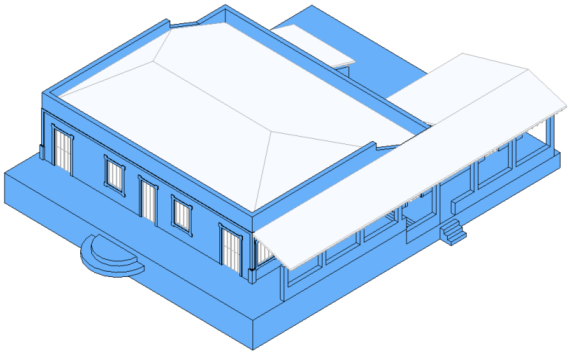


Figure 96 - Revit 3D view, elements classified under Level 2. Source: Author.

At the time of writing, 73 elements of the Fazenda Ribeiro casa-grande have been surveyed and classified under this framework, distributed between Level 1 and Level 2 according to the criteria described above.

4.5. Assessment results

The completed assessment was exported directly from the plugin's Export Passport function, covering all 80 surveyed elements: 42 under Level 1 (Disassembly Potential) and 38 under Level 2 (TRACE), as confirmed by the export dialogue shown in Figure 97. This closes the element count left open in Section 4.4. Two files were generated, a structured JSON and an Excel workbook, each organised into one sheet per element category (Doors, Windows, Roofs, Walls, Columns, Floors, Stairs).

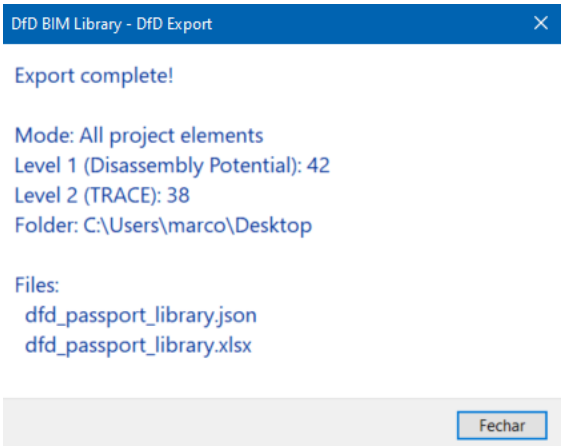


Figure 97 - Revit export dialogue confirming 80 exported elements. Source: Author.

Given the size of the complete dataset, Table 20 reproduces a representative sample of the Level 1 records, three from each of the Doors, Windows, and Roofs sheets, structured around the four Disassembly Potential criteria. The complete JSON and Excel files accompany this dissertation as supplementary material.

Table 20 - Sample of exported Level 1 (Disassembly Potential) records. Source: Author.

DfD BIM Library - Level 1 - Disassembly Potential | Fazenda SJM 1820							
Passport ID	Element	CT Score	CA Score	ID Score	GPE Score	Disassembly Score	Disassembly Class
MP-SJM-2026-0001	Door	0.8	0.8	1	0.4	0.666666…	B
MP-SJM-2026-0002	Door	0.8	0.6	1	0.4	0.623376…	B
MP-SJM-2026-0003	Door	0.8	0.6	1	0.4	0.623376…	B
MP-SJM-2026-0017	Window	0.8	0.6	0.4	1	0.623376…	B
MP-SJM-2026-0018	Window	0.8	0.8	0.4	1	0.666666…	B
MP-SJM-2026-0019	Window	0.8	0.6	0.4	1	0.623376…	B
MP-SJM-2026-0077	Purlin	0.5	0.8	0.4	0.7	0.5572	B
MP-SJM-2026-0087	Rafter	0.5	0.8	1	0.7	0.622	B
MP-SJM-2026-0083	Tiles	1	1	1	1	1	A
MP-SJM-2026-0081	Batten	0.5	0.8	0.4	0.7	0.5572	B

Table 21 presents an equivalent sample of Level 2 records, three from each of the Walls, Columns, Floors, and Stairs sheets, structured instead around the four TRACE Protocol criteria.

Table 21 - Sample of exported Level 2 (TRACE) records. Source: Author.

DfD BIM Library - Level 2 - TRACE Protocol | Fazenda SJM 1820							
Passport ID	Element	Physical Integrity	Recoverability	Reuse Feasibility	Information Confidence	TRACE Score	Recommendation
MP-SJM-2026-0062	Walls	1	1	1	1	4	Conditional
MP-SJM-2026-0043	Walls	1	1	1	1	4	Conditional
MP-SJM-2026-0045	Walls	1	1	1	1	4	Conditional
MP-SJM-2026-0030	Columns	1	1	1	1	4	Conditional
MP-SJM-2026-0024	Columns	1	1	1	1	4	Conditional
MP-SJM-2026-0023	Columns	1	1	1	1	4	Conditional
MP-SJM-2026-0032	Floors	1	1	1	1	4	Conditional
MP-SJM-2026-0093	Floors	1	0	1	1	3	End of Life
MP-SJM-2026-0092	Floors	1	0	1	1	3	End of Life
MP-SJM-2026-0096	Stairs	1	0	1	1	3	End of Life
MP-SJM-2026-0097	Stairs	1	0	1	1	3	End of Life
MP-SJM-2026-0098	Stairs	1	0	1	1	3	End of Life

The dataset was also published to the public results dashboard introduced in Chapter 3, which aggregates these records and classifies each into one of three reuse-potential tiers: Direct Reuse (Level 1 Class A-B, or Level 2 score 7-8), Conditional (Class C, or score 4-6), and End of Life (Class D-E, or score 0-3). Of the 80 elements assessed, 42 fall under Direct Reuse, 31 under Conditional, and 7 under End of Life, as shown in Figure 98.

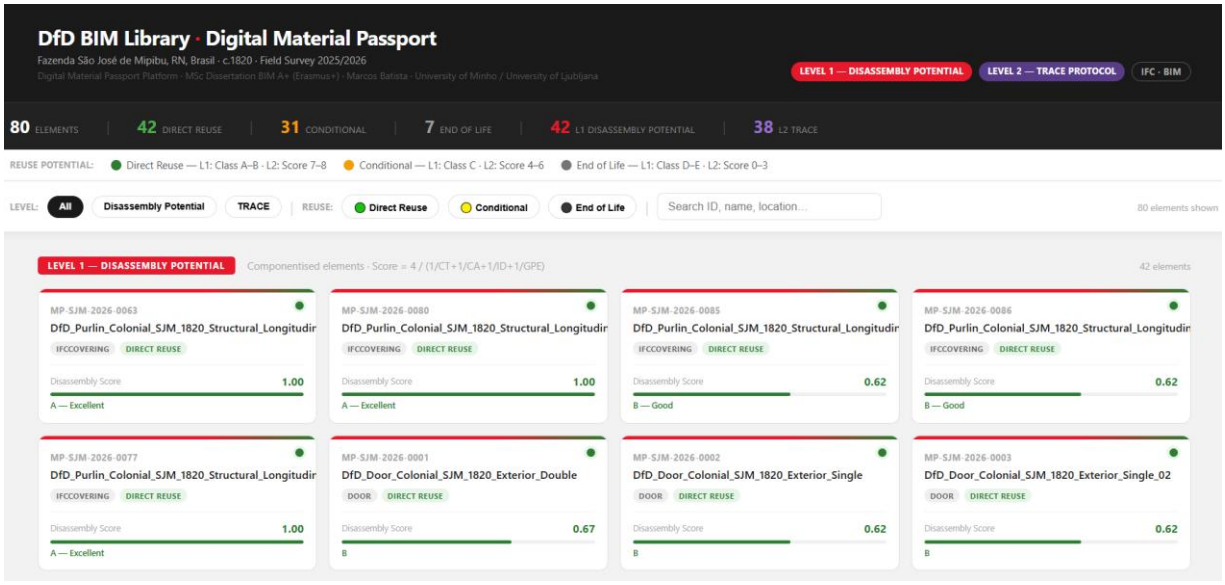


Figure 98 - Public results dashboard, overall reuse-potential distribution. Source: Author.

Reading the dashboard level by level clarifies how the two assessment methods distribute across the building. Filtering the dashboard to Level 1 (Disassembly Potential) returns all 42 componentised elements, doors, windows, and the roof's timber and tile components, as shown in Figure 99.

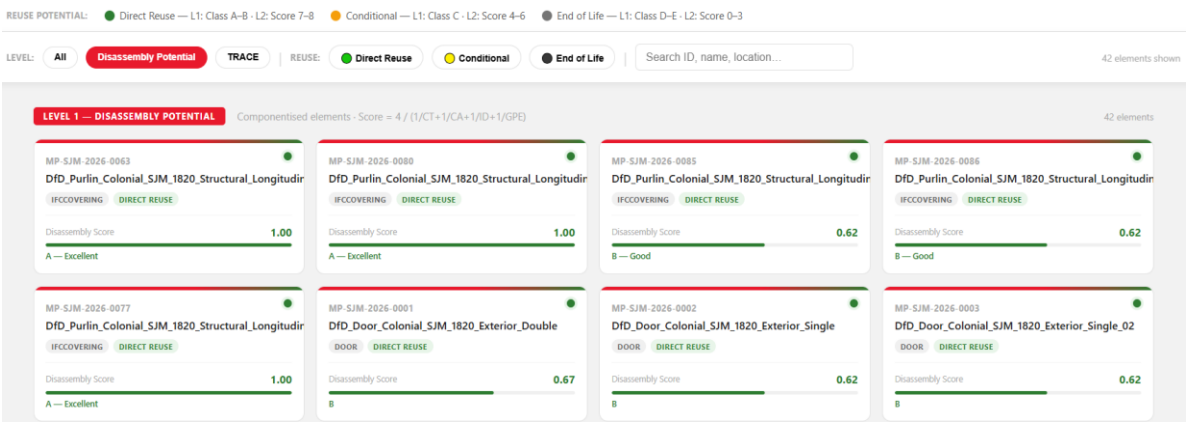


Figure 99 - Results dashboard filtered to Level 1, 42 elements. Source: Author.

Filtering instead to Level 2 (TRACE Protocol) returns the remaining 38 monolithic elements, walls, columns, floors, and stairs, as shown in Figure 100.

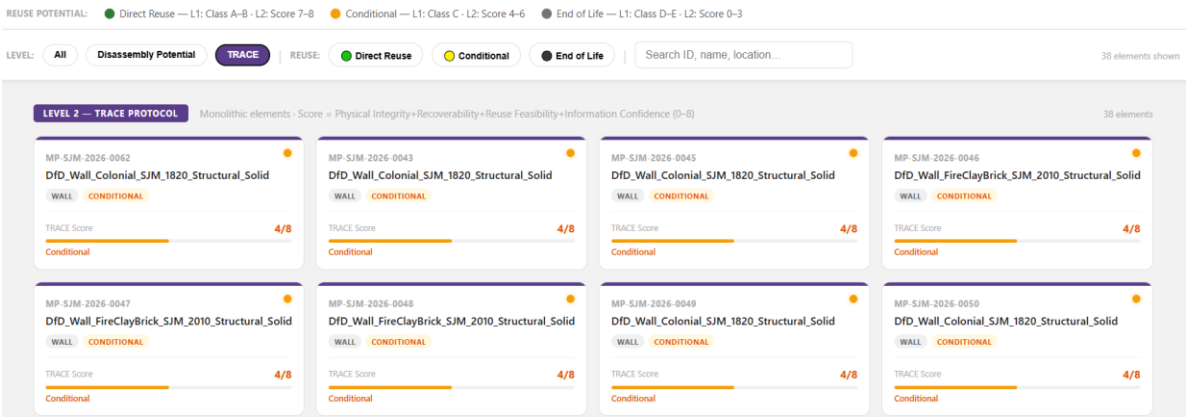


Figure 100 - Results dashboard filtered to Level 2, 38 elements. Source: Author.

Cross-referencing these two levels against the dashboard's reuse-potential tiers reveals a sharper separation than the level split alone suggests. Returning the Level filter to All and selecting Direct Reuse shows all 42 elements in this tier belong to Level 1: every componentised element assessed, without exception, is classified as directly reusable (Figure 101).

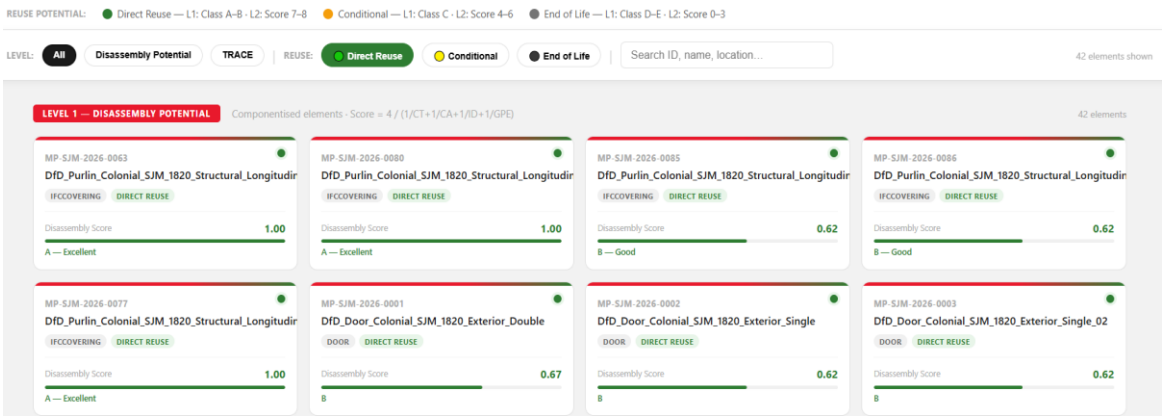


Figure 101 - Results dashboard filtered to Direct Reuse, 42 elements. Source: Author.

Selecting Conditional instead returns 31 elements, all of them Level 2: the building's 21 walls and all 8 columns, including one column individually flagged as Material Upcycling rather than simply Conditional, though both labels fall within the same 4–6 score range, together with the two interior floor sections (Figure 102). This Conditional tier therefore spans both the c.1820 adobe walls and the later fired-clay brick partitions discussed in Section 4.2, despite their different construction periods.

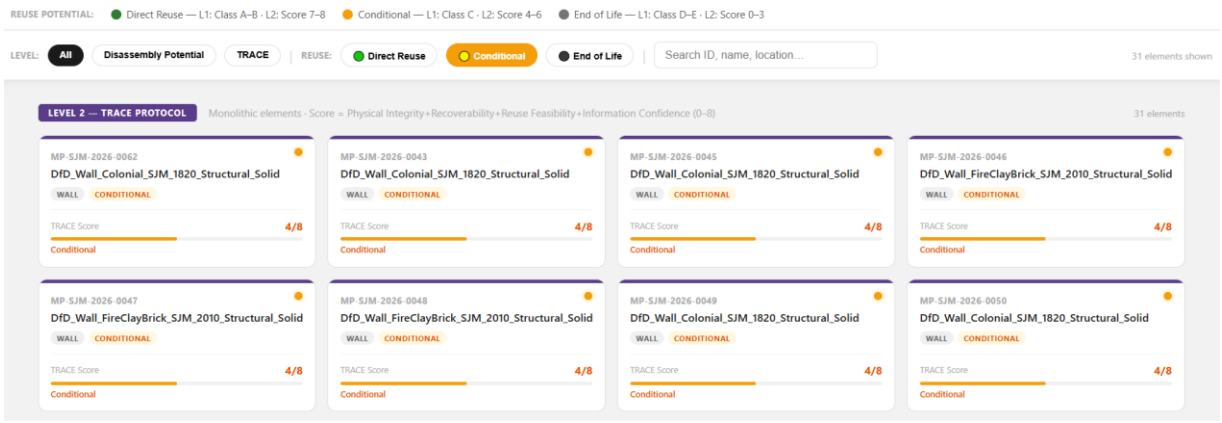


Figure 102 - Results dashboard filtered to Conditional, 31 elements. Source: Author.

Selecting End of Life returns the remaining 7 elements, also entirely Level 2: all five assessed stairs and the two exterior stained-tile floor sections (Figure 103). In both cases, a Recoverability score of 0 is the main factor pulling the overall TRACE score down to this tier.

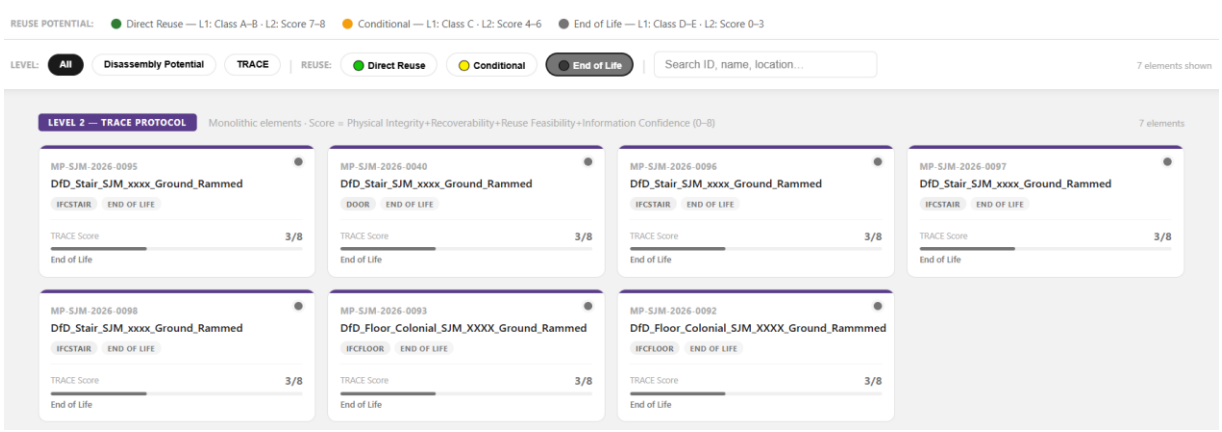


Figure 103 - Results dashboard filtered to End of Life, 7 elements. Source: Author.

The dashboard's search function makes this last distinction visible within a single element category. Searching for "floor" returns all four assessed floor sections: the two interior sections, in rammed earth or brick, fall under Conditional, while the two exterior stained-tile sections fall under End of Life (Figure 104). This confirms, at the level of an individual category, the functional distinction drawn in Section 4.2 between the house's interior and exterior paving: the two materials were installed for different purposes, and here they also receive different reuse recommendations. The dashboard's category-level search therefore offers a convenient way to verify such functional distinctions without consulting the full spreadsheet.

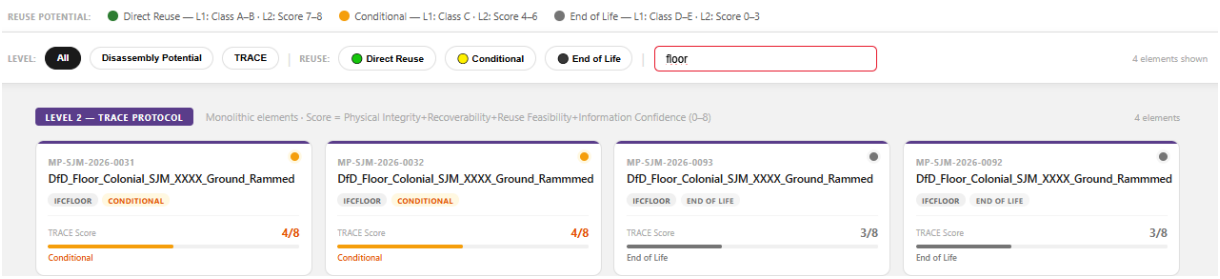


Figure 104 - Results dashboard, search results for "floor", 4 elements. Source: Author.

Selecting an element card opens a detailed passport view: identification and location, the assessment breakdown, and a live 3D view highlighting the element, with layer toggles (Walls, Structure, Floors, Stairs, Doors, Windows, Roof) to isolate it in context.

Figure 105 shows the door - MP-SJM-2026-0003 (DfD_Door_Colonial_SJM_1820_Exterior_Single), Level 1, Direct Reuse: installed c.1820 at the main entrance, bolted connection (CT 0.8, CA 0.6, ID 1.0, GPE 0.4), scoring 0.623, Class B, highlighted in the 3D viewer.

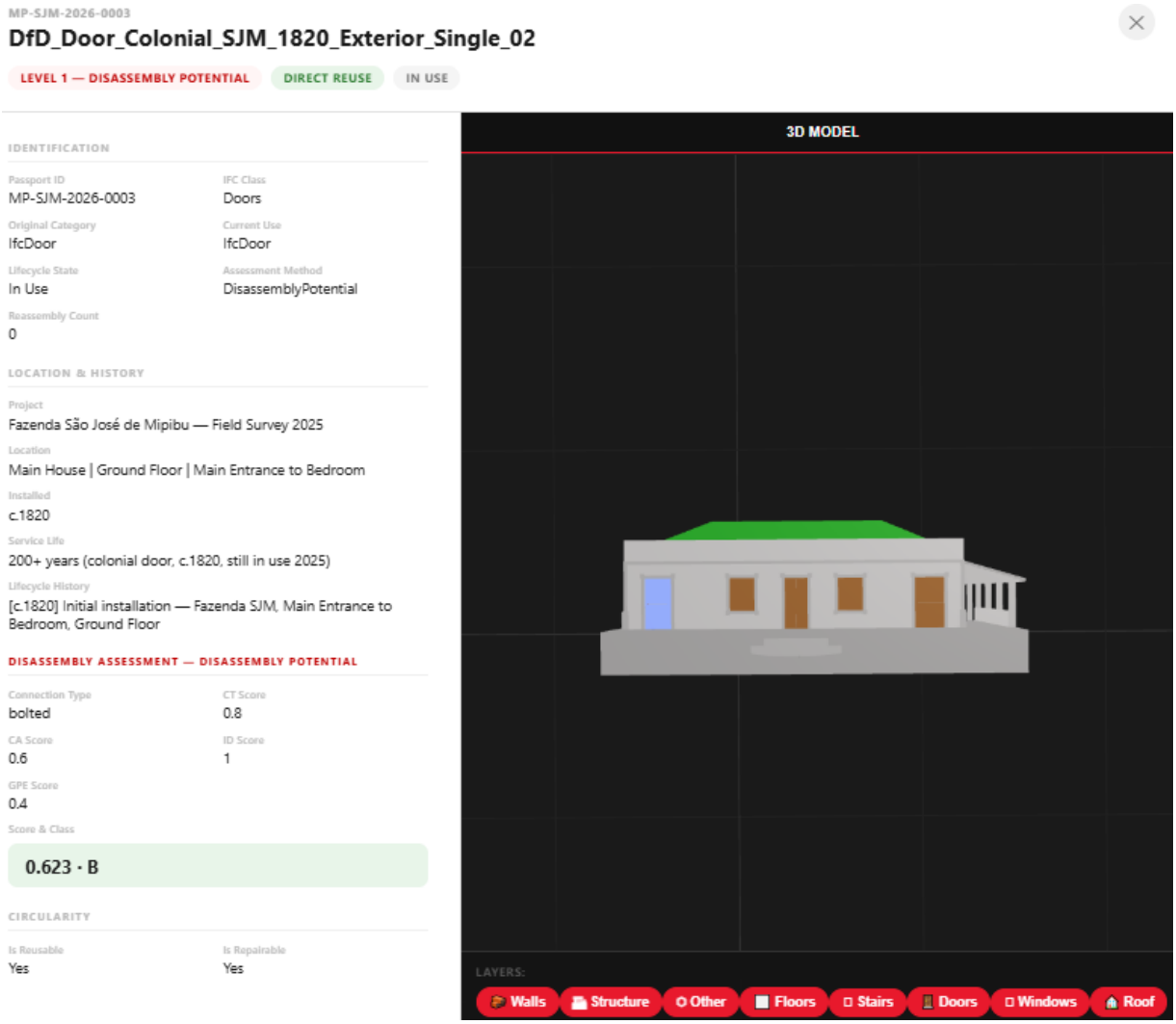


Figure 105 - Dashboard: element detail view for door MP-SJM-2026-0003. Source: Author.

Figure 106 shows the equivalent view for wall MP-SJM-2026-0062 (DfD_Wall_Colonial_SJM_1820_Structural_Solid), Level 2, Conditional: installed c.1820 on the main façade, TRACE Protocol scores of 1/2 across all four criteria (Physical Integrity, Recoverability, Reuse Feasibility, Information Confidence), scoring 4/8, Conditional, highlighted in light blue in the 3D viewer, confirming the same interface applies across both assessment levels. The wall's Reassembly Count, like every other element examined in this chapter, remains at 0, consistent with a building that has not yet undergone any documented disassembly or reuse event.

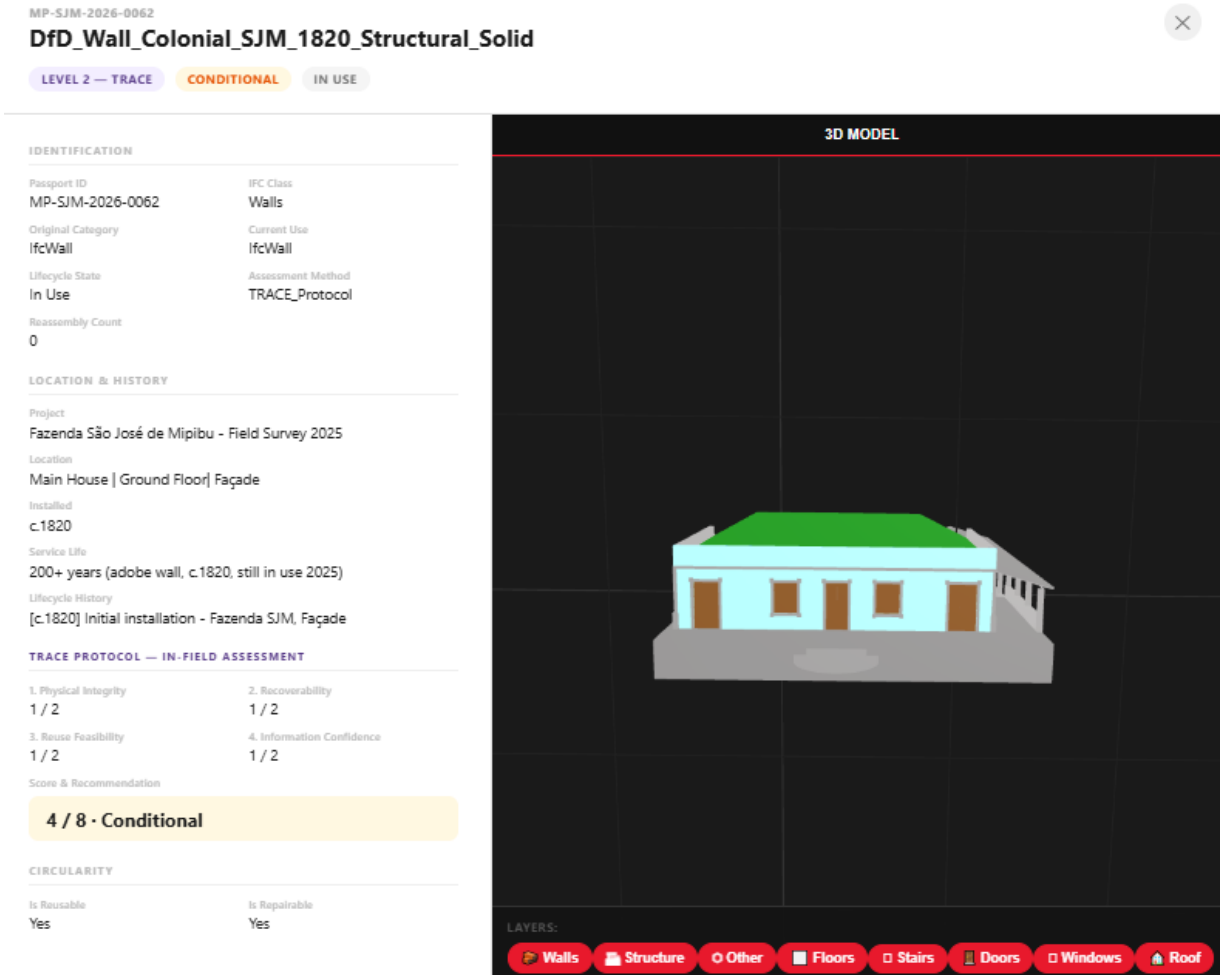


Figure 106 - Dashboard: element detail view for wall MP-SJM-2026-0062. Source: Author.

This detail view is available for every one of the 80 assessed elements, whether reached through the dashboard's cards or cross-referenced against the underlying JSON and Excel export, providing full traceability between an aggregate reuse-potential figure and the specific field observations, criteria, and 3D location that produced it. The layer toggles beneath the 3D viewer are not limited to highlighting the selected element: entire categories can be switched off to isolate the element within a simplified view of the model. Figure 107 shows this applied to door MP-SJM-2026-0009 (DfD_Door_Colonial_SJM_1820_Interior_Single_02), with the Floors, Stairs, Windows, and Roof categories hidden, leaving only the Walls, Structure, and Doors categories visible around the highlighted element. This category-level control is independent of the reuse-potential filters described

earlier in this section, and can be combined with them freely when inspecting any element in the dataset.

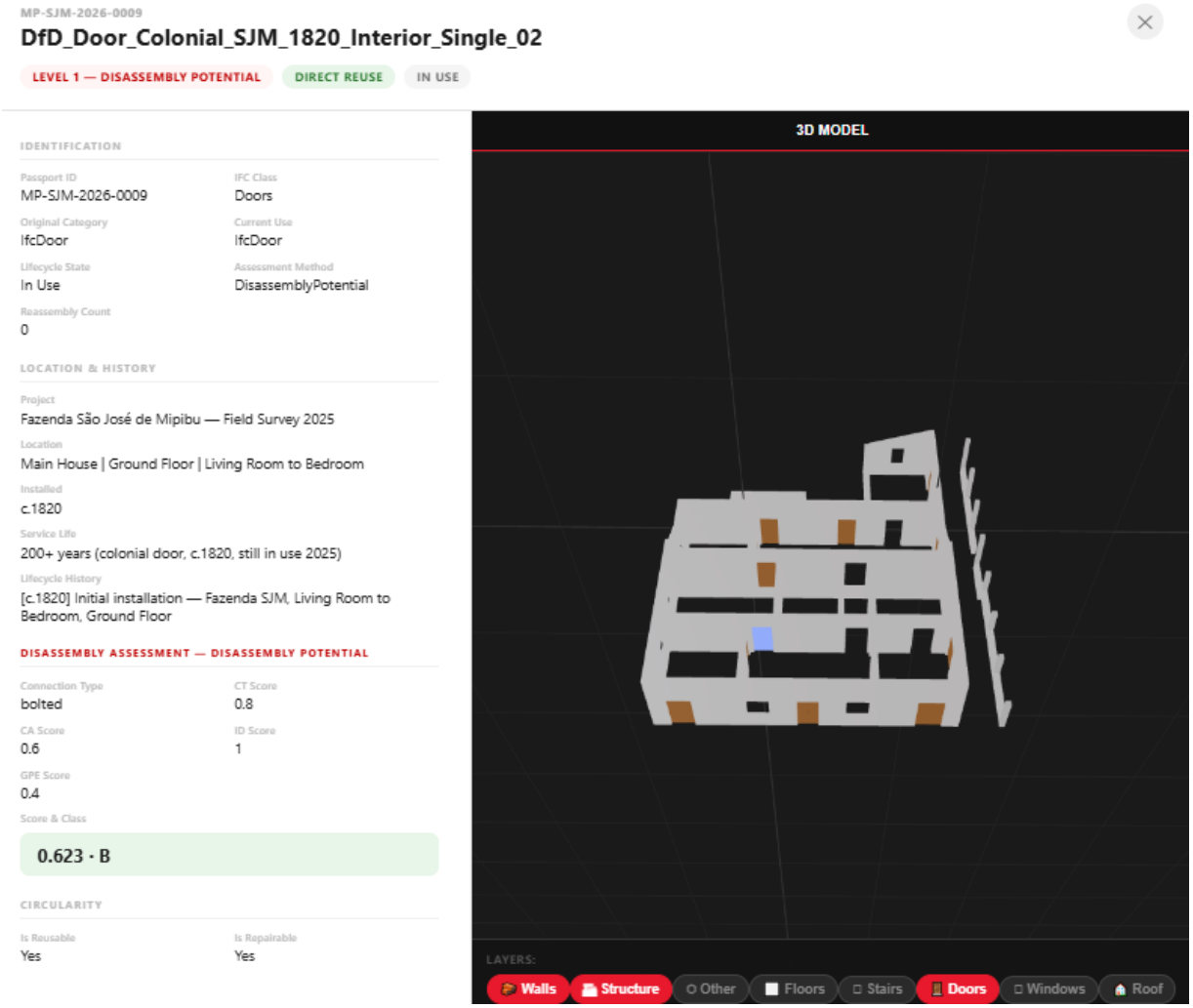


Figure 107 - Dashboard: element detail view for door MP-SJM-2026-0009. Source: Author.

Together with the highlighting shown in Figures 105 and 106, this confirms that the dashboard's 3D view supports not only locating a single element, but also controlling how much of the surrounding building is shown around it, a useful feature when comparing an element against only the categories relevant to its own disassembly sequence.

4.6. Cross-project passport portability

The framework's plugin includes an Import to New Project function, introduced in Chapter 3 but not yet demonstrated against real data. This section closes that gap, using one of the elements already presented in this chapter to verify that a passport's identification, location history, and assessment data survive intact when moved outside the building that produced them, a basic requirement for the framework's circularity claim to hold beyond a single project.

To test this without conflating the demonstration with a second case study, the destination is a minimal, unrelated Revit project, containing no elements or history of its own (Figure 108).

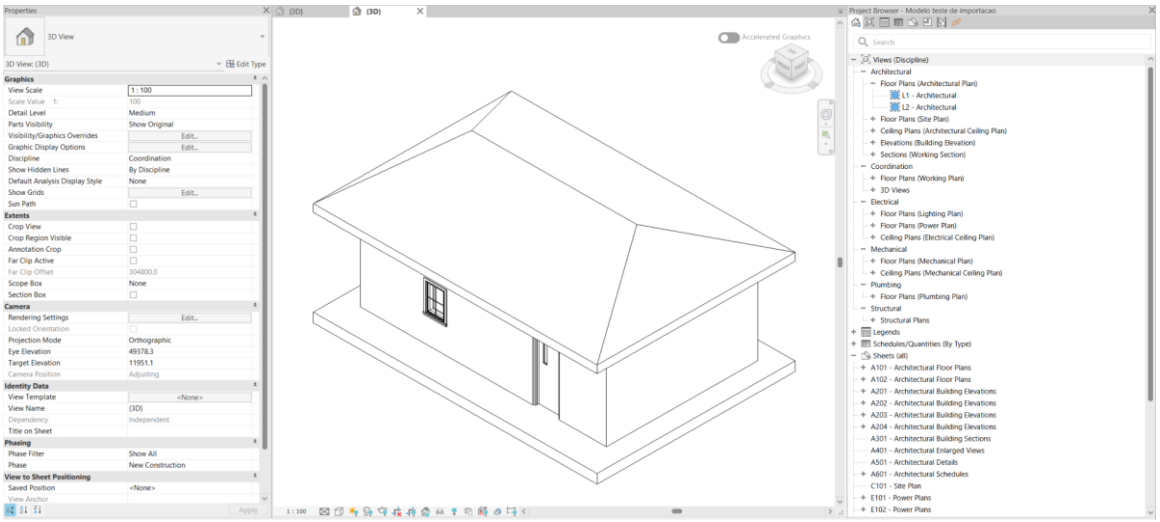


Figure 108 - Generic destination project, containing no DfD data to import. Source: Author.

The receiving element selected within this project was a generic 300 mm floor slab. Figure 109 shows the plugin's Select Passport interface, listing every passport exported from the Fazenda Ribeiro dataset and allowing any one of them to be picked for import regardless of its originating IFC category; as the dialogue itself states, "any IFC category can be reused as this element, the original category is preserved in history, only Current Use changes." Wall MP-SJM-2026-0062 (DfD_Wall_Colonial_SJM_1820_Structural_Solid), the same element examined in Figure 109, was selected for import onto this floor element.

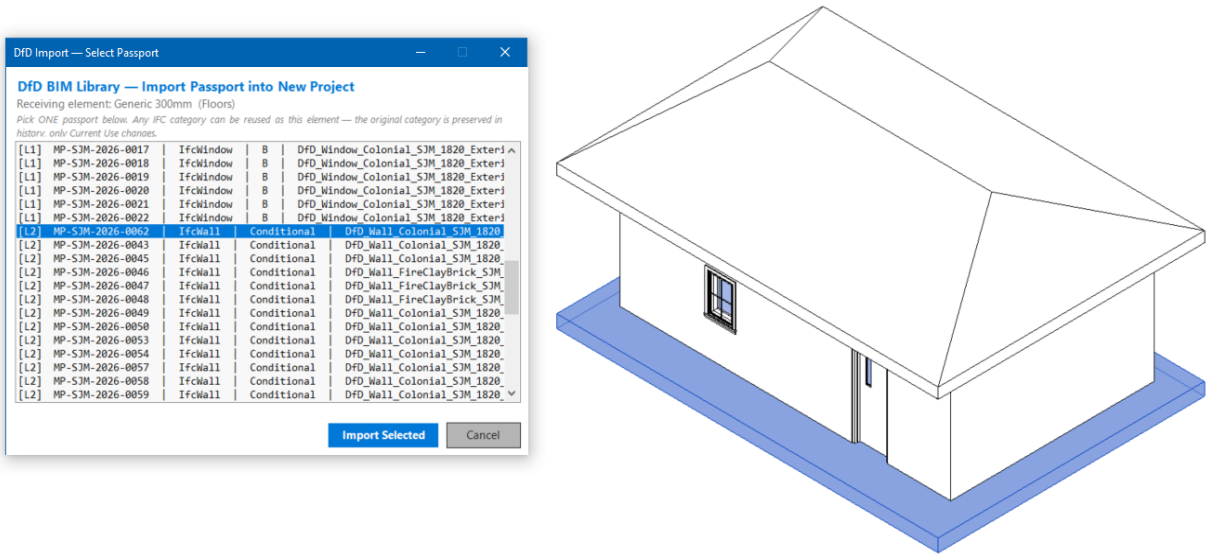


Figure 109 - Plugin's Select Passport interface (wall MP-SJM-2026-0062). Source: Author.

The import completed successfully, as confirmed in Figure 110: source category IfcWall, target element Generic 300mm (Floors), assessment level retained as Level 2 (TRACE Protocol), and Reassembly Count incremented to 1.

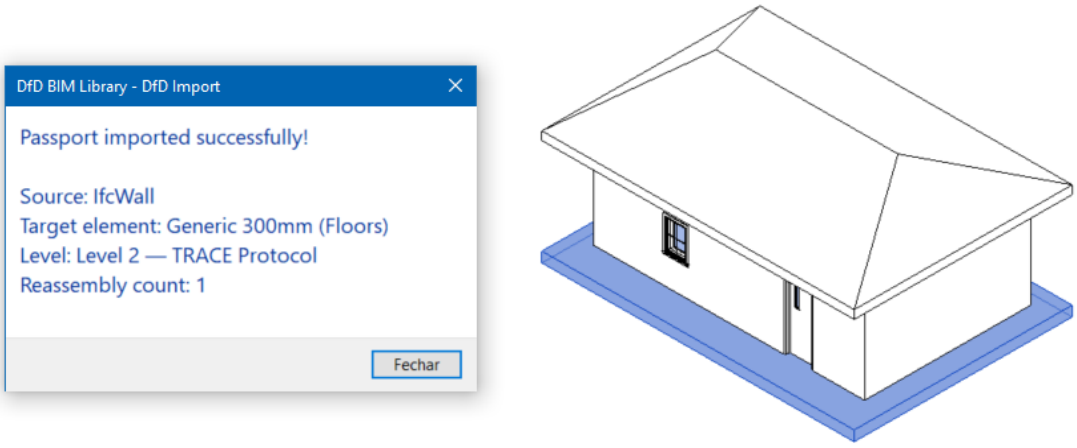


Figure 110 - Import confirmation dialogue confirmation. Source: Author.

Figure 111 shows the resulting passport within the destination project. Three fields are worth examining individually. The Passport ID (MP-SJM-2026-0062) persists unchanged, preserving a traceable link back to the element's origin regardless of how many times it is subsequently reused. The Reassembly Count, static at 0 throughout every element examined earlier in this chapter, is now 1, providing a concrete, incrementing record of the element's reuse. The Lifecycle History does not overwrite its original entry but appends to it, growing from a single installation record into a concatenated one: "[c.1820] Initial installation - Fazenda SJM, Façade -> [2026-08-02] Reused: IfcWall -> Floors | Reassembly #1 | Target: Generic 300mm", preserving the element's full history rather than replacing it. All remaining fields can be edited freely on import to reflect the receiving project's own context, as needed for each specific reuse case.

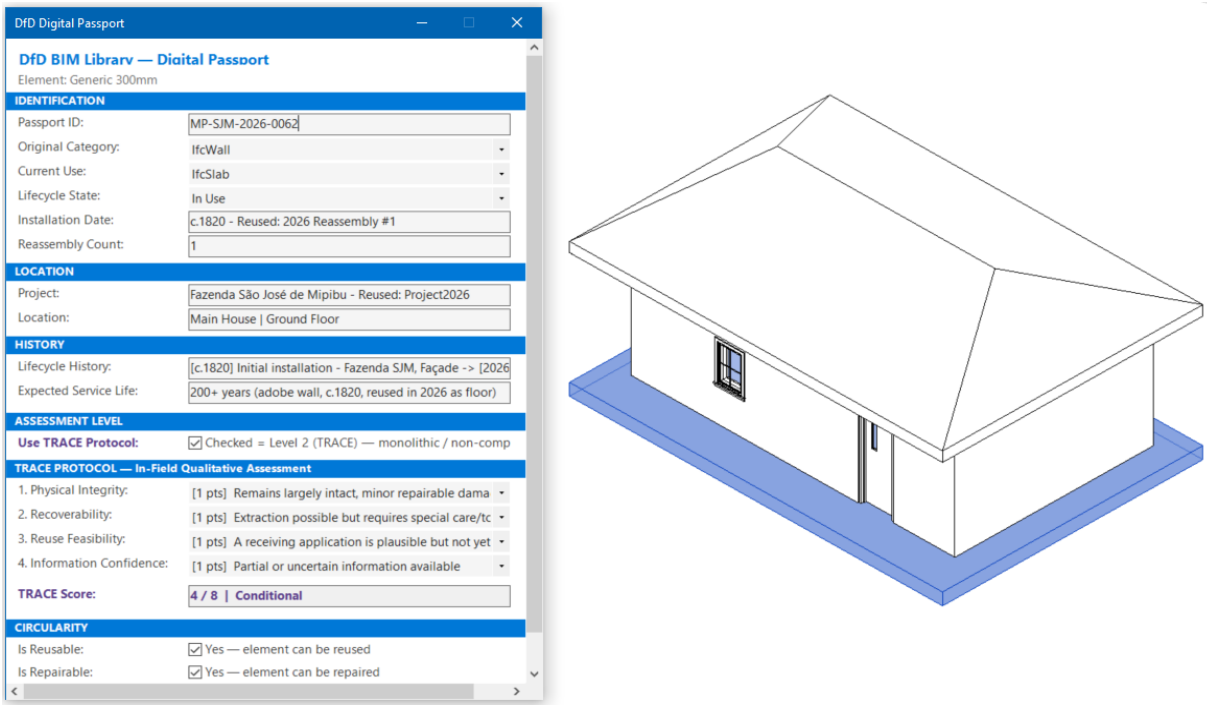


Figure 111 - Imported passport within the destination project. Source: Author.

Taken together, these four steps confirm that the passport functions as intended beyond the boundaries of a single project: its identity and assessment history are additive rather than overwritten, its original IFC category is preserved even when reused under a different one, and the Reassembly Count provides a concrete, incrementing measure of how many times a given element has already been recovered and reinstalled elsewhere.

This chapter has demonstrated the framework's complete workflow against a real, monolithic vernacular building: from historical and architectural documentation, through constructive-layer analysis and BIM model development, to element-by-element assessment, aggregate results, and cross-project passport portability.

5. DISCUSSION

The previous chapter demonstrated that the framework developed in this dissertation works: it produced differentiated, traceable assessment results for 80 real elements of a monolithic, pre-industrial building, and showed that those results survive intact when an element moves between projects. This chapter turns from demonstrating the framework to interpreting what that demonstration means. It begins by returning explicitly to the research questions set out in Chapter 1, showing how the evidence assembled across Chapters 2 to 4 answers each of them, before considering how the framework might be applied beyond this single case, how it compares to conventional procurement and assessment flows, and what the Fazenda Ribeiro case specifically contributes to the wider argument for treating existing, non-standard building fabric as a legitimate object of Design for Disassembly and Reuse thinking.

The chapter then situates the framework against the regulatory context introduced in Chapter 1, considering how closely its structure aligns with the information requirements of the EU DPP, before stepping back to reflect critically on the two-level approach itself, where it holds up, and where its assumptions are more fragile than the results in Chapter 4 might suggest on first reading. It closes by setting out the limitations of the work as a whole, distinct from the case-study-specific caveats already noted at the end of Chapter 4, which concern the framework's scope and generalisability rather than the execution of this particular application.

5.1. Answer to the research question and sub-questions

This dissertation set out to investigate how the reuse potential of existing building elements can be assessed in a consistent and operational way. The response developed in this research is the two-level assessment framework introduced in Chapter 2 and later implemented through the Revit plugin described in Chapter 3. Rather than remaining as a theoretical scoring method, the framework was applied directly to the case study and used to assess doors, windows, roof components, walls, columns, floors, and stairs. Its consistency lies in the use of the same assessment logic across different element categories, instead of adapting the method on a case-by-case basis for each material. Chapter 4 shows how this worked in practice: 80 elements at Fazenda Ribeiro were surveyed in situ using standardised field sheets, transferred to the digital workflow through the plugin, and later aggregated into the results dashboard. In this way, the assessment process could be followed from the initial field observation to a structured digital output.

A second, more specific question concerned elements that do not fit conventional component-based Design for Disassembly frameworks. Monolithic and irregular elements, in particular, cannot be meaningfully assessed through criteria based on discrete and reversible connections. The Level 2 TRACE Protocol was developed in Chapter 2 to address this limitation through four criteria that can be evaluated directly in the field: Physical Integrity, Recoverability, Reuse Feasibility, and Information Confidence. In the Fazenda Ribeiro case study, 38 of the 80 assessed elements fell into this category, including adobe walls, columns, floors, and stairs. These elements could not have been

meaningfully evaluated through a connection-based approach such as Durmisevic's, but they were not therefore excluded from the assessment. Instead, the TRACE results produced different outcomes depending on their condition and recovery potential, including Conditional and End of Life classifications. This suggests that monolithic construction can be assessed according to its own physical characteristics, rather than being forced into a framework originally developed for discrete building components.

The third question addressed what happens to the assessment information after it has been produced. For reuse information to remain useful, it must be structured in a way that allows it to be preserved and transferred beyond the project in which it was first recorded. This was addressed through the Pset_DfD_LifeCycle schema and the plugin functions developed in Chapter 3. Setup DfD Params attaches the required parameters to a family or category, Write Passport records the assessment information, and Export Passport makes this information available as structured, IFC-compatible data. Chapter 4 demonstrates this continuity through the transfer of a passport from Fazenda Ribeiro into a separate destination project. The Passport ID was retained, the Reassembly Count was updated, and the Lifecycle History was extended rather than replaced. The resulting record therefore functions as an evolving lifecycle history rather than as a one-time export.

A further issue running through these questions is what information is actually needed to support a credible reuse decision. Describing the present condition of an element is not necessarily enough to determine whether it can or should be reused. This distinction is reflected directly in the Level 2 criteria. Following Lambec et al. (2025), who identify the predominantly descriptive nature of many existing assessment procedures, the TRACE Protocol includes Recoverability and Reuse Feasibility alongside Physical Integrity and Information Confidence. The assessment therefore considers not only the current state of an element, but also whether it can realistically be extracted and whether a plausible second use exists. The results from Fazenda Ribeiro show the importance of this distinction. Some elements retained a reasonable degree of physical integrity but were still classified as End of Life because their recoverability or reuse feasibility was limited. A condition-based assessment alone would not have captured this difference.

5.2. Post-assessment Reuse Pathways

The assessment framework developed in this dissertation does not assign a fixed destination to an element. It establishes its reuse potential at the time of assessment. What follows depends on factors that sit outside the scoring procedure itself, such as whether a receiving project exists, whether the element can be stored, whether repair or processing is needed, and whether transport and handling remain viable.

Reuse potential and actual reuse should therefore be treated as separate questions. The Disassembly Score and the TRACE score indicate what an element may support based on the conditions observed during assessment, but they do not determine what will happen afterwards. A component with a high Disassembly Score may remain in storage for a long period if no compatible receiving project is available. On the other hand, a damaged timber element that is no longer suitable for its original use may still retain value if it can be cut, reprocessed, and used elsewhere. The same applies to monolithic materials assessed under Level 2. An element may not be recoverable as a complete unit, but part of its

material may still be retained through selective dismantling, cleaning, separation, or reforming. This is one of the situations addressed by the TRACE Protocol's Recoverability criterion.

Figure 112 separates the assessment result from the decisions that follow it. Direct Reuse, Conditional, and End of Life are treated here as starting points rather than fixed destinations. Direct Reuse may lead directly to reinstallation, but it may also involve temporary storage while a suitable receptor is found. Conditional elements may require repair, cleaning, resizing, or transformation before a second use becomes possible. Even where reuse is no longer viable, some material value may still be retained through recycling or other recovery routes before disposal becomes the final option.

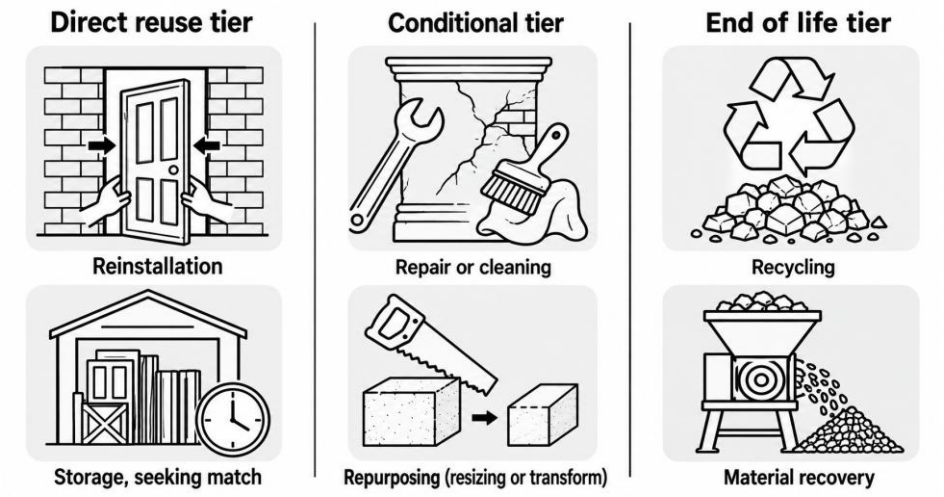


Figure 112 - General post-assessment routes by tier. Source: Author.

The same assessment class can therefore lead to different outcomes. Availability of a receiving project, timing, storage capacity, transport distance, required processing, and market demand may all influence what happens next. Figures 115 and 116 illustrate two possible cases. They are not predictions, and no probability is attached to either pathway. Their purpose is simply to show how similar assessment results may lead to different decisions once project-specific conditions are considered.

A component classified under Direct Reuse, for example, may be dismantled and stored rather than installed immediately if no suitable project is available at the time. It may only return to use once a compatible demand appears (Figure 113).

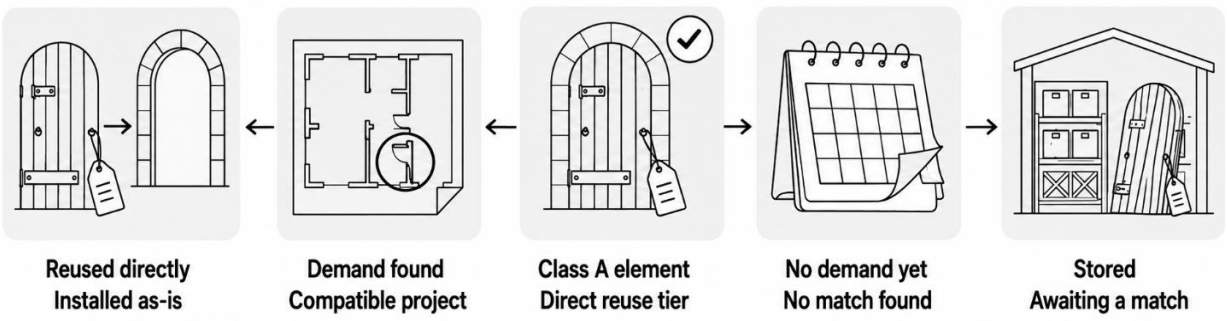


Figure 113 - Demand-contingent destination branch (storage vs immediate). Source: Author.

In another case, an element may no longer be suitable for its original function but still provide usable material. A timber door that cannot be reused as a door, for example, may still be cut into smaller sections and used for flooring, lining, or repair work elsewhere. In this case, the component itself is not retained, but part of its material remains in use (Figure 114).

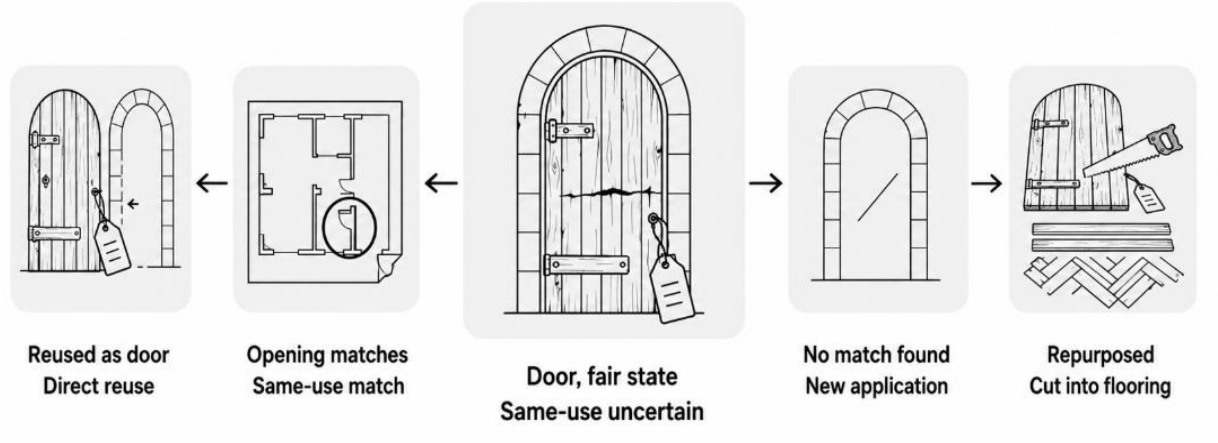


Figure 114 - Same-use reuse versus adaptive repurposing branch (door into flooring). Source: Author.

These pathways also help define the limits of the framework. The assessment records reuse potential from the evidence available at a particular moment, but it cannot determine whether a buyer, receiving project, storage facility, or processing route will actually exist later. Those conditions influence the final outcome, but they belong to a later stage of the reuse process, one the framework was never designed to model or predict. The assessment should therefore be understood as one decision point within a broader sequence, rather than as a score that automatically determines what happens to the element next. This distinction becomes particularly relevant when the framework's outputs are used to support planning or investment decisions, where the temptation to treat a high score as a guarantee of reuse is strongest.

5.3. Application scenarios: hypotheses for element pathways

The results in Chapter 4 measured reuse potential; they did not execute any reuse. This section proposes, for each of the three reuse-potential tiers that emerged from the Fazenda Ribeiro dataset, a concrete hypothesis for what happens after assessment, grounded in specific elements already examined earlier in this dissertation rather than in generic categories.

Door MP-SJM-2026-0002, Class B under Direct Reuse, illustrates the most straightforward pathway. Its bolted hinge connection allows it to be removed as a whole, intact component; its digital passport, already shown in Section 4.6 to survive transfer into an unrelated project with its identity and history preserved, travels with it; and it is reinstalled directly in a compatible opening elsewhere, without reprocessing. Figure 115 sets out this sequence. This pathway represents the least disruptive form of reuse, since the element retains both its physical integrity and its recorded identity throughout the transfer. It therefore provides the clearest example of how assessment can lead directly to a practical second-life scenario.

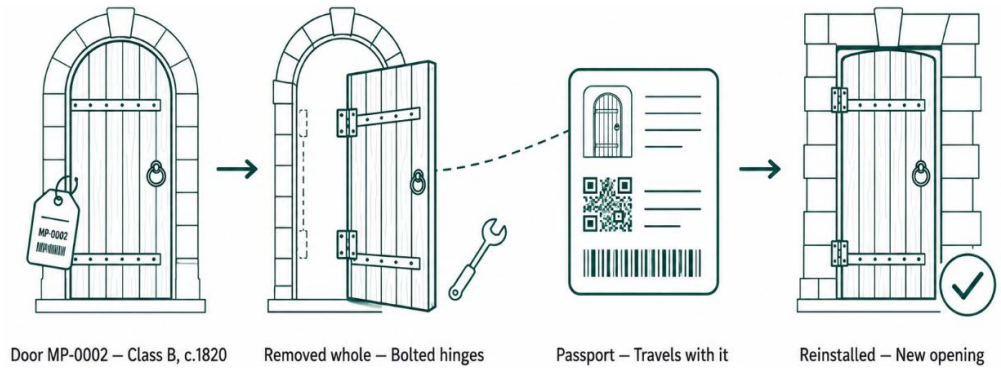


Figure 115 - Hypothetical direct reuse pathway for door MP-SJM-2026-0002. Source: Author.

Wall MP-SJM-2026-0062, Conditional at 4/8, follows a different logic entirely. Its adobe construction offers no discrete component to lift out; recovery instead means careful, manual dismantling of the wall section, yielding adobe blocks or earthen fragments rather than a reusable wall. The TRACE Protocol's own Reuse Feasibility criterion already flags this pathway as plausible but unconfirmed, since no specific receiving project exists yet, only a generic compatible use, such as repair material for another earthen structure, once the recovered fragments are reformed, that is, reconsolidated or remolded into new blocks. Figure 116 sets out this sequence.

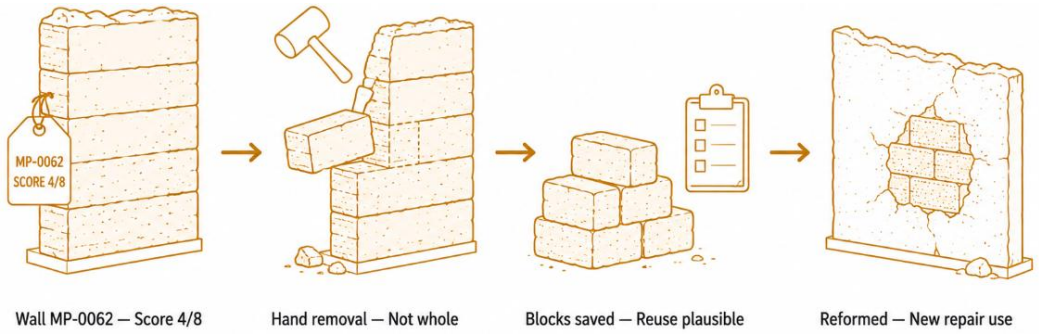


Figure 116 - Hypothetical conditional pathway for wall MP-SJM-2026-0062. Source: Author.

Stair MP-SJM-2026-0095, End of Life at 3/8, represents the pathway with the least available options. Its Recoverability score of 0 reflects that extraction is expected to be destructive, leaving no intact material to recover and no plausible receiving use for it as a component or as salvaged material stock. The most realistic pathway is therefore not reuse at all, but downcycling, the material crushed into aggregate or fill for an unrelated application. Figure 117 sets out this sequence.

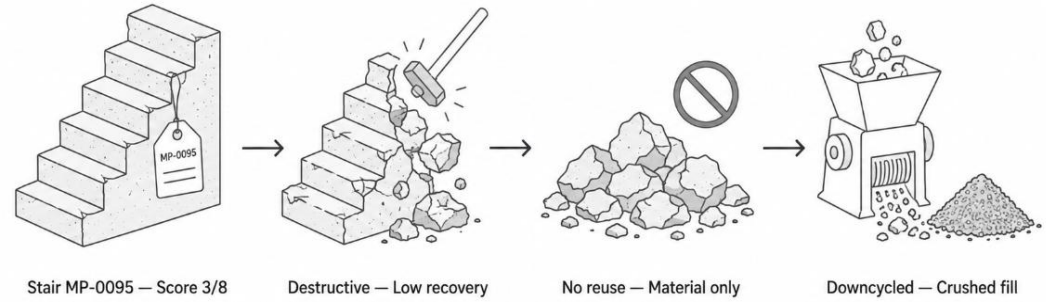


Figure 117 - Hypothetical end-of-life pathway for stair MP-SJM-2026-0095. Source: Author.

Read together, these three pathways show that the framework's three-tier classification is not only a scoring output but a decision structure: it points to a materially different recovery strategy, direct component reuse, material recycling, or downcycling, for each tier, rather than treating "reuse potential" as a single undifferentiated outcome.

5.4. Comparative flows: conventional vs DfADR reuse

Conventional construction procurement follows a largely linear process. A product is specified, manufactured or sourced, transported to site, and installed. Once in use, however, the information associated with that product rarely remains connected to it in a form that is useful at the end of the building's life. Supplier certificates, warranties, datasheets, and other documentation usually relate to the original transaction and are seldom available when the element is later removed during refurbishment or demolition. At that stage, the element is rarely reassessed against the criteria that originally justified its use. In most cases, it is simply removed and discarded. This absence of a structured decision point before demolition is one of the central problems identified in Chapter 1: many elements are not rejected for reuse after assessment; they are never assessed for reuse in the first place.

The DfADR pathway developed in this dissertation introduces such a decision point without changing the way the original building was designed or procured. It starts with an existing element and evaluates it in place using either the Level 1 or Level 2 assessment, depending on its construction logic. The resulting information is then recorded in a digital passport. As demonstrated in Section 4.6, this record can remain associated with the element as it moves between projects, preserving its identity, assessment data, and lifecycle history. The next step depends on the outcome of the assessment: an element may be reused directly, recovered and processed for another application, or ultimately directed to end of life. The important difference is that this outcome is based on an explicit and documented assessment rather than occurring by default.

The main difference between the two flows is therefore not simply what happens to the material, but how information is handled throughout the process. Conventional procurement generates detailed information when an element enters a project, but much of this information is lost by the time the element reaches the end of its first use. The DfADR pathway introduces new information at that later stage, when the physical condition, recoverability, and potential second use of the element can actually be evaluated. That information can then accompany the element into its next stage. Figure 118 shows the conventional flow on its own, from specification through to demolition.

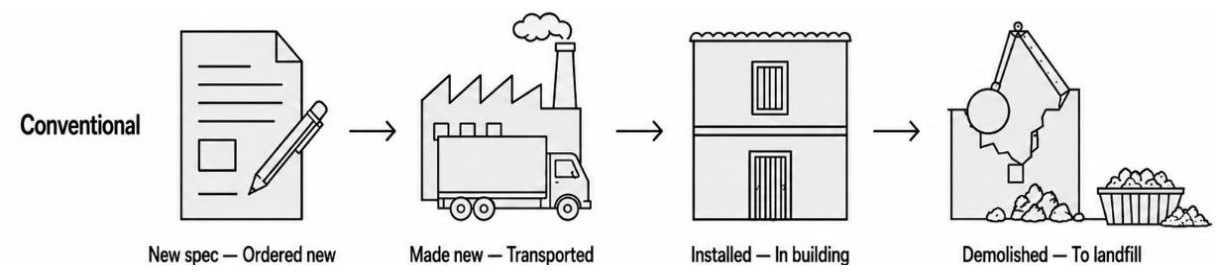


Figure 118 - Conventional procurement flow. Source: Author.

Figure 119 shows the DfADR pathway that this dissertation introduces in its place, from the same point in a building's life, an existing element already in use, through to its recovery.

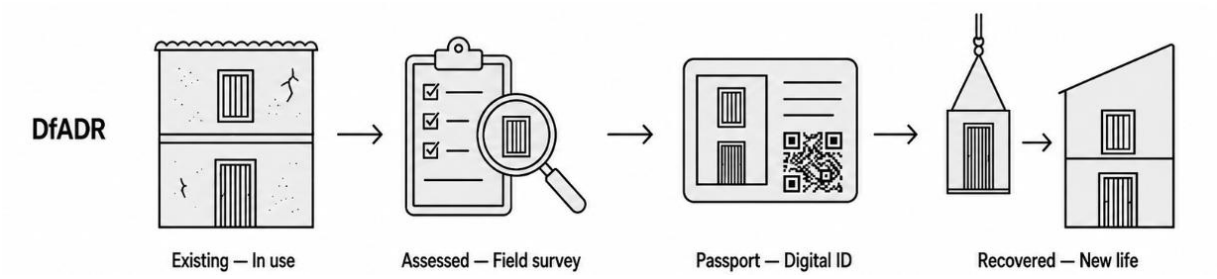


Figure 119 - DfADR reuse pathway. Source: Author.

The Fazenda Ribeiro case study makes this difference more tangible. The 42 elements classified as Direct Reuse in Chapter 4 would not necessarily have been identified as reusable under a conventional demolition process. Without a specific assessment step, they could simply have followed the linear route shown in the upper part of Figure 116, regardless of their actual condition or reuse potential.

5.5. The colonial case as DfADR argument

Fazenda Ribeiro was selected as the case study because it provided a demanding context in which to test the framework. A modern building composed largely of steel connections, dry-fixed panels, and standardised fasteners would have allowed the Level 1 criteria to address most of the elements, while leaving the Level 2 assessment comparatively underused. The farmhouse, by contrast, dates from approximately 1820 and includes a substantial proportion of elements that do not follow a discrete component logic. Of the 80 elements assessed, 38 consisted of adobe walls, columns, floors, and stairs that could not be evaluated meaningfully through reversible connections alone. This made it possible to test one of the framework's central claims directly: that reuse potential can still be assessed where conventional Design for Disassembly criteria are not applicable.

The case study also reflects the type of building that remains poorly served by the current regulatory and methodological landscape. As discussed in Section 1.7, exclusions and limitations within the Construction Products Regulation (CPR) concerning heritage materials, locally specific construction techniques, and certain reused elements overlap closely with the types of construction found at Fazenda Ribeiro. Its adobe walls, traditional masonry, and hand-laid roof tiles do not fit easily within the standardised component logic assumed by many existing DfD and passport approaches. For this reason, the case study does more than provide a setting in which to apply the framework. It tests the proposed method against a category of existing building that is particularly difficult to address using current assessment tools.

The case also helps explain the use of DfADR terminology throughout this dissertation. Disassembly alone is not sufficient to describe what happens to many of the building's monolithic elements. An adobe wall, for example, has no reversible joint that can be evaluated through Connection Type or Connection Accessibility. Applying those criteria would therefore say very little about whether its material could still have value after selective demolition. The Level 2 assessment addresses this problem through Physical Integrity, Recoverability, Reuse Feasibility, and Information Confidence. In

Chapter 4, this allowed many monolithic elements to receive a Conditional recommendation even though they could not be assessed through conventional disassembly logic. In these cases, the possibility of reuse depends less on taking an element apart intact and more on whether material can be recovered and adapted to another application.

Fazenda Ribeiro therefore plays several roles within the dissertation. It provides a challenging technical test for the two-level framework, represents the type of existing construction that current regulatory and assessment approaches address only partially, and demonstrates why a broader DfADR perspective is needed alongside conventional Design for Disassembly.

5.6. Alignment with the EU digital product passport

Any comparison between the passport structure developed in this dissertation and the EU DPP needs to be made with some caution. The Construction Products Regulation establishes the basis for a construction-specific DPP, but the detailed technical fields have not yet been defined through a delegated act. There is therefore no complete construction-product data structure against which the framework developed here can be tested for compliance. The comparison made in this section is instead based on the broader principles already established under the ESPR and expected to inform the CPR passport once its technical requirements are defined.

Several of those principles are already reflected in the framework developed in this research. First, each assessed element is given a unique identifier through the DfD_MaterialPassportID parameter. As demonstrated in Chapter 4, this identifier remains associated with the element when it is transferred between projects. Second, the information is not intended to remain confined to a single software environment. The use of Pset_DfD_LifeCycle and IFC-compatible data structures allows assessment and lifecycle information to be carried beyond the original Revit model. Third, the passport is designed as an evolving record rather than a one-time export. The Lifecycle History and Reassembly Count fields retain previous events and are updated when the element enters another stage of its lifecycle, as shown in Section 4.6.

The comparison becomes less direct when the scope of the CPR is considered. As discussed in Section 1.7, heritage materials, locally specific construction techniques, and certain elements that are directly reused without being placed back on the market do not fall neatly within the regulation's intended application. Many of the elements assessed at Fazenda Ribeiro, including adobe walls, traditional roof tiles, and timber construction, belong to precisely this type of existing building fabric. The framework proposed in this dissertation should therefore not be presented as an implementation of the CPR DPP. Rather, it applies similar principles of identification, interoperability, and lifecycle continuity to elements that current product-oriented regulation does not yet fully address.

The relationship is therefore one of structural alignment rather than regulatory compliance. The framework already incorporates mechanisms that are consistent with the general direction of the DPP: persistent identification, interoperable information exchange, and the accumulation of lifecycle data over time. If future construction-product requirements are extended more clearly to reused or heritage elements, these mechanisms would provide a useful basis for adaptation. The present work does not claim that the framework already satisfies a future CPR passport specification, only that its

information structure has been developed in a way that is compatible with several of the principles on which that specification is expected to build.

5.7. Critical reflection on the two-level framework

The two-level structure is the framework's main methodological choice, but it is also one of its main limitations. Whether an element is assessed under Level 1 or Level 2 depends on how it is interpreted in the field. In clear cases, such as a hinged door or an adobe wall, the decision is straightforward. The difficulty appears with elements that sit somewhere between these two conditions. A masonry unit fixed in mortar, for example, may be physically separable, but only with considerable effort and possible damage. In such cases, different assessors could reasonably make different routing decisions. At present, the framework does not provide a formal test for resolving this type of ambiguity.

A second issue is that the two levels do not operate on the same measurement scale. The Level 1 Disassembly Score is calculated as a harmonic mean of four criteria ranging from 0.00 to 1.00, while the TRACE score is obtained by summing four qualitative criteria scored from 0 to 2. Both are later grouped into the same three reuse-potential categories, Direct Reuse, Conditional, and End of Life, mainly to allow the results to be presented together. This does not mean, however, that the two scores are directly comparable. A Class B door and a wall with a TRACE score of 4/8 reach similar reporting categories through different assessment logics.

The case study also revealed a limitation in the fixed vocabulary used for Level 1 scoring. The predefined Connection Type categories were introduced to improve consistency, but they do not cover every condition found in existing buildings. The loose-laid roof tiles at Fazenda Ribeiro are one example. They are held in place by overlap and gravity, without a mechanical fixing, adhesive bond, or monolithic connection. Because no exact category existed, the condition had to be matched to the closest available option. This illustrates the trade-off involved in using a closed vocabulary: it improves consistency, but unusual construction details may not always fit it neatly.

Another limitation concerns the type of validation achieved in this research. Chapter 4 showed that the framework can be applied to real elements, can produce differentiated results, and can preserve passport information when an element moves between projects. It did not, however, test whether the scores predict what actually happens to those elements later. The dissertation does not demonstrate, for example, that an element classified as Direct Reuse is more likely to be reused in practice. Establishing that relationship would require long-term monitoring across several projects and reuse events. The results should therefore be read as an assessment of reuse potential, rather than as a prediction of future reuse.

The equal weighting of the four criteria in each level is another simplifying assumption. The framework treats the criteria as having the same influence on the final result, but this weighting was not derived from empirical evidence. It is possible that some criteria have a stronger effect on real reuse outcomes than others. A different weighting system could therefore change the classification of borderline cases without changing the underlying field observations. This sensitivity was not tested in the present study and remains an area for further work.

5.8. Methodological interchangeability

The two-level framework developed in this dissertation can be understood as two different assessment methods operating within the same digital structure. Identification, location, lifecycle history, Reassembly Count, cross-project import and export, and the dashboard's 3D highlighting work in the same way regardless of whether an element is assessed through Level 1 Disassembly Potential or the Level 2 TRACE Protocol. The difference lies in the assessment criteria themselves. Each level introduces its own four criteria, while the passport structure around them remains unchanged. In this sense, the passport is not tied to one particular scoring method; it provides a common structure into which different assessment methods can be incorporated.

This becomes relevant when considering the wider range of disassembly assessment methods documented in the literature. Attia et al. (2024) show that the field includes several different approaches, from Durmisevic's (2006) Transformation Capacity model and Akinade et al.'s (2015) BIM-based deconstructability scoring to later methods developed by Verberne, Van Vliet and Denis, Akanbi et al., the Dutch GDBC framework, ISO 20887:2020, ISSO 110250, and CEN-TC 350. Figure 120 illustrates this development chronologically, showing how disassembly assessment methods have evolved over time without converging on a single set of criteria or a common scoring scale. This fragmentation was already identified in Chapter 1 and creates a practical problem for any digital passport structure that is built around only one specific method.

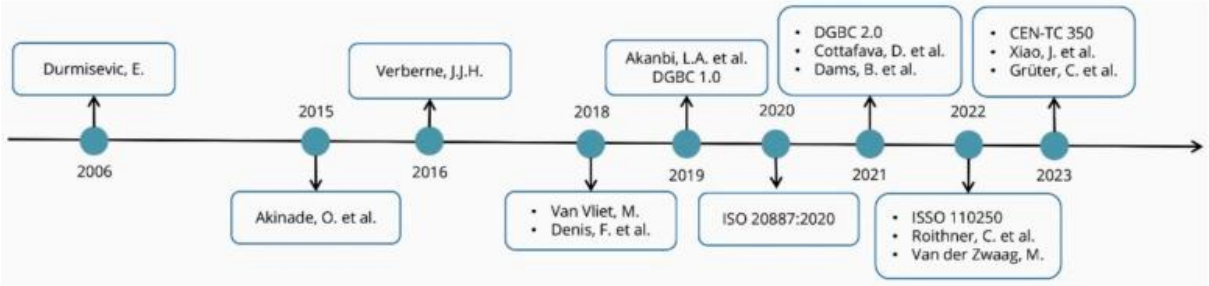


Figure 120 - Evolution of disassembly assessment methods. Source: Attia et al. (2024).

The framework proposed here was designed to avoid that dependency. In principle, a different assessment method could replace the current Level 1 or Level 2 criteria without changing the passport's identification, history, or transfer mechanisms. The assessment-related parameters within Pset_DfD_LifeCycle would need to be adapted, but the broader structure used to identify the element, record lifecycle events, preserve its history, and move the passport between projects would remain the same. The two methods implemented in this dissertation provide an initial demonstration of that separation between assessment logic and passport infrastructure.

This should not, however, be interpreted as a fully validated claim of interchangeability. Chapter 4 demonstrated that Disassembly Potential and TRACE can operate within the same infrastructure without requiring separate passport systems. It did not test a third external method, such as ISO 20887:2020 or an industry-specific assessment scheme. The possibility of replacing one scoring method with another is therefore supported by the architecture of the framework, but it was not independently tested beyond the two methods implemented in this research.

5.9. Limitations

Six broader limitations apply to this dissertation, in addition to the case-study-specific observations discussed at the end of Chapter 4 and the methodological issues raised in Sections 5.7 and 5.8.

First, the framework was tested on only one building, representing one constructive context and one climatic condition. Fazenda Ribeiro provided a useful case for testing monolithic vernacular construction, particularly adobe and rammed earth, but these materials represent only part of a much wider range of traditional building systems. Rubble stone, cob, unfired brick, timber-frame infill, and other forms of vernacular construction behave differently and may present different challenges for recovery and reuse. The results obtained in Chapter 4 therefore cannot be assumed to apply directly to all monolithic or irregular construction. A hot, humid climate also shapes decay patterns in ways a temperate or arid context would not, further narrowing how far these specific results can travel. Further testing on materially and geographically different case studies would be needed to evaluate how well the TRACE Protocol performs beyond the context examined here.

A second limitation concerns the software environment in which the framework was implemented. The main workflow validated in Chapter 4 relies on Autodesk Revit and a custom C# plugin. In its current form, this means that the framework cannot be applied in exactly the same way by practitioners working outside the Revit environment. The underlying Pset_DfD_LifeCycle structure is intended to remain compatible with IFC-based exchange, and Pathway A demonstrated that a more open workflow is technically possible. However, that pathway was developed as a proof of concept in Chapter 3 and does not yet offer the same level of usability or integration as the Revit plugin.

A related limitation concerns the standing of the Pset_DfD_LifeCycle schema itself within the wider BIM ecosystem. The property set developed in this dissertation is IFC-compatible in the sense that it exports and reads correctly as a custom property set within an IFC file, but it has not been submitted to, or recognised by, buildingSMART's own data dictionary (bSDD) or any other formal standardisation body. This distinguishes it from an officially registered IFC property set, whose definitions are guaranteed to be interpreted consistently across compliant software from different vendors. In its current form, another BIM authoring tool could read the raw parameter values Pset_DfD_LifeCycle carries, but nothing guarantees it would interpret them, or expose them to a user, in the way this dissertation's own plugin does. Formal registration of the schema, or its alignment with an existing bSDD property set where one becomes available, would be a natural precondition for the kind of cross-platform, long-term interoperability a genuine DPP is expected to sustain.

All 80 field assessments in Chapter 4 were also carried out by a single assessor. No inter-rater reliability test was included to determine whether another assessor applying the same criteria to the same elements would produce similar results. This is particularly relevant where scoring depends on visual interpretation or where field information remains incomplete, exactly the situation already flagged for several of the photograph-based door and window assessments in Section 4.4. Although the use of predefined categories was intended to reduce variation, the extent to which the framework produces consistent results across different assessors has not yet been tested.

The TRACE Protocol introduces a further limitation because it is itself a new methodological proposal. Its four criteria and 0-2 scoring system were developed in response to the gap identified in the literature, but they have not yet been externally calibrated. The protocol was not compared directly with another assessment method applied to the same elements, nor was it evaluated through an industry panel or a wider group of experts. Its current validity therefore rests on the literature review, the methodological reasoning developed in Chapter 2, and its application in the Fazenda Ribeiro case study. Further comparative testing would be needed to strengthen that validation.

Finally, the passport portability demonstrated in Section 4.6 was tested digitally rather than through an actual reuse process. No element was physically removed from Fazenda Ribeiro, stored, transported, and installed in another project. Instead, the test demonstrated that the passport information could be transferred into another Revit project while preserving its identity and lifecycle record. This confirms the digital continuity of the proposed structure, but not its performance over a real reuse cycle. Longer-term questions, such as how the passport would perform across several reuse events, software changes, or future IFC versions, remain outside the evidence produced in this dissertation.

6. CONCLUSIONS

This dissertation began from a clear gap in the way reuse is currently addressed in the construction sector. Existing methods provide a relatively established basis for assessing the disassembly potential of discrete, component-based construction, but they are much less suited to monolithic and irregular fabric such as adobe, rammed earth, rubble stone, and similar materials that were never assembled from separable parts. At the same time, even when an element can be assessed, there is often no reliable way to keep that information associated with it once it is removed, transferred, or considered for another use. These two issues, assessment and information continuity, are particularly relevant for older buildings that are often poorly documented in the first place.

BIM is central to how this dissertation addresses both problems. The framework does not treat the assessment as a separate report or checklist; the results are written directly into the BIM model as element-level, IFC-compatible parameters. This allows the assessment data to remain linked to the element and to be exported, read, and transferred between projects. The role of BIM is therefore not limited to visualisation or documentation. It provides the structure through which the assessment can remain connected to the element over time.

The framework was implemented as a working BIM plugin and tested on an existing building containing both monolithic and discrete elements. Eighty elements were assessed during the case study, their results were compiled in a public dashboard, and the transfer of a digital passport into an unrelated BIM project was also demonstrated. The transferred record preserved the element's identity, assessment data, and lifecycle history. These results show that reuse potential can be assessed across different forms of construction and that the information produced can remain usable beyond the project in which it was first created.

There are, however, clear limits to what has been demonstrated. The framework was tested on one building, representing one constructive context and one climate, and all assessments were carried out by a single assessor. Its performance across other forms of monolithic construction, different climatic conditions, or independent assessors remains to be tested. The scoring criteria developed in this research have also not yet been benchmarked against other assessment methods. In addition, the passport transfer demonstrated here was virtual rather than physical: no element was followed through an actual process of removal, storage, transport, and reinstallation. The long-term performance of the passport across software changes, evolving IFC standards, and multiple reuse cycles therefore remains outside the scope of the present study.

The contribution of this dissertation is not a claim that every building can now be assessed for reuse. Rather, it shows that BIM-based reuse assessment can be extended to types of construction that are not easily represented by conventional component-based DfD methods. The case study demonstrates that a historic building with extensive monolithic fabric can be modelled, assessed, and given a digital record capable of moving forward with its elements. This provides a practical basis for bringing older and non-standard building fabric into reuse workflows that have so far been developed mainly around modern, componentised construction.

In this sense, the argument returns to an idea that is much older than BIM, material passports, or circular economy policy. From Ovid's observation that everything changes while nothing simply disappears, to the principle of conservation associated with Lavoisier and Drexler's later formulation that "nada se pierde, todo se transforma," the same intuition persists across very different contexts. Applied to the built environment, the important question is not whether materials transform, because they inevitably do, but whether that transformation can occur without their value, identity, and history being lost. The framework developed in this dissertation is one attempt to make that continuity visible and usable.

This has a broader implication for BIM itself, beyond reuse assessment specifically. Most BIM-based circularity work to date has assumed a model built from identifiable, manufactured components, an assumption that a farmhouse built from adobe two centuries ago simply does not meet. That such a building can still be modelled, assessed, and carried forward as structured, exportable BIM data suggests that BIM's usefulness for circularity does not have to end where a building's fabric stops being made of parts. If BIM can hold this kind of information for a building this far outside its usual assumptions, there is little reason to assume it cannot do the same for the much larger stock of existing buildings that sit somewhere between the fully componentised and the fully monolithic.

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APPENDICES

APPENDIX 1: PSET_DFD_LIFECYCLE: FULL PARAMETER TABLE

This is a Revit shared parameter file.

Do not edit manually.

*META VERSION MINVERSION

META 2 1

*GROUP ID NAME

GROUP 1 DfD_ID

GROUP 2 DfD_LifeCycle

GROUP 3 DfD_DisassemblyPotential

GROUP 4 DfD_TRACE

*PARAM GUID NAME DATATYPE DATACATEGORY GROUP VISIBLE DESCRIPTION USERMODIFIABLE HIDEWHENNOVALUE

PARAM 0cd86702-f37d-4f13-b44d-19d5e1e0474a DfD_TRACE_Recoverability INTEGER 4 1 Score, 0 to 2, reflecting the feasibility of extracting the element while preserving reuse potential. 1 0

PARAM 78c86e02-d39d-4ec1-884a-07e2dd8ad83b DfD_GPE_Score NUMBER 3 1 Geometry of Product Edge score, reflecting the geometric interface between the element and adjoining components. 1 0

PARAM b5265306-7fdd-4b8d-81da-0a265e9c7ab7 DfD_InstallationDate TEXT 2 1 The date the element was installed in its current location. 1 0

PARAM bc717c06-837e-4e2e-8d1b-fd701355e76b DfD_CurrentUse TEXT 2 1 A description of how the element is currently being used. 1 0

PARAM 67e5c41a-69a5-4fda-a5d6-1f6dc1d7de2f DfD_IsRepairable YESNO 2 1 Boolean flag indicating whether the element can be repaired. 1 0

PARAM b5f30323-f4de-47da-8aa8-e19e7290c2d6 DfD_ReassemblyCount INTEGER 2 1 The number of times the element has been reassembled into a project. 1 0

PARAM c5ecb039-d04f-4c58-b860-14548b14c007 DfD_LifecycleHistory TEXT 2 1 A chronological log of the element's recorded lifecycle events. 1 0

PARAM 45177161-0cf0-4e1a-bfad-61ac2f82bace DfD_TRACE_InformationConfidence INTEGER 4 1 Score, 0 to 2, reflecting the availability and reliability of information supporting reuse decisions. 1 0

PARAM d019146f-df5f-4d58-98d2-aabc37e40c21 DfD_IsReusable YESNO 2 1 Boolean flag indicating whether the element is considered reusable. 1 0

PARAM a318a06f-e973-4cd0-8b3a-24d379db71c8 DfD_CurrentLocation TEXT 2 1 The physical location of the element at the time of the current record. 1 0

PARAM 79b7a26f-ceab-4508-8e47-15fe2516ff9f DfD_TRACE_Score NUMBER 4 1 Aggregate TRACE score, 0 to 8, summing the four criterion scores. 1 0

PARAM a8a62b78-352b-4e6c-a8e6-8306855e74cf DfD_CurrentProject TEXT 2 1 The project in which the element is currently installed or stored. 1 0

PARAM 08571f82-a224-4f84-a69b-62a4da26e9b1 DfD_OriginalCategory TEXT 1 1 The Revit/IFC category of the element as originally modelled. 1 0

PARAM 6741af83-5390-4a3a-a902-32e8d946bc05 DfD_TRACE_Recommendation TEXT 4 1 The destination classification, Direct Reuse, Conditional, or End of Life, derived from the TRACE score. 1 0

PARAM 81eb3f94-78ca-4232-a186-754b6947654e DfD_ConnectionType TEXT 3 1 A description of the physical connection type used to fix the element. 1 0

PARAM aed90896-4d28-400f-b6e5-a29ffad6191a DfD_DisassemblyScore NUMBER 3 1 Aggregate Disassembly Potential score, calculated from CT, CA, ID, and GPE. 1 0

PARAM 64f498ac-d2be-425e-ad75-d142d9b001a9 DfD_ExpectedServiceLife TEXT 2 1 The anticipated remaining service life of the element. 1 0

PARAM c9e2bdb0-e948-418c-90a0-e9711fb2ea98 DfD_UseTraceProtocol YESNO 1 1 Boolean flag indicating whether the element was routed to Level 2 (TRACE) assessment. 1 0

PARAM 1aef6bb3-5cb6-4b1e-a83a-071df00e0e4c DfD_CT_Score NUMBER 3 1 Connection Type score, reflecting the ease of separating the element's connections. 1 0

PARAM 59bee5bb-e30c-47b2-ba18-bec4d16bd907 DfD_CA_Score NUMBER 3 1 Connection Accessibility score, reflecting how accessible the connections are for disassembly. 1 0

PARAM b55064cb-3f1a-4c54-aeb1-bd3c9dfa3974 DfD_TRACE_PhysicalIntegrity INTEGER 4 1 Score, 0 to 2, reflecting the degree to which the element remains physically intact. 1 0

PARAM 16e751d2-5e3d-4796-98c2-72500dc527b0 DfD_DisassemblyClass TEXT 3 1 The classification, A to E, derived from the Disassembly Potential score. 1 0

PARAM e64f2dda-8a44-4d3c-ac46-bcb041d91813 DfD_ID_Score NUMBER 3 1 Independence score, reflecting the degree to which the element can be removed without affecting other components. 1 0

PARAM 146c30e3-5323-4fbc-bedc-bb3d4a7a1fc1 DfD_LifeCycleState TEXT 2 1 The current stage of the element's lifecycle, such as in use, stored, or reused. 1 0

PARAM 22478de6-ce15-4668-9bf4-0ebae0a301bf DfD_TRACE_ReuseFeasibility INTEGER 4 1 Score, 0 to 2, reflecting the likelihood of a realistic receiving application for the element. 1 0

PARAM ba7698e8-c393-42de-86a2-b67809f2b553 DfD_AssessmentMethod TEXT 1 1 Indicates which protocol, Disassembly Potential or TRACE, was used to assess the element. 1 0

PARAM 8a06d2fd-5c61-4b0e-b037-99ad11488562 DfD_MaterialPassportID TEXT 1 1 Unique identifier for the element's digital material passport. 1 0

APPENDIX 2: FIELD ASSESSMENT SHEETS (TEMPLATES)

Level 1 Field Assessment Sheet

In-situ building survey

1. Survey and Element Identification			
Survey date		**Assessor**	
Building / case study		**Element reference**	
Level / storey		**Room / zone / grid**	
Element category		**Element type / description**	
2. In-situ Physical Information			
Primary material		**Finish / secondary material**	
Approx. dimensions	L: _____ W: _____ H/T: _____	**Units**	☐ mm ☐ cm ☐ m
Current use / function		**Current state**	☐ In use ☐ Unused ☐ Damaged ☐ Other
Visible condition	☐ Good ☐ Fair ☐ Poor	**Visible defects**	
Repairable on visual inspection?	☐ Yes ☐ No ☐ Uncertain	**Reusable on visual inspection?**	☐ Yes ☐ No ☐ Uncertain
3. Level 1 Assessment — Observed Disassembly Conditions			
Connection description			
Connection location			

Criterion	Points to check (tick all that apply)	Score	Field observation / justification
Connection Type (CT)	☐ Fixed with mechanical fasteners (screws, bolts, nails, clips, hinges) ☐ Fixed with wet/adhesive methods (mortar, glue, chemical sealant) ☐ Cast-in-place or monolithically bonded to adjoining material ☐ More than one connection type present	Score: ___ *0.00–1.00*	
Connection Accessibility (CA)	☐ Fixings are exposed and visible ☐ Fixings are concealed behind finishes, render, or other components ☐ Standard hand tools are sufficient to access the connection ☐ Specialised equipment or scaffolding would be required ☐ Accessing the connection would likely damage adjoining finishes	Score: ___ *0.00–1.00*	
Independence (ID)	☐ Element can be removed without dismantling neighbouring elements ☐ Element shares a structural or load path with adjoining components ☐ Removal is sequence-dependent on other elements being removed first	Score: ___ *0.00–1.00*	
Geometry / Product Edge (GPE)	☐ Element is bounded by a discrete frame or opening ☐ Element is fully embedded, with no exposed edge ☐ Extraction would require cutting or breaking adjoining material	Score: ___ *0.00–1.00*	

4. Reuse / Recovery Observations			
Observed recovery constraints		**Possible reuse context**	
Interfaces / adjoining materials		**Other relevant observations (qualitative notes only — no calculated scores)**	

5. Photographic Record	
Photo 1	**Photo 2**
INSERT PHOTOGRAPH HERE	*INSERT PHOTOGRAPH HERE*

Level 2 Field Assessment Sheet

In-situ building survey

1. Survey and Element Identification			
Survey date		**Assessor**	
Building / case study		**Element reference**	
Level / storey		**Room / zone / grid**	
Element category		**Element type / description**	
2. In-situ Physical Information			
Primary material		**Finish / secondary material**	
Approx. dimensions	L: _____ W: _____ H/T: _____	**Units**	☐ mm ☐ cm ☐ m
Current use / function		**Current state**	☐ In use ☐ Unused ☐ Damaged ☐ Other
Visible condition	☐ Good ☐ Fair ☐ Poor	**Visible defects**	
Repairable on visual inspection?	☐ Yes ☐ No ☐ Uncertain	**Reusable on visual inspection?**	☐ Yes ☐ No ☐ Uncertain

3. Level 2 Assessment — In-situ Criteria (TRACE Protocol)			
Criterion	**Points to check (tick all that apply)**	**Score**	**Field observation / justification**
Physical Integrity	☐ Material/element is structurally coherent and intact ☐ Visible cracks, losses, or structural weaknesses are present ☐ Element would likely survive removal without collapse or major loss	Score: ___ *0 / 1 / 2*	

Recoverability	☐ Element/material can be recovered in whole or usable units ☐ Removal is likely to be controlled rather than destructive ☐ Monolithic or composite construction limits clean separation ☐ Fragmentation or material loss is expected during removal	Score: ___ *0/1/2*	
Reuse Feasibility	☐ A plausible reuse route exists for the recovered material ☐ A specific receiving project or use is already confirmed ☐ Recovered material would require processing or treatment before reuse	Score: ___ *0/1/2*	
Information Confidence	☐ Photographic and visual documentation is available ☐ Dimensions and material data are recorded ☐ Material testing or detailed condition survey has been carried out ☐ Further investigation would be needed before a confident classification	Score: ___ *0/1/2*	

4. Reuse / Recovery Observations			
Observed recovery constraints		**Possible reuse context**	
Interfaces / adjoining materials		**Other relevant observations (qualitative notes only — no calculated scores)**	

5. Photographic Record	
Photo 1	**Photo 2**
INSERT PHOTOGRAPH HERE	*INSERT PHOTOGRAPH HERE*

APPENDIX 3: COMPLETE FIELD ASSESSMENT SHEETS

Level 1 Field Assessment Sheet

In-situ building survey

1. Survey and Element Identification			
Survey date	24/06/2026	**Assessor**	Author
Building / case study	Fazenda Ribeiro	**Element reference**	D-01
Level / storey	Ground floor	**Room / zone / grid**	Exterior veranda / façade
Element category	Door	**Element type / description**	Painted timber plank door in arched opening
2. In-situ Physical Information			
Primary material	Timber	**Finish / secondary material**	Blue painted finish; metal hardware
Approx. dimensions	L: 1.45 W: 0.05 H/T: 2.50	**Units**	[ ] mm [ ] cm [X] m
Current use / function	External access / enclosure	**Current state**	[X] In use [ ] Unused [X] Damaged [ ] Other
Visible condition	[ ] Good [X] Fair [ ] Poor	**Visible defects**	Longitudinal cracks and splits; local loss at lower edge; paint wear/flaking; gaps between boards; weathering near base.
Repairable on visual inspection?	[X] Yes [ ] No [ ] Uncertain	**Reusable on visual inspection?**	[X] Yes [ ] No [ ] Uncertain
3. Level 1 Assessment — Observed Disassembly Conditions			
Connection description	Timber door/frame mechanically fixed within rendered adobe wall opening; fixings concealed by frame/render.		
Connection location	Frame perimeter at jambs/head; leaf-to-frame hardware at side jamb.		

Criterion	Points to check (tick all that apply)	Score	Field observation / justification
Connection Type (CT)	**[X] Fixed with mechanical fasteners (screws, bolts, nails, clips, hinges)** [ ] Fixed with wet/adhesive methods (mortar, glue, chemical sealant) [ ] Cast-in-place or monolithically bonded to adjoining material [ ] More than one connection type present	**Score: 0.80** *0.00–1.00*	Timber door connected through mechanical fixing elements, most likely hinges and screws/fasteners. No evidence that the door leaf itself is chemically bonded to the surrounding construction.
Connection Accessibility (CA)	[ ] Fixings are exposed and visible **[X] Fixings are concealed behind finishes, render, or other components** **[X] Standard hand tools are sufficient to access the connection** [ ] Specialised equipment or scaffolding would be required **[X] Accessing the connection would likely damage adjoining finishes**	**Score: 0.60** *0.00–1.00*	Connections appear reachable, although paint layers, ageing and the existing interface with the frame may require additional actions and may cause minor repairable damage during removal.
Independence (ID)	**[X] Element can be removed without dismantling neighbouring elements** [ ] Element shares a structural or load path with adjoining components [ ] Removal is sequence-dependent on other elements being removed first	**Score: 1.00** *0.00–1.00*	The door can reasonably be removed as an individual component without requiring the dismantling of major adjoining building elements.
Geometry / Product Edge (GPE)	**[X] Element is bounded by a discrete frame or opening** [ ] Element is fully embedded, with no exposed edge [ ] Extraction would require cutting or breaking adjoining material	**Score: 0.40** *0.00–1.00*	The component is bounded by the surrounding frame, creating some obstruction, but it is not fully embedded or geometrically inseparable from the building fabric.

4. Reuse / Recovery Observations

Observed recovery	Hidden fixings; risk of damage during extraction; cracked/split	**Possible reuse context**	Heritage repair/restoration or adaptive reuse in a compatible

constraints	timber at lower edge; non-standard opening and geometry.		opening after timber repair and hardware inspection.
Interfaces / adjoining materials	Timber frame; rendered adobe wall; mortar/plaster bedding; metal hardware.	**Other relevant observations (qualitative notes only — no calculated scores)**	Repair splits and damaged lower boards; renew finish as needed. Confirm dimensions, operation and concealed fixings before removal.

5. Photographic Record

Photo 1	**Photo 2**
 *Exterior veranda, door in context*	 *Door, frontal view*
Photo 3	**Photo 4**
 *Detail: paint wear, splits, board gap*	 *Detail: frame/jamb, crack at leaf edge*

Level 1 Field Assessment Sheet

In-situ building survey

1. Survey and Element Identification			
Survey date	24/06/2026	**Assessor**	Author
Building / case study	Fazenda Ribeiro	**Element reference**	D-02
Level / storey	Ground floor	**Room / zone / grid**	Exterior veranda / façade
Element category	Door	**Element type / description**	Painted timber double-leaf door in arched opening
2. In-situ Physical Information			
Primary material	Timber	**Finish / secondary material**	Blue painted finish; metal hardware (sliding bolt latch, lock plate)
Approx. dimensions	L: 1.13 W: 0.05 H/T: 2.50	**Units**	[ ] mm [ ] cm [x] m
Current use / function	External access / enclosure	**Current state**	[X] In use [ ] Unused [X] Damaged [ ] Other
Visible condition	[ ] Good [X] Fair [ ] Poor	**Visible defects**	Surface scratches and paint wear/flaking; minor gaps at leaf meeting stile; corrosion visible on latch and lock plate hardware.
Repairable on visual inspection?	[X] Yes [ ] No [ ] Uncertain	**Reusable on visual inspection?**	[X] Yes [ ] No [ ] Uncertain
3. Level 1 Assessment — Observed Disassembly Conditions			
Connection description	Timber double-leaf door mechanically fixed within rendered wall opening, most likely via hinges at each outer jamb (not visible in available photographs); leaves joined at the central meeting stile by a surface-mounted sliding bolt latch and lock plate.		
Connection location	Frame perimeter at jambs/head (hinges, assumed); central meeting stile (bolt latch and lock plate, both faces photographed).		

Criterion	Points to check (tick all that apply)	Score	Field observation / justification
Connection Type (CT)	**[X] Fixed with mechanical fasteners (screws, bolts, nails, clips, hinges)** [ ] Fixed with wet/adhesive methods (mortar, glue, chemical sealant) [ ] Cast-in-place or monolithically bonded to adjoining material [ ] More than one connection type present	**Score: 0.80** *0.00–1.00*	Consistent with a hinged timber door; surface-mounted bolt latch and lock plate confirm mechanical fixing at the leaf interface. No evidence of chemical bonding. Hinge type/condition not confirmed from available photographs.
Connection Accessibility (CA)	**[X] Fixings are exposed and visible** [ ] Fixings are concealed behind finishes, render, or other components **[X] Standard hand tools are sufficient to access the connection** [ ] Specialised equipment or scaffolding would be required [ ] Accessing the connection would likely damage adjoining finishes	**Score: 0.80** *0.00–1.00*	The bolt latch and lock plate are surface-mounted and fully exposed, more accessible than a concealed fixing. Hinges are assumed present at the jambs but were not visible in the photographed views; this score should be confirmed once the hinge side is inspected directly.
Independence (ID)	**[X] Element can be removed without dismantling neighbouring elements** [ ] Element shares a structural or load path with adjoining components [ ] Removal is sequence-dependent on other elements being removed first	**Score: 1.00** *0.00–1.00*	As a double-leaf door, each leaf (or the pair together) can reasonably be removed as an individual component without requiring the dismantling of adjoining building elements.
Geometry / Product Edge (GPE)	**[X] Element is bounded by a discrete frame or opening** [ ] Element is fully embedded, with no exposed edge [ ] Extraction would require cutting or breaking adjoining material	**Score: 0.40** *0.00–1.00*	The door leaves are bounded by the surrounding arched frame, creating some obstruction, but are not fully embedded or geometrically inseparable from the building fabric.

4. Reuse / Recovery Observations

Observed recovery	Hinge condition and fixing method not confirmed (not	**Possible reuse context**	Heritage repair/restoration or adaptive reuse in a compatible

constraints	visible in available photographs); corroded latch/lock hardware may complicate clean removal; non-standard arched opening geometry.		opening after hardware inspection and timber condition assessment.
Interfaces / adjoining materials	Timber frame; rendered wall; mortar/plaster bedding; metal hardware (latch, lock plate, hinges assumed).	**Other relevant observations (qualitative notes only — no calculated scores)**	Confirm dimensions, hinge type/condition, and exact room/zone location on site before finalising this record. Scores for CT and CA are preliminary, based on photographic evidence only, and should be revisited during direct inspection.

5. Photographic Record

Photo 1	**Photo 2**
	
Door, frontal view	*Exterior wall, door in context*

Level 1 Field Assessment Sheet

In-situ building survey

1. Survey and Element Identification			
Survey date	24/06/2026	**Assessor**	Author
Building / case study	Fazenda Ribeiro	**Element reference**	D-03
Level / storey	Ground floor	**Room / zone / grid**	Exterior veranda / façade
Element category	Door	**Element type / description**	Painted timber plank door in arched opening
2. In-situ Physical Information			
Primary material	Timber	**Finish / secondary material**	Blue painted finish; metal hardware (sliding bolt latch, keyhole plate)
Approx. dimensions	L: 1.45 W: 0.05 H/T: 2.50	**Units**	[ ] mm [ ] cm [x] m
Current use / function	External access / enclosure	**Current state**	[X] In use [ ] Unused [X] Damaged [ ] Other
Visible condition	[ ] Good [X] Fair [ ] Poor	**Visible defects**	Horizontal split/joint across the leaf; paint wear and surface staining; minor gaps between boards; corrosion visible on latch and keyhole hardware.
Repairable on visual inspection?	[X] Yes [ ] No [ ] Uncertain	**Reusable on visual inspection?**	[X] Yes [ ] No [ ] Uncertain
3. Level 1 Assessment — Observed Disassembly Conditions			
Connection description	Timber door mechanically fixed within rendered wall opening, most likely via hinges at the left jamb (not visible in available photographs); a surface-mounted sliding bolt latch and keyhole plate are fitted at mid-height on the right side.		
Connection location	Frame perimeter at jambs/head (hinges, assumed); mid-height at right jamb (latch and keyhole plate).		

Criterion	Points to check (tick all that apply)	Score	Field observation / justification
Connection Type (CT)	**[X] Fixed with mechanical fasteners (screws, bolts, nails, clips, hinges)** [ ] Fixed with wet/adhesive methods (mortar, glue, chemical sealant) [ ] Cast-in-place or monolithically bonded to adjoining material [ ] More than one connection type present	**Score: 0.80** *0.00–1.00*	Consistent with a hinged timber door; surface-mounted latch and keyhole plate confirm mechanical fixing. No evidence of chemical bonding. Hinge type/condition not confirmed from available photographs.
Connection Accessibility (CA)	**[X] Fixings are exposed and visible** [ ] Fixings are concealed behind finishes, render, or other components **[X] Standard hand tools are sufficient to access the connection** [ ] Specialised equipment or scaffolding would be required [ ] Accessing the connection would likely damage adjoining finishes	**Score: 0.60** *0.00–1.00*	The latch and keyhole plate are surface-mounted and exposed. Hinges are assumed present at the opposite jamb but were not visible in the photographed views; this score should be confirmed once the hinge side is inspected directly.
Independence (ID)	**[X] Element can be removed without dismantling neighbouring elements** [ ] Element shares a structural or load path with adjoining components [ ] Removal is sequence-dependent on other elements being removed first	**Score: 1.00** *0.00–1.00*	The door can reasonably be removed as an individual component without requiring the dismantling of adjoining building elements.
Geometry / Product Edge (GPE)	**[X] Element is bounded by a discrete frame or opening** [ ] Element is fully embedded, with no exposed edge [ ] Extraction would require cutting or breaking adjoining material	**Score: 0.40** *0.00–1.00*	The door is bounded by the surrounding arched frame, creating some obstruction, but is not fully embedded or geometrically inseparable from the building fabric.

4. Reuse / Recovery Observations

Observed recovery	Hinge condition and fixing method not confirmed (not	**Possible reuse context**	Heritage repair/restoration or adaptive reuse in a compatible

constraints	visible in available photographs); horizontal split across the leaf; corroded latch/keyhole hardware may complicate clean removal.		opening after hardware inspection and timber condition assessment.
Interfaces / adjoining materials	Timber frame; rendered wall; mortar/plaster bedding; metal hardware (latch, keyhole plate, hinges assumed).	**Other relevant observations (qualitative notes only — no calculated scores)**	Confirm dimensions, hinge type/condition, and exact room/zone location on site before finalising this record. Scores for CT and CA are preliminary, based on photographic evidence only.

5. Photographic Record

Photo 1	**Photo 2**
 *Door, frontal view*	 *Door, oblique view showing frame and latch*

Level 1 Field Assessment Sheet

In-situ building survey

1. Survey and Element Identification			
Survey date	24/06/2026	**Assessor**	Author
Building / case study	Fazenda Ribeiro	**Element reference**	D-04
Level / storey	Ground floor	**Room / zone / grid**	Interior room
Element category	Door	**Element type / description**	Painted timber plank door in arched opening
2. In-situ Physical Information			
Primary material	Timber	**Finish / secondary material**	Blue painted finish; metal hardware
Approx. dimensions	L: 1.40 W: 0.05 H/T: 2.50	**Units**	[ ] mm [ ] cm [X] m
Current use / function	Internal access / enclosure	**Current state**	[X] In use [ ] Unused [X] Damaged [ ] Other
Visible condition	[ ] Good [X] Fair [ ] Poor	**Visible defects**	Horizontal split/joint across the leaf; extensive paint wear and surface staining; visible nail heads and minor surface splits.
Repairable on visual inspection?	[X] Yes [ ] No [ ] Uncertain	**Reusable on visual inspection?**	[X] Yes [ ] No [ ] Uncertain

3. Level 1 Assessment — Observed Disassembly Conditions			
Connection description	Timber door mechanically fixed within a rendered wall opening, most likely via hinges at one jamb (not visible in available photographs).		
Connection location	Frame perimeter at jambs/head (hinges, assumed).		
Criterion	**Points to check (tick all that apply)**	**Score**	**Field observation / justification**
Connection Type (CT)	**[X] Fixed with mechanical fasteners (screws, bolts, nails, clips, hinges)** [ ] Fixed with wet/adhesive methods (mortar,	**Score: 0.80** *0.00–1.00*	Consistent with a hinged timber door. No evidence of chemical bonding. Hinge type/condition not confirmed

	glue, chemical sealant) [ ] Cast-in-place or monolithically bonded to adjoining material [ ] More than one connection type present		from available photographs.
Connection Accessibility (CA)	[ ] Fixings are exposed and visible **[X] Fixings are concealed behind finishes, render, or other components** **[X] Standard hand tools are sufficient to access the connection** [ ] Specialised equipment or scaffolding would be required [ ] Accessing the connection would likely damage adjoining finishes	**Score: 0.60** *0.00–1.00*	No hardware is visible on the photographed face; hinges are assumed concealed at the opposite jamb. This score should be confirmed once the hinge side is inspected directly.
Independence (ID)	**[X] Element can be removed without dismantling neighbouring elements** [ ] Element shares a structural or load path with adjoining components [ ] Removal is sequence-dependent on other elements being removed first	**Score: 1.00** *0.00–1.00*	The door can reasonably be removed as an individual component without requiring the dismantling of adjoining building elements.
Geometry / Product Edge (GPE)	**[X] Element is bounded by a discrete frame or opening** [ ] Element is fully embedded, with no exposed edge [ ] Extraction would require cutting or breaking adjoining material	**Score: 0.40** *0.00–1.00*	The door is bounded by the surrounding arched frame, creating some obstruction, but is not fully embedded or geometrically inseparable from the building fabric.

4. Reuse / Recovery Observations

Observed recovery constraints	Hinge condition and fixing method not confirmed (not visible in available photographs); horizontal split across the leaf.	**Possible reuse context**	Heritage repair/restoration or adaptive reuse in a compatible opening after hardware inspection and timber condition assessment.
Interfaces / adjoining materials	Timber frame; rendered wall; mortar/plaster bedding; metal	**Other relevant observations (qualitative notes only — no**	Confirm length (L) and hinge type/condition on site before finalising this record. CA score is

	hardware (hinges assumed).	**calculated scores)**	preliminary, based on photographic evidence only.

5. Photographic Record



Photo 1 — frontal view



Photo 2 — oblique view

Level 1 Field Assessment Sheet

In-situ building survey

1. Survey and Element Identification			
Survey date	24/06/2026	**Assessor**	Author
Building / case study	Fazenda Ribeiro	**Element reference**	D-05
Level / storey	Ground floor	**Room / zone / grid**	Interior room
Element category	Door	**Element type / description**	Painted timber plank door in arched opening
2. In-situ Physical Information			
Primary material	Timber	**Finish / secondary material**	Blue painted finish
Approx. dimensions	L: 1.13 W: 0.05 H/T: 2.50	**Units**	[ ] mm [ ] cm [X] m
Current use / function	Internal access / enclosure	**Current state**	[X] In use [ ] Unused [X] Damaged [ ] Other
Visible condition	[ ] Good [X] Fair [ ] Poor	**Visible defects**	Horizontal split/joint across the leaf; paint wear and staining; small corrosion spots near the head, possibly from exposed fixings.
Repairable on visual inspection?	[X] Yes [ ] No [ ] Uncertain	**Reusable on visual inspection?**	[X] Yes [ ] No [ ] Uncertain
3. Level 1 Assessment — Observed Disassembly Conditions			
Connection description	Timber door mechanically fixed within a rendered wall opening, most likely via hinges at one jamb (not visible in available photographs).		
Connection location	Frame perimeter at jambs/head (hinges, assumed).		
Criterion	**Points to check (tick all that apply)**	**Score**	**Field observation / justification**
Connection Type (CT)	**[X] Fixed with mechanical fasteners (screws, bolts, nails, clips, hinges)**	**Score: 0.80**	Consistent with a hinged timber door. No evidence of chemical bonding. Hinge type/condition not confirmed

	[ ] Fixed with wet/adhesive methods (mortar, glue, chemical sealant) [ ] Cast-in-place or monolithically bonded to adjoining material [ ] More than one connection type present	*0.00–1.00*	from available photographs.
Connection Accessibility (CA)	[ ] Fixings are exposed and visible **[X] Fixings are concealed behind finishes, render, or other components** **[X] Standard hand tools are sufficient to access the connection** [ ] Specialised equipment or scaffolding would be required [ ] Accessing the connection would likely damage adjoining finishes	**Score: 0.60** *0.00–1.00*	No hardware is visible on the photographed face; hinges are assumed concealed at the opposite jamb. This score should be confirmed once the hinge side is inspected directly.
Independence (ID)	**[X] Element can be removed without dismantling neighbouring elements** [ ] Element shares a structural or load path with adjoining components [ ] Removal is sequence-dependent on other elements being removed first	**Score: 1.00** *0.00–1.00*	The door can reasonably be removed as an individual component without requiring the dismantling of adjoining building elements.
Geometry / Product Edge (GPE)	**[X] Element is bounded by a discrete frame or opening** [ ] Element is fully embedded, with no exposed edge [ ] Extraction would require cutting or breaking adjoining material	**Score: 0.40** *0.00–1.00*	The door is bounded by the surrounding arched frame, creating some obstruction, but is not fully embedded or geometrically inseparable from the building fabric.

4. Reuse / Recovery Observations

Observed recovery constraints	Hinge condition and fixing method not confirmed (not visible in available photographs); horizontal split across the leaf.	**Possible reuse context**	Heritage repair/restoration or adaptive reuse in a compatible opening after hardware inspection and timber condition assessment.
Interfaces / adjoining	Timber frame; rendered wall; mortar/plaster bedding; metal	**Other relevant observations (qualitative**	Confirm length (L), exact room/zone, and hinge

materials	hardware (hinges assumed).	**notes only — no calculated scores)**	type/condition on site before finalising this record. CA score is preliminary, based on photographic evidence only.

5. Photographic Record



Photo 1 — frontal view



Photo 2 — oblique view

Level 1 Field Assessment Sheet

In-situ building survey

1. Survey and Element Identification			
Survey date	24/06/2026	**Assessor**	Author
Building / case study	Fazenda Ribeiro	**Element reference**	D-06
Level / storey	Ground floor	**Room / zone / grid**	Interior room
Element category	Door	**Element type / description**	Painted timber plank door in rectangular opening
2. In-situ Physical Information			
Primary material	Timber	**Finish / secondary material**	Blue painted finish
Approx. dimensions	L: 1.13 W: 0.05 H/T: 2.00	**Units**	[ ] mm [ ] cm [X] m
Current use / function	Internal access / enclosure	**Current state**	[X] In use [ ] Unused [X] Damaged [ ] Other
Visible condition	[ ] Good [X] Fair [ ] Poor	**Visible defects**	Horizontal split/joint across the leaf; paint wear and flaking; surface scratches and staining near the base.
Repairable on visual inspection?	[X] Yes [ ] No [ ] Uncertain	**Reusable on visual inspection?**	[X] Yes [ ] No [ ] Uncertain

3. Level 1 Assessment — Observed Disassembly Conditions			
Connection description	Timber door mechanically fixed within a rendered wall opening, most likely via hinges at one jamb (not visible in available photographs).		
Connection location	Frame perimeter at jambs/head (hinges, assumed).		
Criterion	**Points to check (tick all that apply)**	**Score**	**Field observation / justification**
Connection Type (CT)	**[X] Fixed with mechanical fasteners (screws, bolts, nails, clips, hinges)** [ ] Fixed with wet/adhesive methods (mortar,	**Score: 0.80** *0.00–1.00*	Consistent with a hinged timber door. No evidence of chemical bonding. Hinge type/condition not confirmed

	glue, chemical sealant) [ ] Cast-in-place or monolithically bonded to adjoining material [ ] More than one connection type present		from available photographs.
Connection Accessibility (CA)	[ ] Fixings are exposed and visible **[X] Fixings are concealed behind finishes, render, or other components** **[X] Standard hand tools are sufficient to access the connection** [ ] Specialised equipment or scaffolding would be required [ ] Accessing the connection would likely damage adjoining finishes	**Score: 0.60** *0.00–1.00*	No hardware is visible on the photographed face; hinges are assumed concealed at the opposite jamb. This score should be confirmed once the hinge side is inspected directly.
Independence (ID)	**[X] Element can be removed without dismantling neighbouring elements** [ ] Element shares a structural or load path with adjoining components [ ] Removal is sequence-dependent on other elements being removed first	**Score: 1.00** *0.00–1.00*	The door can reasonably be removed as an individual component without requiring the dismantling of adjoining building elements.
Geometry / Product Edge (GPE)	**[X] Element is bounded by a discrete frame or opening** [ ] Element is fully embedded, with no exposed edge [ ] Extraction would require cutting or breaking adjoining material	**Score: 0.40** *0.00–1.00*	The door is bounded by the surrounding frame, creating some obstruction, but is not fully embedded or geometrically inseparable from the building fabric.

4. Reuse / Recovery Observations

Observed recovery constraints	Hinge condition and fixing method not confirmed (not visible in available photographs); horizontal split across the leaf.	**Possible reuse context**	Heritage repair/restoration or adaptive reuse in a compatible opening after hardware inspection and timber condition assessment.
Interfaces / adjoining materials	Timber frame; rendered wall; mortar/plaster bedding; metal	**Other relevant observations (qualitative notes only — no**	Confirm length (L), exact room/zone, and hinge type/condition on site before

	hardware (hinges assumed).	**calculated scores)**	finalising this record. CA score is preliminary, based on photographic evidence only.

5. Photographic Record



Photo 1 — frontal view



Photo 2 — oblique view

Level 1 Field Assessment Sheet

In-situ building survey

1. Survey and Element Identification			
Survey date	24/06/2026	**Assessor**	Author
Building / case study	Fazenda Ribeiro	**Element reference**	D-07
Level / storey	Ground floor	**Room / zone / grid**	Exterior wall (rear/side, tbc)
Element category	Door	**Element type / description**	Ledged timber door, rectangular opening
2. In-situ Physical Information			
Primary material	Timber	**Finish / secondary material**	Worn teal paint, bare timber exposed
Approx. dimensions	L: 1.13 W: 0.05 H/T: 2.50	**Units**	[ ] mm [ ] cm [X] m
Current use / function	External access / enclosure	**Current state**	[X] In use [ ] Unused [X] Damaged [ ] Other
Visible condition	[ ] Good [ ] Fair [X] Poor	**Visible defects**	Extensive paint loss and weathering; cracked, stained render at lintel; vegetation against leaf base; no hardware visible on photographed face.
Repairable on visual inspection?	[X] Yes [ ] No [ ] Uncertain	**Reusable on visual inspection?**	[ ] Yes [ ] No [X] Uncertain
3. Level 1 Assessment — Observed Disassembly Conditions			
Connection description	Timber ledged door (boards battened by two horizontal ledges), mechanically fixed within a rectangular opening, likely via hinges (not visible).		
Connection location	Frame perimeter at jambs/head (hinges, assumed); horizontal ledges visible on the photographed face.		
Criterion	**Points to check (tick all that apply)**	**Score**	**Field observation / justification**
Connection Type (CT)	**[X] Fixed with mechanical fasteners (screws,**	**Score:**	Consistent with a hinged, nailed ledge-and-board door. No evidence of

	bolts, nails, clips, hinges) [ ] Fixed with wet/adhesive methods (mortar, glue, chemical sealant) [ ] Cast-in-place or monolithically bonded to adjoining material [ ] More than one connection type present	**0.80** *0.00–1.00*	chemical bonding; hinge condition unconfirmed.
Connection Accessibility (CA)	[ ] Fixings are exposed and visible **[X] Fixings are concealed behind finishes, render, or other components** **[X] Standard hand tools are sufficient to access the connection** [ ] Specialised equipment or scaffolding would be required [ ] Accessing the connection would likely damage adjoining finishes	**Score: 0.60** *0.00–1.00*	No leaf-to-frame hardware (handle, lock, or bolt) is visible; hinges are assumed concealed at the opposite jamb. Advanced paint loss may complicate clean removal.
Independence (ID)	**[X] Element can be removed without dismantling neighbouring elements** [ ] Element shares a structural or load path with adjoining components [ ] Removal is sequence-dependent on other elements being removed first	**Score: 1.00** *0.00–1.00*	The door can reasonably be removed as an individual component without requiring the dismantling of adjoining building elements.
Geometry / Product Edge (GPE)	**[X] Element is bounded by a discrete frame or opening** [ ] Element is fully embedded, with no exposed edge [ ] Extraction would require cutting or breaking adjoining material	**Score: 0.40** *0.00–1.00*	The door is bounded by the surrounding frame, creating some obstruction, but is not fully embedded or geometrically inseparable from the building fabric.

4. Reuse / Recovery Observations

Observed recovery constraints	Hinge condition and fixing method not confirmed; advanced surface weathering; vegetation in direct contact with the leaf base, with possible moisture	**Possible reuse context**	Reuse feasibility uncertain given advanced weathering; salvage of sound upper boards or ledge/batten hardware may be more realistic than reuse of the

	damage to the lower boards.		whole leaf.
Interfaces / adjoining materials	Timber frame; rendered wall; mortar/plaster bedding; metal hardware (hinges assumed); adjoining vegetation.	**Other relevant observations (qualitative notes only — no calculated scores)**	Confirm length (L), exact room/zone, and hinge condition on site. Inspect lower boards for rot given vegetation contact. CA score is preliminary, from photographs only.

5. Photographic Record



Photo 1 — frontal view, in context



Photo 2 — detail, ledges and weathering

Level 1 Field Assessment Sheet

In-situ building survey

1. Survey and Element Identification			
Survey date	24/06/2026	**Assessor**	Author
Building / case study	Fazenda Ribeiro	**Element reference**	RF-01
Level / storey	Roof	**Room / zone / grid**	Veranda roof (later construction, c. 20 years old)
Element category	Roof — Timber framing	**Element type / description**	Timber roof framing (rafters, purlins, and a lattice of thin battens) supporting the tile covering

2. In-situ Physical Information			
Primary material	Timber	**Finish / secondary material**	Unfinished / natural timber, exposed underside
Approx. dimensions	Not applicable (system assessed collectively, not as a single discrete unit)	**Units**	[ ] mm [ ] cm [X] m
Current use / function	Structural support for roof tile covering	**Current state**	[X] In use [ ] Unused [ ] Damaged [X] Other
Visible condition	[X] Good [ ] Fair [ ] Poor	**Visible defects**	Minor surface staining and biological growth on some battens; otherwise sound, consistent with more recent construction.
Repairable on visual inspection?	[X] Yes [ ] No [ ] Uncertain	**Reusable on visual inspection?**	[X] Yes [ ] No [ ] Uncertain

3. Level 1 Assessment — Observed Disassembly Conditions	
Connection description	Timber members nailed and jointed, bearing on wall plate and posts; no chemical or monolithic bonding.

Connection location	Joints between rafters, purlins, and battens; bearing points at wall plate and posts, visible from beneath.		
Criterion	**Points to check (tick all that apply)**	**Score**	**Field observation / justification**
Connection Type (CT)	**[X] Fixed with mechanical fasteners (screws, bolts, nails, clips, hinges)** [ ] Fixed with wet/adhesive methods (mortar, glue, chemical sealant) [ ] Cast-in-place or monolithically bonded to adjoining material [ ] More than one connection type present	**Score: 0.50** *0.00–1.00*	Timber members are nailed and jointed; no chemical bonding. A fully mechanical carpentry connection.
Connection Accessibility (CA)	**[X] Fixings are exposed and visible** [ ] Fixings are concealed behind finishes, render, or other components **[X] Standard hand tools are sufficient to access the connection** [ ] Specialised equipment or scaffolding would be required [ ] Accessing the connection would likely damage adjoining finishes	**Score: 0.80** *0.00–1.00*	The veranda ceiling is left exposed, with no lining concealing the framing; joints and nails are directly visible and reachable from below.
Independence (ID)	[ ] Element can be removed without dismantling neighbouring elements **[X] Element shares a structural or load path with adjoining components** **[X] Removal is sequence-dependent on other elements being removed first**	**Score: 0.40** *0.00–1.00*	Rafters, purlins, and battens share a continuous structural system; removal likely requires a defined sequence and may affect adjoining members.
Geometry / Product Edge (GPE)	[ ] Element is bounded by a discrete frame or opening [ ] Element is fully embedded, with no exposed edge [ ] Extraction would require cutting or breaking adjoining material	**Score: 0.70** *0.00–1.00*	Members run continuously and interlock at joints, but are not embedded in masonry and remain exposed along their length.

4. Reuse / Recovery Observations			
Observed recovery constraints	Sequence-dependent removal within the system; minor staining and biological growth on some members.	**Possible reuse context**	Direct reuse of sound members likely, given the more recent construction and good condition.
Interfaces / adjoining materials	Wall plate; veranda posts; tile covering above; lattice battens between rafters.	**Other relevant observations (qualitative notes only — no calculated scores)**	Assessed collectively (one Revit family per element type). Veranda roof is c. 20 years old, not part of the c.1820 original fabric.

5. Photographic Record	
 *Photo 1 — veranda roof, exterior view*	 *Photo 2 — detail, lattice battens from beneath*

Level 1 Field Assessment Sheet

In-situ building survey

1. Survey and Element Identification			
Survey date	24/06/2026	**Assessor**	Author
Building / case study	Fazenda Ribeiro	**Element reference**	RF-01
Level / storey	Roof	**Room / zone / grid**	Veranda roof (later construction, c. 20 years old)
Element category	Roof — Timber framing	**Element type / description**	Timber roof framing (rafters, purlins, and a lattice of thin battens) supporting the tile covering

2. In-situ Physical Information			
Primary material	Timber	**Finish / secondary material**	Unfinished / natural timber, exposed underside
Approx. dimensions	Not applicable (system assessed collectively, not as a single discrete unit)	**Units**	[ ] mm [ ] cm [X] m
Current use / function	Structural support for roof tile covering	**Current state**	[X] In use [ ] Unused [ ] Damaged [X] Other
Visible condition	[X] Good [ ] Fair [ ] Poor	**Visible defects**	Minor surface staining and biological growth on some battens; otherwise sound, consistent with more recent construction.
Repairable on visual inspection?	[X] Yes [ ] No [ ] Uncertain	**Reusable on visual inspection?**	[X] Yes [ ] No [ ] Uncertain

3. Level 1 Assessment — Observed Disassembly Conditions	
Connection description	Timber members nailed and jointed, bearing on wall plate and posts; no chemical or monolithic bonding.

Connection location	Joints between rafters, purlins, and battens; bearing points at wall plate and posts, visible from beneath.		
Criterion	**Points to check (tick all that apply)**	**Score**	**Field observation / justification**
Connection Type (CT)	**[X] Fixed with mechanical fasteners (screws, bolts, nails, clips, hinges)** [ ] Fixed with wet/adhesive methods (mortar, glue, chemical sealant) [ ] Cast-in-place or monolithically bonded to adjoining material [ ] More than one connection type present	**Score: 0.50** *0.00–1.00*	Timber members are nailed and jointed; no chemical bonding. A fully mechanical carpentry connection.
Connection Accessibility (CA)	**[X] Fixings are exposed and visible** [ ] Fixings are concealed behind finishes, render, or other components **[X] Standard hand tools are sufficient to access the connection** [ ] Specialised equipment or scaffolding would be required [ ] Accessing the connection would likely damage adjoining finishes	**Score: 0.80** *0.00–1.00*	The veranda ceiling is left exposed, with no lining concealing the framing; joints and nails are directly visible and reachable from below.
Independence (ID)	[ ] Element can be removed without dismantling neighbouring elements **[X] Element shares a structural or load path with adjoining components** **[X] Removal is sequence-dependent on other elements being removed first**	**Score: 0.40** *0.00–1.00*	Rafters, purlins, and battens share a continuous structural system; removal likely requires a defined sequence and may affect adjoining members.
Geometry / Product Edge (GPE)	[ ] Element is bounded by a discrete frame or opening [ ] Element is fully embedded, with no exposed edge [ ] Extraction would require cutting or breaking adjoining material	**Score: 0.70** *0.00–1.00*	Members run continuously and interlock at joints, but are not embedded in masonry and remain exposed along their length.

4. Reuse / Recovery Observations			
Observed recovery constraints	Sequence-dependent removal within the system; minor staining and biological growth on some members.	**Possible reuse context**	Direct reuse of sound members likely, given the more recent construction and good condition.
Interfaces / adjoining materials	Wall plate; veranda posts; tile covering above; lattice battens between rafters.	**Other relevant observations (qualitative notes only — no calculated scores)**	Assessed collectively (one Revit family per element type). Veranda roof is c. 20 years old, not part of the c.1820 original fabric.

5. Photographic Record	
	
Photo 1 — interior roof view showing fired-clay tiles above the timber structure	*Photo 2 — underside detail of the tile covering and supporting timber lattice*

Level 1 Field Assessment Sheet

In-situ building survey

1. Survey and Element Identification			
Survey date	24/06/2026	**Assessor**	Author
Building / case study	Fazenda Ribeiro	**Element reference**	RT-01
Level / storey	Roof	**Room / zone / grid**	Veranda roof (later construction, c. 20 years old)
Element category	Roof — Tile covering	**Element type / description**	Fired clay roof tiles (colonial capa-canal type), loose-laid by overlap on the timber lattice

2. In-situ Physical Information			
Primary material	Fired clay (ceramic tile)	**Finish / secondary material**	Unglazed, natural fired clay
Approx. dimensions	Not applicable (system assessed collectively, not as a single discrete unit)	**Units**	[ ] mm [ ] cm [X] m
Current use / function	Weatherproofing / roof covering	**Current state**	[X] In use [ ] Unused [ ] Damaged [X] Other
Visible condition	[X] Good [ ] Fair [ ] Poor	**Visible defects**	Some staining and biological growth (moss/lichen); no cracking or displacement observed.
Repairable on visual inspection?	[X] Yes [ ] No [ ] Uncertain	**Reusable on visual inspection?**	[X] Yes [ ] No [ ] Uncertain

3. Level 1 Assessment — Observed Disassembly Conditions	
Connection description	Tiles rest loose on the timber lattice, held by overlap and gravity alone; no mechanical, adhesive, or mortar fixing observed.
Connection location	Bearing on the lattice battens, overlapping the adjacent tile at each course.

Criterion	Points to check (tick all that apply)	Score	Field observation / justification
Connection Type (CT)	[ ] Fixed with mechanical fasteners (screws, bolts, nails, clips, hinges) [ ] Fixed with wet/adhesive methods (mortar, glue, chemical sealant) [ ] Cast-in-place or monolithically bonded to adjoining material [ ] More than one connection type present	**Score: 1.00** *0.00–1.00*	No listed connection type applies: the tile is not fastened at all, resting loose by overlap and gravity, a more favourable condition than any listed type.
Connection Accessibility (CA)	**[X] Fixings are exposed and visible** [ ] Fixings are concealed behind finishes, render, or other components **[X] Standard hand tools are sufficient to access the connection** [ ] Specialised equipment or scaffolding would be required [ ] Accessing the connection would likely damage adjoining finishes	**Score: 1.00** *0.00–1.00*	No tool is required: each tile can be lifted off once the overlapping course above is cleared. Roof access itself (ladder) does not affect the connection's own accessibility.
Independence (ID)	**[X] Element can be removed without dismantling neighbouring elements** [ ] Element shares a structural or load path with adjoining components **[X] Removal is sequence-dependent on other elements being removed first**	**Score: 1.00** *0.00–1.00*	Each tile is independent and non-structural, but removal generally proceeds course by course given the overlap with adjoining tiles.
Geometry / Product Edge (GPE)	[ ] Element is bounded by a discrete frame or opening [ ] Element is fully embedded, with no exposed edge [ ] Extraction would require cutting or breaking adjoining material	**Score: 1.00** *0.00–1.00*	The tile is not bounded, embedded, or fixed in any way; it is entirely exposed at the roof surface and geometrically independent of the surrounding fabric.

4. Reuse / Recovery Observations			
Observed recovery	Fragility during handling; some tiles show biological growth that	**Possible reuse context**	Very high potential for direct reuse, given the loose-laid fixing

constraints	may need cleaning before reuse.		method and good observed condition.
Interfaces / adjoining materials	Timber lattice battens beneath; adjoining tiles at each overlap.	**Other relevant observations (qualitative notes only — no calculated scores)**	Assessed collectively (as modelled in Revit). The checklist has no 'loose-laid, no fixing' option; noted for the methodology discussion.

5. Photographic Record



Photo 1 — tiles on the timber lattice, from beneath



Photo 2 — tile covering seen from outside

Level 1 Field Assessment Sheet

In-situ building survey

1. Survey and Element Identification			
Survey date	24/06/2026	**Assessor**	Author
Building / case study	Fazenda Ribeiro	**Element reference**	RT-01
Level / storey	Roof	**Room / zone / grid**	Veranda roof (later construction, c. 20 years old)
Element category	Roof — Tile covering	**Element type / description**	Fired clay roof tiles (colonial capa-canal type), loose-laid by overlap on the timber lattice

2. In-situ Physical Information			
Primary material	Fired clay (ceramic tile)	**Finish / secondary material**	Unglazed, natural fired clay
Approx. dimensions	Not applicable (system assessed collectively, not as a single discrete unit)	**Units**	[ ] mm [ ] cm [X] m
Current use / function	Weatherproofing / roof covering	**Current state**	[X] In use [ ] Unused [ ] Damaged [X] Other
Visible condition	[X] Good [ ] Fair [ ] Poor	**Visible defects**	Some staining and biological growth (moss/lichen); no cracking or displacement observed.
Repairable on visual inspection?	[X] Yes [ ] No [ ] Uncertain	**Reusable on visual inspection?**	[X] Yes [ ] No [ ] Uncertain

3. Level 1 Assessment — Observed Disassembly Conditions	
Connection description	Tiles rest loose on the timber lattice, held by overlap and gravity alone; no mechanical, adhesive, or mortar fixing observed.
Connection location	Bearing on the lattice battens, overlapping the adjacent tile at each course.

Criterion	Points to check (tick all that apply)	Score	Field observation / justification
Connection Type (CT)	[ ] Fixed with mechanical fasteners (screws, bolts, nails, clips, hinges) [ ] Fixed with wet/adhesive methods (mortar, glue, chemical sealant) [ ] Cast-in-place or monolithically bonded to adjoining material [ ] More than one connection type present	**Score: 1.00** *0.00–1.00*	No listed connection type applies: the tile is not fastened at all, resting loose by overlap and gravity, a more favourable condition than any listed type.
Connection Accessibility (CA)	**[X] Fixings are exposed and visible** [ ] Fixings are concealed behind finishes, render, or other components **[X] Standard hand tools are sufficient to access the connection** [ ] Specialised equipment or scaffolding would be required [ ] Accessing the connection would likely damage adjoining finishes	**Score: 1.00** *0.00–1.00*	No tool is required: each tile can be lifted off once the overlapping course above is cleared. Roof access itself (ladder) does not affect the connection's own accessibility.
Independence (ID)	**[X] Element can be removed without dismantling neighbouring elements** [ ] Element shares a structural or load path with adjoining components **[X] Removal is sequence-dependent on other elements being removed first**	**Score: 1.00** *0.00–1.00*	Each tile is independent and non-structural, but removal generally proceeds course by course given the overlap with adjoining tiles.
Geometry / Product Edge (GPE)	[ ] Element is bounded by a discrete frame or opening [ ] Element is fully embedded, with no exposed edge [ ] Extraction would require cutting or breaking adjoining material	**Score: 1.00** *0.00–1.00*	The tile is not bounded, embedded, or fixed in any way; it is entirely exposed at the roof surface and geometrically independent of the surrounding fabric.

4. Reuse / Recovery Observations			
Observed recovery	Fragility during handling; some tiles show biological growth that	**Possible reuse context**	Very high potential for direct reuse, given the loose-laid fixing

constraints	may need cleaning before reuse.		method and good observed condition.
Interfaces / adjoining materials	Timber lattice battens beneath; adjoining tiles at each overlap.	**Other relevant observations (qualitative notes only — no calculated scores)**	Assessed collectively (as modelled in Revit). The checklist has no 'loose-laid, no fixing' option; noted for the methodology discussion.

5. Photographic Record



Photo 1 — interior roof view showing fired-clay tiles above the timber structure



Photo 2 — underside detail of the tile covering and supporting timber lattice

Level 1 Field Assessment Sheet

In-situ building survey

1. Survey and Element Identification			
Survey date	24/06/2026	**Assessor**	Author
Building / case study	Fazenda Ribeiro	**Element reference**	WN-01
Level / storey	Ground floor	**Room / zone / grid**	Exterior wall / façade (exact room tbc)
Element category	Window	**Element type / description**	Painted timber shutter window in arched opening
2. In-situ Physical Information			
Primary material	Timber	**Finish / secondary material**	Blue painted finish
Approx. dimensions	L: 1.22 W: 0.05 H/T: 1.61 (sill height above floor: 0.90 m)	**Units**	[ ] mm [ ] cm [X] m
Current use / function	Ventilation / light, external	**Current state**	[X] In use [ ] Unused [X] Damaged [ ] Other
Visible condition	[ ] Good [X] Fair [ ] Poor	**Visible defects**	Paint wear and minor surface cracking; weathering at the sill; no visible hardware (handle or latch) on the photographed face.
Repairable on visual inspection?	[X] Yes [ ] No [ ] Uncertain	**Reusable on visual inspection?**	[X] Yes [ ] No [ ] Uncertain
3. Level 1 Assessment — Observed Disassembly Conditions			
Connection description	Timber shutter window mechanically fixed within a rendered wall opening, likely via hinges at one jamb (not visible).		
Connection location	Frame perimeter at jambs/head (hinges, assumed).		
Criterion	**Points to check (tick all that apply)**	**Score**	**Field observation / justification**
Connection Type (CT)	**[X] Fixed with mechanical fasteners (screws,**	**Score:**	Consistent with a hinged timber shutter. No evidence of chemical

	bolts, nails, clips, hinges) [ ] Fixed with wet/adhesive methods (mortar, glue, chemical sealant) [ ] Cast-in-place or monolithically bonded to adjoining material [ ] More than one connection type present	**0.80** *0.00–1.00*	bonding; hinge condition unconfirmed.
Connection Accessibility (CA)	[ ] Fixings are exposed and visible **[X] Fixings are concealed behind finishes, render, or other components** **[X] Standard hand tools are sufficient to access the connection** [ ] Specialised equipment or scaffolding would be required [ ] Accessing the connection would likely damage adjoining finishes	**Score: 0.60** *0.00–1.00*	No hardware is visible on the photographed face; hinges are assumed concealed at the opposite jamb. To be confirmed on direct inspection.
Independence (ID)	**[X] Element can be removed without dismantling neighbouring elements** [ ] Element shares a structural or load path with adjoining components [ ] Removal is sequence-dependent on other elements being removed first	**Score: 1.00** *0.00–1.00*	The shutter can reasonably be removed as an individual component without requiring the dismantling of adjoining building elements.
Geometry / Product Edge (GPE)	**[X] Element is bounded by a discrete frame or opening** [ ] Element is fully embedded, with no exposed edge [ ] Extraction would require cutting or breaking adjoining material	**Score: 0.40** *0.00–1.00*	The shutter is bounded by the surrounding arched frame, creating some obstruction, but is not fully embedded or geometrically inseparable from the building fabric.

4. Reuse / Recovery Observations

Observed recovery constraints	Hinge condition and fixing method not confirmed; sill weathering may complicate clean removal.	**Possible reuse context**	Heritage repair/restoration or adaptive reuse in a compatible opening after hardware inspection and timber condition assessment.

Interfaces / adjoining materials	Timber frame; rendered wall; mortar/plaster bedding; metal hardware (hinges assumed).	**Other relevant observations (qualitative notes only — no calculated scores)**	Confirm width (L) and hinge condition on site. CA score is preliminary, from photographs only.

5. Photographic Record



Photo 1 — frontal view



Photo 2 — oblique view

Level 1 Field Assessment Sheet

In-situ building survey

1. Survey and Element Identification			
Survey date	24/06/2026	**Assessor**	Author
Building / case study	Fazenda Ribeiro	**Element reference**	WN-02
Level / storey	Ground floor	**Room / zone / grid**	Exterior wall / façade (exact room tbc)
Element category	Window	**Element type / description**	Painted timber shutter window in arched opening

2. In-situ Physical Information			
Primary material	Timber	**Finish / secondary material**	Blue painted finish
Approx. dimensions	L: 1.22 W: 0.05 H/T: 1.61 (sill height above floor: 0.90 m)	**Units**	[ ] mm [ ] cm [X] m
Current use / function	Ventilation / light, external	**Current state**	[X] In use [ ] Unused [X] Damaged [ ] Other
Visible condition	[ ] Good [X] Fair [ ] Poor	**Visible defects**	Diagonal crack in the render at the left jamb; paint wear on the shutter face; no visible hardware on the photographed face.
Repairable on visual inspection?	[X] Yes [ ] No [ ] Uncertain	**Reusable on visual inspection?**	[X] Yes [ ] No [ ] Uncertain

3. Level 1 Assessment — Observed Disassembly Conditions			
Connection description	Timber shutter window mechanically fixed within a rendered wall opening, likely via hinges at one jamb (not visible).		
Connection location	Frame perimeter at jambs/head (hinges, assumed).		
Criterion	**Points to check (tick all that apply)**	**Score**	**Field observation / justification**
Connection Type (CT)	**[X] Fixed with mechanical fasteners (screws,**	**Score:**	Consistent with a hinged timber shutter. No evidence of chemical

	bolts, nails, clips, hinges) [ ] Fixed with wet/adhesive methods (mortar, glue, chemical sealant) [ ] Cast-in-place or monolithically bonded to adjoining material [ ] More than one connection type present	**0.80** *0.00–1.00*	bonding; hinge condition unconfirmed.
Connection Accessibility (CA)	[ ] Fixings are exposed and visible **[X] Fixings are concealed behind finishes, render, or other components** **[X] Standard hand tools are sufficient to access the connection** [ ] Specialised equipment or scaffolding would be required [ ] Accessing the connection would likely damage adjoining finishes	**Score: 0.60** *0.00–1.00*	No hardware is visible on the photographed face; hinges are assumed concealed at the opposite jamb. To be confirmed on direct inspection.
Independence (ID)	**[X] Element can be removed without dismantling neighbouring elements** [ ] Element shares a structural or load path with adjoining components [ ] Removal is sequence-dependent on other elements being removed first	**Score: 1.00** *0.00–1.00*	The shutter can reasonably be removed as an individual component without requiring the dismantling of adjoining building elements.
Geometry / Product Edge (GPE)	**[X] Element is bounded by a discrete frame or opening** [ ] Element is fully embedded, with no exposed edge [ ] Extraction would require cutting or breaking adjoining material	**Score: 0.40** *0.00–1.00*	The shutter is bounded by the surrounding arched frame, creating some obstruction, but is not fully embedded or geometrically inseparable from the building fabric.

4. Reuse / Recovery Observations

Observed recovery constraints	Hinge condition and fixing method not confirmed; crack in the surrounding render may extend during removal work.	**Possible reuse context**	Heritage repair/restoration or adaptive reuse in a compatible opening after hardware inspection and timber condition assessment.

Interfaces / adjoining materials	Timber frame; rendered wall; mortar/plaster bedding; metal hardware (hinges assumed).	**Other relevant observations (qualitative notes only — no calculated scores)**	Confirm width (L) and hinge condition on site. CA score is preliminary, from photographs only.

5. Photographic Record



Photo 1 — frontal view



Photo 2 — oblique view

Level 1 Field Assessment Sheet

In-situ building survey

1. Survey and Element Identification			
Survey date	24/06/2026	**Assessor**	Author
Building / case study	Fazenda Ribeiro	**Element reference**	WN-03
Level / storey	Ground floor	**Room / zone / grid**	Exterior wall / façade (exact room tbc)
Element category	Window	**Element type / description**	Painted timber shutter window in arched opening

2. In-situ Physical Information			
Primary material	Timber	**Finish / secondary material**	Blue painted finish
Approx. dimensions	L: 1.33 W: 0.05 H/T: 1.61 (sill height above floor: 0.90 m)	**Units**	[ ] mm [ ] cm [X] m
Current use / function	Ventilation / light, external	**Current state**	[X] In use [ ] Unused [X] Damaged [ ] Other
Visible condition	[ ] Good [X] Fair [ ] Poor	**Visible defects**	Paint wear on the shutter face and surrounding frame; minor cracking in the render at the arch; no visible hardware on the photographed face.
Repairable on visual inspection?	[X] Yes [ ] No [ ] Uncertain	**Reusable on visual inspection?**	[X] Yes [ ] No [ ] Uncertain

3. Level 1 Assessment — Observed Disassembly Conditions	
Connection description	Timber shutter window mechanically fixed within a rendered wall opening, likely via hinges at one jamb (not visible).
Connection location	Frame perimeter at jambs/head (hinges, assumed).

Criterion	Points to check (tick all that apply)	Score	Field observation / justification
Connection Type (CT)	**[X] Fixed with mechanical fasteners (screws, bolts, nails, clips, hinges)** [ ] Fixed with wet/adhesive methods (mortar, glue, chemical sealant) [ ] Cast-in-place or monolithically bonded to adjoining material [ ] More than one connection type present	**Score: 0.80** *0.00–1.00*	Consistent with a hinged timber shutter. No evidence of chemical bonding; hinge condition unconfirmed.
Connection Accessibility (CA)	[ ] Fixings are exposed and visible **[X] Fixings are concealed behind finishes, render, or other components** **[X] Standard hand tools are sufficient to access the connection** [ ] Specialised equipment or scaffolding would be required [ ] Accessing the connection would likely damage adjoining finishes	**Score: 0.60** *0.00–1.00*	No hardware is visible on the photographed face; hinges are assumed concealed at the opposite jamb. To be confirmed on direct inspection.
Independence (ID)	**[X] Element can be removed without dismantling neighbouring elements** [ ] Element shares a structural or load path with adjoining components [ ] Removal is sequence-dependent on other elements being removed first	**Score: 1.00** *0.00–1.00*	The shutter can reasonably be removed as an individual component without requiring the dismantling of adjoining building elements.
Geometry / Product Edge (GPE)	**[X] Element is bounded by a discrete frame or opening** [ ] Element is fully embedded, with no exposed edge [ ] Extraction would require cutting or breaking adjoining material	**Score: 0.40** *0.00–1.00*	The shutter is bounded by the surrounding arched frame, creating some obstruction, but is not fully embedded or geometrically inseparable from the building fabric.

4. Reuse / Recovery Observations

Observed recovery constraints	Hinge condition and fixing method not confirmed; minor	**Possible reuse context**	Heritage repair/restoration or adaptive reuse in a compatible opening after hardware

	render cracking around the arch.		inspection and timber condition assessment.
Interfaces / adjoining materials	Timber frame; rendered wall; mortar/plaster bedding; metal hardware (hinges assumed).	**Other relevant observations (qualitative notes only — no calculated scores)**	Confirm width (L) and hinge condition on site. CA score is preliminary, from photographs only.

5. Photographic Record



Photo 1 — frontal view



Photo 2 — oblique view

Level 1 Field Assessment Sheet

In-situ building survey

1. Survey and Element Identification			
Survey date	24/06/2026	**Assessor**	Author
Building / case study	Fazenda Ribeiro	**Element reference**	WN-04
Level / storey	Ground floor	**Room / zone / grid**	Exterior wall / façade (exact room tbc)
Element category	Window	**Element type / description**	Painted timber shutter window in arched opening

2. In-situ Physical Information			
Primary material	Timber	**Finish / secondary material**	Blue painted finish
Approx. dimensions	L: 1.22 W: 0.05 H/T: 1.61 (sill height above floor: 0.90 m)	**Units**	[ ] mm [ ] cm [X] m
Current use / function	Ventilation / light, external	**Current state**	[X] In use [ ] Unused [X] Damaged [ ] Other
Visible condition	[ ] Good [X] Fair [ ] Poor	**Visible defects**	Paint wear and surface staining on the shutter face; minor scratches; no visible hardware on the photographed face.
Repairable on visual inspection?	[X] Yes [ ] No [ ] Uncertain	**Reusable on visual inspection?**	[X] Yes [ ] No [ ] Uncertain

3. Level 1 Assessment — Observed Disassembly Conditions			
Connection description	Timber shutter window mechanically fixed within a rendered wall opening, likely via hinges at one jamb (not visible).		
Connection location	Frame perimeter at jambs/head (hinges, assumed).		
Criterion	**Points to check (tick all that apply)**	**Score**	**Field observation / justification**

Connection Type (CT)	**[X] Fixed with mechanical fasteners (screws, bolts, nails, clips, hinges)** [ ] Fixed with wet/adhesive methods (mortar, glue, chemical sealant) [ ] Cast-in-place or monolithically bonded to adjoining material [ ] More than one connection type present	**Score: 0.80** *0.00–1.00*	Consistent with a hinged timber shutter. No evidence of chemical bonding; hinge condition unconfirmed.
Connection Accessibility (CA)	[ ] Fixings are exposed and visible **[X] Fixings are concealed behind finishes, render, or other components** **[X] Standard hand tools are sufficient to access the connection** [ ] Specialised equipment or scaffolding would be required [ ] Accessing the connection would likely damage adjoining finishes	**Score: 0.60** *0.00–1.00*	No hardware is visible on the photographed face; hinges are assumed concealed at the opposite jamb. To be confirmed on direct inspection.
Independence (ID)	**[X] Element can be removed without dismantling neighbouring elements** [ ] Element shares a structural or load path with adjoining components [ ] Removal is sequence-dependent on other elements being removed first	**Score: 1.00** *0.00–1.00*	The shutter can reasonably be removed as an individual component without requiring the dismantling of adjoining building elements.
Geometry / Product Edge (GPE)	**[X] Element is bounded by a discrete frame or opening** [ ] Element is fully embedded, with no exposed edge [ ] Extraction would require cutting or breaking adjoining material	**Score: 0.40** *0.00–1.00*	The shutter is bounded by the surrounding arched frame, creating some obstruction, but is not fully embedded or geometrically inseparable from the building fabric.

4. Reuse / Recovery Observations

Observed recovery constraints	Hinge condition and fixing method not confirmed.	**Possible reuse context**	Heritage repair/restoration or adaptive reuse in a compatible opening after hardware inspection and timber condition

			assessment.
Interfaces / adjoining materials	Timber frame; rendered wall; mortar/plaster bedding; metal hardware (hinges assumed).	**Other relevant observations (qualitative notes only — no calculated scores)**	Confirm width (L) and hinge condition on site. CA score is preliminary, from photographs only.

5. Photographic Record



Photo 1 — frontal view



Photo 2 — oblique view

Level 1 Field Assessment Sheet

In-situ building survey

1. Survey and Element Identification			
Survey date	24/06/2026	**Assessor**	Author
Building / case study	Fazenda Ribeiro	**Element reference**	WN-05
Level / storey	Ground floor	**Room / zone / grid**	Exterior wall (room tbc)
Element category	Window	**Element type / description**	Timber shutter, rectangular opening
2. In-situ Physical Information			
Primary material	Timber	**Finish / secondary material**	Blue paint, extensive loss, bare timber exposed
Approx. dimensions	L: 1.11 W: 0.05 H/T: 1.61 (sill height above floor: 0.90 m)	**Units**	[ ] mm [ ] cm [X] m
Current use / function	Ventilation / light, external	**Current state**	[X] In use [ ] Unused [X] Damaged [ ] Other
Visible condition	[ ] Good [ ] Fair [X] Poor	**Visible defects**	Extensive paint loss; longitudinal cracks and splits in several boards; gaps at the base; no hardware visible.
Repairable on visual inspection?	[X] Yes [ ] No [ ] Uncertain	**Reusable on visual inspection?**	[ ] Yes [ ] No [X] Uncertain

3. Level 1 Assessment — Observed Disassembly Conditions			
Connection description	Timber shutter window mechanically fixed within a rendered wall opening, likely via hinges at one jamb (not visible).		
Connection location	Frame perimeter at jambs/head (hinges, assumed).		
Criterion	**Points to check (tick all that apply)**	**Score**	**Field observation / justification**
Connection Type (CT)	**[X] Fixed with mechanical fasteners (screws, bolts, nails, clips, hinges)**	**Score: 0.80**	Consistent with a hinged timber shutter. No evidence of chemical bonding; hinge condition

	[ ] Fixed with wet/adhesive methods (mortar, glue, chemical sealant) [ ] Cast-in-place or monolithically bonded to adjoining material [ ] More than one connection type present	*0.00–1.00*	unconfirmed.
Connection Accessibility (CA)	[ ] Fixings are exposed and visible **[X] Fixings are concealed behind finishes, render, or other components** **[X] Standard hand tools are sufficient to access the connection** [ ] Specialised equipment or scaffolding would be required [ ] Accessing the connection would likely damage adjoining finishes	**Score: 0.60** *0.00–1.00*	No hardware visible; hinges assumed concealed. Timber splitting may complicate clean removal.
Independence (ID)	**[X] Element can be removed without dismantling neighbouring elements** [ ] Element shares a structural or load path with adjoining components [ ] Removal is sequence-dependent on other elements being removed first	**Score: 1.00** *0.00–1.00*	The shutter can reasonably be removed as an individual component without requiring the dismantling of adjoining building elements.
Geometry / Product Edge (GPE)	**[X] Element is bounded by a discrete frame or opening** [ ] Element is fully embedded, with no exposed edge [ ] Extraction would require cutting or breaking adjoining material	**Score: 0.40** *0.00–1.00*	The shutter is bounded by the surrounding frame, creating some obstruction, but is not fully embedded or geometrically inseparable from the building fabric.

4. Reuse / Recovery Observations

Observed recovery constraints	Hinge condition not confirmed; split boards increase breakage risk during removal.	**Possible reuse context**	Reuse of the whole leaf uncertain given splitting; salvage of sound sections may be more realistic.
Interfaces / adjoining materials	Timber frame; rendered wall; mortar/plaster bedding; metal	**Other relevant observations (qualitative notes only — no**	Confirm width (L) and hinge condition on site. Inspect split boards before reuse. CA score is

	hardware (hinges assumed).	**calculated scores)**	preliminary, from photographs only.

5. Photographic Record



Photo 1 — frontal view



Photo 2 — oblique view

Level 1 Field Assessment Sheet

In-situ building survey

1. Survey and Element Identification			
Survey date	24/06/2026	**Assessor**	Author
Building / case study	Fazenda Ribeiro	**Element reference**	WN-06
Level / storey	Ground floor	**Room / zone / grid**	Exterior wall (room tbc)
Element category	Window	**Element type / description**	Timber shutter, rectangular opening

2. In-situ Physical Information			
Primary material	Timber	**Finish / secondary material**	Teal paint, scuffed and scratched, paint splashes on sill
Approx. dimensions	L: 0.85 W: 0.05 H/T: 1.61 (sill height above floor: 0.90 m)	**Units**	[ ] mm [ ] cm [X] m
Current use / function	Ventilation / light, external	**Current state**	[X] In use [ ] Unused [X] Damaged [ ] Other
Visible condition	[ ] Good [X] Fair [ ] Poor	**Visible defects**	Paint scuffing, scratches, and drips; narrow gaps between boards; a crack down one board; a corroded metal fragment (possible former hinge) at the upper left corner.
Repairable on visual inspection?	[X] Yes [ ] No [ ] Uncertain	**Reusable on visual inspection?**	[X] Yes [ ] No [ ] Uncertain

3. Level 1 Assessment — Observed Disassembly Conditions	
Connection description	Timber shutter window mechanically fixed within a rendered wall opening. A corroded metal fragment at the upper left jamb may be a remnant of the original hinge; its current function is unconfirmed.
Connection location	Frame perimeter at jambs/head; corroded metal fragment visible at upper left jamb.

Criterion	Points to check (tick all that apply)	Score	Field observation / justification
Connection Type (CT)	**[X] Fixed with mechanical fasteners (screws, bolts, nails, clips, hinges)** [ ] Fixed with wet/adhesive methods (mortar, glue, chemical sealant) [ ] Cast-in-place or monolithically bonded to adjoining material [ ] More than one connection type present	**Score: 0.80** *0.00–1.00*	Consistent with a hinged timber shutter; a corroded metal fragment at the jamb supports this. No evidence of chemical bonding.
Connection Accessibility (CA)	**[X] Fixings are exposed and visible** [ ] Fixings are concealed behind finishes, render, or other components **[X] Standard hand tools are sufficient to access the connection** [ ] Specialised equipment or scaffolding would be required [ ] Accessing the connection would likely damage adjoining finishes	**Score: 0.60** *0.00–1.00*	A metal fixing fragment is partially exposed at the jamb, suggesting somewhat better accessibility than shutters with no visible hardware, though its condition and function are unconfirmed.
Independence (ID)	**[X] Element can be removed without dismantling neighbouring elements** [ ] Element shares a structural or load path with adjoining components [ ] Removal is sequence-dependent on other elements being removed first	**Score: 1.00** *0.00–1.00*	The shutter can reasonably be removed as an individual component without requiring the dismantling of adjoining building elements.
Geometry / Product Edge (GPE)	**[X] Element is bounded by a discrete frame or opening** [ ] Element is fully embedded, with no exposed edge [ ] Extraction would require cutting or breaking adjoining material	**Score: 0.40** *0.00–1.00*	The shutter is bounded by the surrounding frame, creating some obstruction, but is not fully embedded or geometrically inseparable from the building fabric.

4. Reuse / Recovery Observations

Observed recovery constraints	Condition and function of the metal fragment at the jamb unconfirmed; careful removal	**Possible reuse context**	Heritage repair/restoration or adaptive reuse in a compatible opening after hardware

	advised to avoid further corrosion damage.		inspection.
Interfaces / adjoining materials	Timber frame; rendered wall; mortar/plaster bedding; corroded metal fragment at upper jamb.	**Other relevant observations (qualitative notes only — no calculated scores)**	Confirm width (L) and inspect the jamb fragment on site. CA score is preliminary, from photographs only.

5. Photographic Record



Photo 1 — frontal view



Photo 2 — frontal view, closer

Level 1 Field Assessment Sheet

In-situ building survey

1. Survey and Element Identification			
Survey date	24/06/2026	**Assessor**	Author
Building / case study	Fazenda Ribeiro	**Element reference**	WN-07
Level / storey	Ground floor	**Room / zone / grid**	Exterior wall / façade (room tbc)
Element category	Window	**Element type / description**	Painted timber shutter window in arched opening

2. In-situ Physical Information			
Primary material	Timber	**Finish / secondary material**	Blue painted finish
Approx. dimensions	L: 1.33 W: 0.05 H/T: 1.61 (sill height above floor: 0.90 m)	**Units**	[ ] mm [ ] cm [X] m
Current use / function	Ventilation / light, external	**Current state**	[X] In use [ ] Unused [X] Damaged [ ] Other
Visible condition	[ ] Good [X] Fair [ ] Poor	**Visible defects**	Dark staining at the underside of the lintel, possibly soot or biological growth; worn sill with paint splashes; minor surface cracking on the shutter; no visible hardware.
Repairable on visual inspection?	[X] Yes [ ] No [ ] Uncertain	**Reusable on visual inspection?**	[X] Yes [ ] No [ ] Uncertain

3. Level 1 Assessment — Observed Disassembly Conditions	
Connection description	Timber shutter window mechanically fixed within a rendered wall opening, likely via hinges at one jamb (not visible).
Connection location	Frame perimeter at jambs/head (hinges, assumed).

Criterion	Points to check (tick all that apply)	Score	Field observation / justification
Connection Type (CT)	**[X] Fixed with mechanical fasteners (screws, bolts, nails, clips, hinges)** [ ] Fixed with wet/adhesive methods (mortar, glue, chemical sealant) [ ] Cast-in-place or monolithically bonded to adjoining material [ ] More than one connection type present	**Score: 0.80** *0.00–1.00*	Consistent with a hinged timber shutter. No evidence of chemical bonding; hinge condition unconfirmed.
Connection Accessibility (CA)	[ ] Fixings are exposed and visible **[X] Fixings are concealed behind finishes, render, or other components** **[X] Standard hand tools are sufficient to access the connection** [ ] Specialised equipment or scaffolding would be required [ ] Accessing the connection would likely damage adjoining finishes	**Score: 0.60** *0.00–1.00*	No hardware is visible on the photographed face; hinges are assumed concealed at the opposite jamb. To be confirmed on direct inspection.
Independence (ID)	**[X] Element can be removed without dismantling neighbouring elements** [ ] Element shares a structural or load path with adjoining components [ ] Removal is sequence-dependent on other elements being removed first	**Score: 1.00** *0.00–1.00*	The shutter can reasonably be removed as an individual component without requiring the dismantling of adjoining building elements.
Geometry / Product Edge (GPE)	**[X] Element is bounded by a discrete frame or opening** [ ] Element is fully embedded, with no exposed edge [ ] Extraction would require cutting or breaking adjoining material	**Score: 0.40** *0.00–1.00*	The shutter is bounded by the surrounding arched frame, creating some obstruction, but is not fully embedded or geometrically inseparable from the building fabric.

4. Reuse / Recovery Observations

Observed recovery constraints	Hinge condition and fixing method not confirmed; source of	**Possible reuse context**	Heritage repair/restoration or adaptive reuse in a compatible opening after hardware

	lintel staining not investigated.		inspection and timber condition assessment.
Interfaces / adjoining materials	Timber frame; rendered wall; mortar/plaster bedding; metal hardware (hinges assumed).	**Other relevant observations (qualitative notes only — no calculated scores)**	Confirm width (L) and hinge condition on site. Only one photograph was available for this element. CA score is preliminary, from photographic evidence only.

5. Photographic Record



Photo 1 — frontal/oblique view

Level 1 Field Assessment Sheet

In-situ building survey

1. Survey and Element Identification			
Survey date	24/06/2026	**Assessor**	Author
Building / case study	Fazenda Ribeiro	**Element reference**	WN-08
Level / storey	Ground floor	**Room / zone / grid**	Exterior wall / façade (room tbc)
Element category	Window	**Element type / description**	Timber shutter, arched opening
2. In-situ Physical Information			
Primary material	Timber	**Finish / secondary material**	Blue paint, extensive peeling on frame
Approx. dimensions	L: 1.22 W: 0.05 H/T: 1.61 (sill height above floor: 0.90 m)	**Units**	[ ] mm [ ] cm [X] m
Current use / function	Ventilation / light, external	**Current state**	[X] In use [ ] Unused [X] Damaged [ ] Other
Visible condition	[ ] Good [X] Fair [ ] Poor	**Visible defects**	Extensive paint peeling on the frame; diagonal crack at the lower right corner; a broken hinge fragment protruding at the base; paint splashes on the sill.
Repairable on visual inspection?	[X] Yes [ ] No [ ] Uncertain	**Reusable on visual inspection?**	[X] Yes [ ] No [ ] Uncertain
3. Level 1 Assessment — Observed Disassembly Conditions			
Connection description	Timber shutter mechanically fixed within a rendered opening. A broken hinge fragment is visible at the leaf/jamb junction near the base.		
Connection location	Frame perimeter at jambs/head; broken hinge fragment at lower jamb.		
Criterion	**Points to check (tick all that apply)**	**Score**	**Field observation / justification**
Connection Type (CT)	**[X] Fixed with mechanical fasteners (screws,**	**Score:**	Confirmed hinge fixing, evidenced by the broken metal fragment at the

	bolts, nails, clips, hinges) [ ] Fixed with wet/adhesive methods (mortar, glue, chemical sealant) [ ] Cast-in-place or monolithically bonded to adjoining material [ ] More than one connection type present	**0.80** *0.00–1.00*	lower jamb. No evidence of chemical bonding.
Connection Accessibility (CA)	**[X] Fixings are exposed and visible** [ ] Fixings are concealed behind finishes, render, or other components **[X] Standard hand tools are sufficient to access the connection** [ ] Specialised equipment or scaffolding would be required [ ] Accessing the connection would likely damage adjoining finishes	**Score: 0.80** *0.00–1.00*	A hinge fragment is directly visible and exposed at the lower jamb, though already broken, which may complicate a clean, controlled removal.
Independence (ID)	**[X] Element can be removed without dismantling neighbouring elements** [ ] Element shares a structural or load path with adjoining components [ ] Removal is sequence-dependent on other elements being removed first	**Score: 1.00** *0.00–1.00*	The shutter can reasonably be removed as an individual component without requiring the dismantling of adjoining building elements.
Geometry / Product Edge (GPE)	**[X] Element is bounded by a discrete frame or opening** [ ] Element is fully embedded, with no exposed edge [ ] Extraction would require cutting or breaking adjoining material	**Score: 0.40** *0.00–1.00*	The shutter is bounded by the surrounding arched frame, creating some obstruction, but is not fully embedded or geometrically inseparable from the building fabric.

4. Reuse / Recovery Observations

Observed recovery constraints	Hinge already broken, limiting a clean release at that point; crack in the frame at lower right.	**Possible reuse context**	Heritage repair/restoration or adaptive reuse after hardware replacement and timber condition assessment.
Interfaces / adjoining	Timber frame; rendered wall;	**Other relevant**	Confirm width (L) on site. Hinge

materials	mortar/plaster bedding; broken metal hinge fragment.	**observations (qualitative notes only — no calculated scores)**	likely needs full replacement given visible breakage. CA score is preliminary, from photographs only.

5. Photographic Record



Photo 1 — frontal/oblique view



Photo 2 — detail, broken hinge at sill

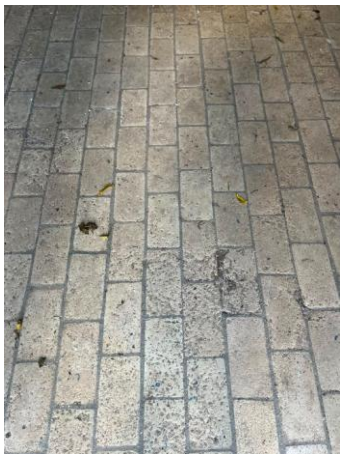
Level 2 Field Assessment Sheet

In-situ building survey

1. Survey and Element Identification			
Survey date	24/06/2026	**Assessor**	Author
Building / case study	Fazenda Ribeiro	**Element reference**	F-01
Level / storey	Ground floor	**Room / zone / grid**	Interior floor
Element category	Floor	**Element type / description**	Interior floor finish composed of small rectangular paving units laid in a staggered pattern; assessed as an existing floor assembly
2. In-situ Physical Information			
Primary material	Rectangular masonry / stone-like paving units (exact material not confirmed in situ)	**Finish / secondary material**	Exposed, uncoated surface; visible joints between units
Approx. dimensions	Not measured	**Units**	—
Current use / function	Interior walking surface / floor finish	**Current state**	[X] In use [ ] Unused [X] Damaged [ ] Other
Visible condition	[ ] Good [X] Fair [ ] Poor	**Visible defects**	General surface wear and staining; localised chips/losses and small damaged areas are visible. Most paving units remain in place and visually coherent.
Repairable on	[X] Yes [ ] No [ ]	**Reusable on visual**	[ ] Yes [ ] No [X]

visual inspection?	Uncertain	**inspection?**	Uncertain

3. Level 2 Assessment — In-situ Criteria (TRACE Protocol)			
Criterion	**Points to check (tick all that apply)**	**Score**	**Field observation / justification**
Physical Integrity	[ ] Material/element is fully intact with no visible damage [X] Minor repairable damage / local losses are present [ ] Extensive degradation or major loss is visible	**Score: 1** 0 / 1 / 2	The floor remains largely continuous and serviceable, but localised chips, surface wear, staining and small losses are visible. The observed damage appears limited rather than widespread.
Recoverability	[ ] Units can clearly be lifted using standard methods with little risk of damage [X] Extraction appears possible but would require careful / selective work [ ] Recovery would be destructive or would significantly damage the material	**Score: 1** 0 / 1 / 2	Selective recovery of individual paving units appears possible, but the bedding and jointing method is not visible. Careful lifting would therefore be required to limit breakage and edge damage.
Reuse Feasibility	[X] A plausible reuse route exists for the recovered material [ ] A specific receiving project or use is already confirmed [X] Cleaning / sorting and condition checking would be required before reuse	**Score: 1** 0 / 1 / 2	Intact units could plausibly be reused as floor paving or for compatible repair work, but no receiving application is currently confirmed. Recovered units would require cleaning and individual condition checking.
Information Confidence	[X] Photographic and visual documentation is available [ ] Dimensions and material data are recorded [ ] Bedding / fixing method has been confirmed [X] Further investigation would be needed before a confident	**Score: 1** 0 / 1 / 2	The assessment is supported by the provided photograph, but the exact material, dimensions, bedding composition, fixing method and hidden condition are not confirmed.

	classification		
4. Reuse / Recovery Observations			
Observed recovery constraints	Unknown bedding/fixing method; risk of edge chipping or breakage during lifting; local surface wear and damaged units; cleaning would be required.	**Possible reuse context**	Potential reuse as interior paving, replacement units for compatible historic floors, or repair material where dimensions and material are suitable.
Interfaces / adjoining materials	Adjacent paving units; jointing material; concealed bedding/substrate beneath the floor.	**Other relevant observations (qualitative notes only — no calculated scores)**	TRACE score: 4 / 8 — Conditional. Assessment is based on visual evidence only; material identification and lifting behaviour should be verified before recovery.
5. Photographic Record			
Photo 1			
 *Interior floor - overall condition*			

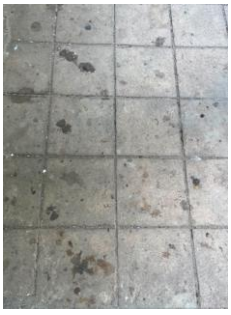
Level 2 Field Assessment Sheet

In-situ building survey

1. Survey and Element Identification			
Survey date	24/06/2026	**Assessor**	Author
Building / case study	Fazenda Ribeiro	**Element reference**	F-02
Level / storey	Ground floor	**Room / zone / grid**	Exterior circulation / covered external area
Element category	Floor	**Element type / description**	Exterior floor composed of square paving units laid in a regular grid pattern; assessed as an existing floor assembly
2. In-situ Physical Information			
Primary material	Square stone- or cement-based paving units (exact material not confirmed in situ)	**Finish / secondary material**	Exposed, uncoated surface; visible joints between units
Approx. dimensions	Not measured	**Units**	—
Current use / function	Exterior walking surface / circulation	**Current state**	[X] In use [ ] Unused [X] Damaged [ ] Other
Visible condition	[ ] Good [X] Fair [ ] Poor	**Visible defects**	General weathering and staining across the surface; local dark marks, dirt accumulation and edge/joint deterioration are visible. Most paving units remain in place and appear structurally coherent.
Repairable on visual inspection?	[X] Yes [ ] No [ ]	**Reusable on visual inspection?**	[ ] Yes [ ] No [X]

	Uncertain		Uncertain

3. Level 2 Assessment — In-situ Criteria (TRACE Protocol)			
Criterion	**Points to check (tick all that apply)**	**Score**	**Field observation / justification**
Physical Integrity	[ ] Material/element is fully intact with no visible damage [X] Minor repairable damage / local losses are present [ ] Extensive degradation or major loss is visible	**Score: 1** 0 / 1 / 2	The exterior floor remains largely intact and continuous, but shows widespread surface weathering, staining and localised deterioration at joints and edges. The damage appears moderate and repairable rather than structurally severe.
Recoverability	[ ] Units can clearly be lifted using standard methods with little risk of damage [X] Extraction appears possible but would require careful / selective work [ ] Recovery would be destructive or would significantly damage the material	**Score: 1** 0 / 1 / 2	Individual paving units are clearly defined, suggesting selective recovery may be possible. However, the bedding and jointing method are not visible, so careful lifting would be needed to limit breakage and loss.
Reuse Feasibility	[X] A plausible reuse route exists for the recovered material [ ] A specific receiving project or use is already confirmed [X] Cleaning / sorting and condition checking would be required before reuse	**Score: 1** 0 / 1 / 2	Intact units could plausibly be reused as exterior paving or as replacement pieces in compatible repair work. No receiving application is confirmed, and cleaning plus individual inspection would be required.
Information Confidence	[X] Photographic and visual documentation is available [ ] Dimensions and material data are recorded [ ] Bedding / fixing method has been confirmed [X] Further investigation would be needed before a confident	**Score: 1** 0 / 1 / 2	The assessment is supported by two photographs, but the exact material, dimensions, bedding composition, fixing method and hidden condition are not confirmed.

	classification		
4. Reuse / Recovery Observations			
Observed recovery constraints	Unknown bedding/fixing method; exterior weathering; dirt and staining; possible edge or joint damage; risk of breakage during lifting.	**Possible reuse context**	Potential reuse as exterior paving, secondary circulation surfaces, or replacement units in compatible historic/repair areas where dimensions and material match.
Interfaces / adjoining materials	Adjacent paving units; jointing material; concealed bedding/sub-base; adjoining walls and edge conditions.	**Other relevant observations (qualitative notes only — no calculated scores)**	TRACE score: 4 / 8 — Conditional. Reuse potential depends on confirming the paving material, dimensions, bedding method and condition after lifting.
5. Photographic Record			
Photo 1		Photo 2	
 *Exterior floor — close view of paving units and surface condition*		 *Exterior floor — wider view showing paving continuity and weathering*	

Level 2 Field Assessment Sheet

In-situ building survey

1. Survey and Element Identification			
Survey date	24/06/2026	**Assessor**	Author
Building / case study	Fazenda Ribeiro	**Element reference**	P-01
Level / storey	Ground floor	**Room / zone / grid**	Exterior veranda / roof-support line
Element category	Pillar / masonry support	**Element type / description**	Rendered brick masonry pillar supporting the veranda roof; later construction, approximately 20 years old

2. In-situ Physical Information			
Primary material	Conventional fired-clay brick masonry	**Finish / secondary material**	Painted render/plaster; large localised area of render loss exposing brick masonry
Approx. dimensions	Not measured	**Units**	—
Current use / function	Vertical support to veranda roof	**Current state**	[X] In use [ ] Unused [X] Damaged [ ] Other
Visible condition	[ ] Good [X] Fair [ ] Poor	**Visible defects**	Significant local render loss and cracking expose the brick substrate along one side. Surface staining and weathering are visible, particularly near the base. The pillar remains standing

			and appears aligned in the supplied photographs.
Repairable on visual inspection?	[X] Yes [ ] No [ ] Uncertain	**Reusable on visual inspection?**	[ ] Yes [ ] No [X] Uncertain

3. Level 2 Assessment — In-situ Criteria (TRACE Protocol)			
Criterion	**Points to check (tick all that apply)**	**Score**	**Field observation / justification**
Physical Integrity	[ ] Material/element remains fully intact with no visible damage [X] Minor to moderate repairable damage is present [ ] Breaks apart or degrades significantly during normal use / handling	**Score: 1** 0 / 1 / 2	The pillar remains upright and apparently functional, but a substantial strip of render has detached and the brickwork is exposed. Visible cracking and weathering indicate deterioration that appears repairable rather than total structural loss.
Recoverability	[ ] Can be removed substantially intact using standard methods [X] Extraction is possible but requires special care / tools [ ] Cannot be extracted without destroying the element or recovered material	**Score: 1** 0 / 1 / 2	The pillar is a mortar-bonded masonry assembly and is not realistically recoverable as one complete unit. Individual bricks could potentially be recovered through careful selective dismantling, but mortar removal and local breakage are expected.
Reuse Feasibility	[X] A plausible receiving application exists for recovered bricks [ ] A specific receiving project or use is confirmed [X] Cleaning / mortar removal and sorting would be required	**Score: 1** 0 / 1 / 2	Sound bricks could plausibly be reused in non-critical masonry, repair work, or compatible secondary construction. However, no receiving application is confirmed and recovered units would require cleaning,

			sorting and inspection.
Information Confidence	[X] Photographic and visual documentation is available [X] Material type and approximate age are known [ ] Dimensions, mortar composition and hidden condition are recorded [X] Further investigation would still be required before confident reuse decisions	**Score: 1** 0 / 1 / 2	The material is confirmed as conventional fired-clay brick masonry and the pillar is known to be approximately 20 years old. However, dimensions, mortar composition, reinforcement (if any), internal condition and brick strength are not documented.

4. Reuse / Recovery Observations			
Observed recovery constraints	Mortar-bonded masonry; local render detachment and cracking; likely brick losses during dismantling; cleaning of residual mortar would be required; hidden condition is unknown.	**Possible reuse context**	Selective recovery of sound bricks for compatible masonry repairs or secondary construction. Reuse of the pillar as a complete element is not considered realistic.
Interfaces / adjoining materials	Veranda roof structure above; adjoining low wall / parapet; rendered finishes; mortar joints between brick units; floor/base connection.	**Other relevant observations (qualitative notes only — no calculated scores)**	TRACE score: 4 / 8 — Conditional. Unlike the original c.1820 walls, this pillar is a later conventional brick-masonry addition, approximately 20 years old.

5. Photographic Record	
Photo 1	Photo 2

	
Pillar P-01 — overall view within the veranda roof-support line	*Pillar P-01 — close view of render loss, cracking and exposed brick masonry*

Level 2 Field Assessment Sheet

In-situ building survey

1. Survey and Element Identification			
Survey date	24/06/2026	**Assessor**	Author
Building / case study	Fazenda Ribeiro	**Element reference**	S-01
Level / storey	Ground floor	**Room / zone / grid**	Exterior veranda / access stair
Element category	Stair	**Element type / description**	Short exterior stair connecting adjacent veranda floor levels; solid stepped construction with a paved/tiled surface finish

2. In-situ Physical Information			
Primary material	Solid masonry / cement-based stair construction (exact substrate not confirmed)	**Finish / secondary material**	Square/rectangular paving finish to treads and landings; painted/rendered risers and sides
Approx. dimensions	Not measured	**Units**	—
Current use / function	Pedestrian access between veranda levels	**Current state**	[X] In use [ ] Unused [X] Damaged [ ] Other
Visible condition	[ ] Good [X] Fair [ ] Poor	**Visible defects**	The stair remains functional and visually stable. Surface staining, dirt accumulation, worn joints and local cracking/chipping are visible, particularly at tread edges and adjoining floor finishes.

Repairable on visual inspection?	[X] Yes [ ] No [ ] Uncertain	**Reusable on visual inspection?**	[ ] Yes [ ] No [X] Uncertain

3. Level 2 Assessment — In-situ Criteria (TRACE Protocol)			
Criterion	**Points to check (tick all that apply)**	**Score**	**Field observation / justification**
Physical Integrity	[ ] Material/element is fully intact with no visible damage [X] Minor repairable damage / local losses are present [ ] Extensive degradation or major loss is visible	**Score: 1** 0 / 1 / 2	The stair remains largely intact and in service, but shows local surface wear, staining, cracking and edge deterioration. No major structural failure is visible in the supplied photographs.
Recoverability	[ ] Element can be extracted substantially intact using standard methods [ ] Extraction appears possible but requires special care / techniques [X] Whole-element recovery would be destructive or cause significant damage	**Score: 0** 0 / 1 / 2	The stair appears to be a solid, built-in construction integrated with the surrounding floor and wall finishes. Removal of the stair as a whole would therefore be expected to be destructive; only individual surface units may be selectively recoverable.
Reuse Feasibility	[X] A plausible reuse route exists for some recovered material [ ] A specific receiving project or use is already confirmed [X] Recovered material would require sorting / cleaning / processing	**Score: 1** 0 / 1 / 2	A plausible secondary reuse route exists for intact paving units or mineral material recovered during dismantling, but reuse of the stair as a complete element is not realistic and no receiving application is confirmed.
Information Confidence	[X] Photographic and visual documentation is available [ ] Dimensions and material data are recorded [ ] Internal construction / substrate is confirmed	**Score: 1** 0 / 1 / 2	The external form and visible condition are documented by two photographs, but the exact structural material, internal build-up, dimensions and bonding of the surface

	[X] Further investigation would be needed before a confident classification		finish are not confirmed.

4. Reuse / Recovery Observations			
Observed recovery constraints	Built-in solid construction; integration with adjacent veranda floor and wall; likely destructive demolition of the stair body; local wear and cracking; uncertain substrate and bonding.	**Possible reuse context**	Selective reuse of intact paving units may be possible. Crushed or separated mineral material could potentially be reused after processing, subject to material identification.
Interfaces / adjoining materials	Adjacent veranda paving; wall/render finish; stair substrate; joints and bedding beneath the visible surface units.	**Other relevant observations (qualitative notes only — no calculated scores)**	TRACE score: 3 / 8 — End of Life for the stair as a complete element. This does not exclude selective recovery of individual surface units or material fractions.

5. Photographic Record	
Photo 1	Photo 2
 *Exterior veranda stair — overall view and relationship with adjoining floor levels*	 *Exterior stair — close view of treads, paving finish and visible surface wear*

Level 2 Field Assessment Sheet

In-situ building survey

1. Survey and Element Identification			
Survey date	24/06/2026	**Assessor**	Author
Building / case study	Fazenda Ribeiro	**Element reference**	W-01
Level / storey	Ground floor	**Room / zone / grid**	Exterior façade / wall section
Element category	Wall	**Element type / description**	Rendered adobe wall section with external door opening

2. In-situ Physical Information			
Primary material	Adobe / earthen masonry	**Finish / secondary material**	Painted render/plaster; local repair patches
Approx. dimensions	—	**Units**	—
Current use / function	External enclosure / load-bearing wall	**Current state**	[X] In use [ ] Unused [X] Damaged [ ] Other
Visible condition	[ ] Good [X] Fair [ ] Poor	**Visible defects**	Extensive render loss and detachment; surface cracking; exposed substrate; weathering and dark staining; vegetation at base.
Repairable on visual inspection?	[X] Yes [ ] No [ ] Uncertain	**Reusable on visual inspection?**	[ ] Yes [ ] No [X] Uncertain

3. Level 2 Assessment — In-situ Criteria (TRACE Protocol)			
Criterion	**Points to check (tick all that apply)**	**Score**	**Field observation / justification**
Physical Integrity	[ ] Material/element is structurally coherent	**Score: 1**	Wall remains standing and generally coherent, but visible render loss,

	and intact **[X] Visible cracks, losses, or structural weaknesses are present** [ ] Element would likely survive removal without collapse or major loss	*0/1/2*	cracking and local exposure indicate moderate, potentially repairable deterioration.
Recoverability	[ ] Element/material can be recovered in whole or usable units [ ] Removal is likely to be controlled rather than destructive **[X] Monolithic or composite construction limits clean separation** **[X] Fragmentation or material loss is expected during removal**	**Score: 1** *0/1/2*	Selective recovery appears possible only through careful/manual dismantling. Whole-section removal would likely cause fragmentation or minor material loss.
Reuse Feasibility	**[X] A plausible reuse route exists for the recovered material** [ ] A specific receiving project or use is already confirmed [ ] Recovered material would require processing or treatment before reuse	**Score: 1** *0/1/2*	A plausible reuse route exists for recovered adobe blocks/fragments or compatible earthen repair material, but no specific receiving project is confirmed.
Information Confidence	**[X] Photographic and visual documentation is available** [ ] Dimensions and material data are recorded [ ] Material testing or detailed condition survey has been carried out **[X] Further investigation would be needed before a confident classification**	**Score: 1** *0/1/2*	Photographic and visual evidence is available, but dimensions, material testing and detailed condition measurements for this wall section are not recorded here.

4. Reuse / Recovery Observations			
Observed recovery constraints	Monolithic construction; risk of fragmentation during removal; weathered/exposed areas; uncertain hidden condition;	**Possible reuse context**	Heritage repair, reconstruction or adaptive reuse using recovered adobe units/fragments or compatible

	vegetation and surface deterioration at base.		earthen material.
Interfaces / adjoining materials	Rendered adobe wall; door opening/frame; plaster/render layers; adjoining wall and roof/parapet construction.	**Other relevant observations (qualitative notes only — no calculated scores)**	Local repair is visually feasible. Removal should be preceded by measurement and material-condition verification.

5. Photographic Record

Photo 1	**Photo 2**
 *Wall section, door opening, frontal view*	 *Wall section, oblique view showing adjoining roofline*

APPENDIX 4: COMPLETE EXPORTED DATASET (EXCEL)

Table 4.1 – Complete Level 1 dataset (Doors)

Passport ID	IFC Class	Original Category	Current Use	Lifecycle State	Assessment Method	Installation Date	Reuse Count
MP-SJM-2026-0001	Doors	IfcDoor	IfcDoor	In Use	DisassemblyPotential	c.1820	0
MP-SJM-2026-0002	Doors	IfcDoor	IfcDoor	In Use	DisassemblyPotential	c.1820	0
MP-SJM-2026-0003	Doors	IfcDoor	IfcDoor	In Use	DisassemblyPotential	c.1820	0
MP-SJM-2026-0004	Doors	IfcDoor	IfcDoor	In Use	DisassemblyPotential	c.1820	0
MP-SJM-2026-0005	Doors	IfcDoor	IfcDoor	In Use	DisassemblyPotential	c.1820	0
MP-SJM-2026-0006	Doors	IfcDoor	IfcDoor	In Use	DisassemblyPotential	c.1820	0
MP-SJM-2026-0007	Doors	IfcDoor	IfcDoor	In Use	DisassemblyPotential	c.1820	0
MP-SJM-2026-0008	Doors	IfcDoor	IfcDoor	In Use	DisassemblyPotential	c.1820	0
MP-SJM-2026-0009	Doors	IfcDoor	IfcDoor	In Use	DisassemblyPotential	c.1820	0
MP-SJM-2026-0010	Doors	IfcDoor	IfcDoor	In Use	DisassemblyPotential	c.1820	0
MP-SJM-2026-0011	Doors	IfcDoor	IfcDoor	In Use	DisassemblyPotential	c.1820	0
MP-SJM-2026-0012	Doors	IfcDoor	IfcDoor	In Use	Durmisevic_DDF	c.1820	0
MP-SJM-2026-0013	Doors	IfcDoor	IfcDoor	In Use	DisassemblyPotential	c.1820	0

Table 4.2 – Complete Level 1 dataset (Doors)

			DfD BIM Library — Level 1 — Disass
Passport ID	Project	Location	Lifecycle History
MP-SJM-2026-0001	Fazenda São José de Mipibu — Field Survey 2025	Main House | Ground Floor | Main Entrance to Living Room	[c.1820] Initial installation — Fazenda SJM, Main Entrance to Living Room, Ground Floor
MP-SJM-2026-0002	Fazenda São José de Mipibu — Field Survey 2025	Main House | Ground Floor | Main Entrance to Bedroom	[c.1820] Initial installation — Fazenda SJM, Main Entrance to Bedroom, Ground Floor
MP-SJM-2026-0003	Fazenda São José de Mipibu — Field Survey 2025	Main House | Ground Floor | Main Entrance to Bedroom	[c.1820] Initial installation — Fazenda SJM, Main Entrance to Bedroom, Ground Floor
MP-SJM-2026-0004	Fazenda São José de Mipibu — Field Survey 2025	Main House | Ground Floor | Lateral Entrance to Bedroom	[c.1820] Initial installation — Fazenda SJM, Lateral Entrance to Bedroom, Ground Floor
MP-SJM-2026-0005	Fazenda São José de Mipibu — Field Survey 2025	Main House | Ground Floor | Lateral Entrance to Bedroom	[c.1820] Initial installation — Fazenda SJM, Lateral Entrance to Bedroom, Ground Floor
MP-SJM-2026-0006	Fazenda São José de Mipibu — Field Survey 2025	Main House | Ground Floor | Lateral Entrance to Kitchen	[c.1820] Initial installation — Fazenda SJM, Lateral Entrance to Kitchen, Ground Floor
MP-SJM-2026-0007	Fazenda São José de Mipibu — Field Survey 2025	Main House | Ground Floor | Back Entrance	[c.1820] Initial installation — Fazenda SJM, Back Entrance, Ground Floor
MP-SJM-2026-0008	Fazenda São José de Mipibu — Field Survey 2025	Main House | Ground Floor | Living Room to Bedroom	[c.1820] Initial installation — Fazenda SJM, Living Room to Bedroom, Ground Floor
MP-SJM-2026-0009	Fazenda São José de Mipibu — Field Survey 2025	Main House | Ground Floor | Living Room to Bedroom	[c.1820] Initial installation — Fazenda SJM, Living Room to Bedroom, Ground Floor
MP-SJM-2026-0010	Fazenda São José de Mipibu — Field Survey 2025	Main House | Ground Floor | Bedroom to Dining Room	[c.1820] Initial installation — Fazenda SJM, Bedroom to Dining Room, Ground Floor
MP-SJM-2026-0011	Fazenda São José de Mipibu — Field Survey 2025	Main House | Ground Floor | Bedroom to Dining Room	[c.1820] Initial installation — Fazenda SJM, Bedroom to Dining Room, Ground Floor
MP-SJM-2026-0012	Fazenda São José de Mipibu — Field Survey 2025	Main House | Ground Floor | Dining Room to Bathroom	[c.1820] Initial installation — Fazenda SJM, Dining Room to Bathroom, Ground Floor
MP-SJM-2026-0013	Fazenda São José de Mipibu — Field Survey 2025	Main House | Ground Floor | Corridor to Bedroom	[c.1820] Initial installation — Fazenda SJM, Corridor to Bedroom, Ground Floor

Table 4.3 – Complete Level 1 dataset (Doors)

embly Potential — Doors | Fazenda SJM 1820 | 13 element(s)								
Passport ID	Expected Service Life	Connection Type	CT Score	CA Score	ID Score	GPE Score	Disassembly Score	Disassembly Class
MP-SJM-2026-0001	200+ years (colonial door, c.1820, still in use 2025)	bolted	0.8	0.8	1	0.4	0.66666666666	B
MP-SJM-2026-0002	200+ years (colonial door, c.1820, still in use 2025)	bolted	0.8	0.6	1	0.4	0.62337662337	B
MP-SJM-2026-0003	200+ years (colonial door, c.1820, still in use 2025)	bolted	0.8	0.6	1	0.4	0.62337662337	B
MP-SJM-2026-0004	200+ years (colonial door, c.1820, still in use 2025)	bolted	0.8	0.6	1	0.4	0.62337662337	B
MP-SJM-2026-0005	200+ years (colonial door, c.1820, still in use 2025)	bolted	0.8	0.6	1	0.4	0.62337662337	B
MP-SJM-2026-0006	200+ years (colonial door, c.1820, still in use 2025)	bolted	0.8	0.6	1	0.4	0.62337662337	B
MP-SJM-2026-0007	200+ years (colonial door, c.1820, still in use 2025)	bolted	0.8	0.6	1	0.4	0.62337662337	B
MP-SJM-2026-0008	200+ years (colonial door, c.1820, still in use 2025)	bolted	0.8	0.6	1	0.4	0.62337662337	B
MP-SJM-2026-0009	200+ years (colonial door, c.1820, still in use 2025)	bolted	0.8	0.6	1	0.4	0.62337662337	B
MP-SJM-2026-0010	200+ years (colonial door, c.1820, still in use 2025)	bolted	0.8	0.6	1	0.4	0.62337662337	B
MP-SJM-2026-0011	200+ years (colonial door, c.1820, still in use 2025)	bolted	0.8	0.6	1	0.4	0.62337662337	B
MP-SJM-2026-0012	200+ years (colonial door, c.1820, still in use 2025)	bolted	0.8	0.6	1	0.4	0.7	B
MP-SJM-2026-0013	200+ years (colonial door, c.1820, still in use 2025)	bolted	0.8	0.6	1	0.4	0.62337662337	B

Table 4.4 – Complete Level 1 dataset (Doors)

Passport ID	Reusable	Repairable	Width (mm)	Height (mm)	IFC GUID	Element Name
MP-SJM-2026-0001	Yes	Yes			5aa8b0fd-9eeb-4020-b703-4d216e8cea49-0005c0a6	DfD_Door_Colonial_SJM_1820_Exterior_Double
MP-SJM-2026-0002	Yes	Yes			5aa8b0fd-9eeb-4020-b703-4d216e8cea49-0005c148	DfD_Door_Colonial_SJM_1820_Exterior_Single
MP-SJM-2026-0003	Yes	Yes			5aa8b0fd-9eeb-4020-b703-4d216e8cea49-0005c18d	DfD_Door_Colonial_SJM_1820_Exterior_Single_02
MP-SJM-2026-0004	Yes	Yes			5aa8b0fd-9eeb-4020-b703-4d216e8cea49-0005cf9f	DfD_Door_Colonial_SJM_1820_Exterior_Single_03
MP-SJM-2026-0005	Yes	Yes			5aa8b0fd-9eeb-4020-b703-4d216e8cea49-0005d005	DfD_Door_Colonial_SJM_1820_Exterior_Single_04
MP-SJM-2026-0006	Yes	Yes			5aa8b0fd-9eeb-4020-b703-4d216e8cea49-0005d0cf	DfD_Door_Colonial_SJM_1820_Exterior_Single_05
MP-SJM-2026-0007	Yes	Yes			5aa8b0fd-9eeb-4020-b703-4d216e8cea49-0005d161	DfD_Door_Colonial_SJM_1820_Exterior_Single_06
MP-SJM-2026-0008	Yes	Yes			8e9e3af1-8108-46e7-a611-feb9d8a08256-00065b0c	DfD_Door_Colonial_SJM_1820_Interior_Single
MP-SJM-2026-0009	Yes	Yes			8e9e3af1-8108-46e7-a611-feb9d8a08256-000668d7	DfD_Door_Colonial_SJM_1820_Interior_Single_02
MP-SJM-2026-0010	Yes	Yes			8e9e3af1-8108-46e7-a611-feb9d8a08256-000677e7	DfD_Door_Colonial_SJM_1820_Interior_Single_03
MP-SJM-2026-0011	Yes	Yes			8e9e3af1-8108-46e7-a611-feb9d8a08256-000685ad	DfD_Door_Colonial_SJM_1820_Interior_Single_04
MP-SJM-2026-0012	Yes	Yes			8e9e3af1-8108-46e7-a611-feb9d8a08256-0006935e	DfD_Door_Colonial_SJM_1820_Interior_Single_05
MP-SJM-2026-0013	Yes	Yes			8e9e3af1-8108-46e7-a611-feb9d8a08256-0006a16e	DfD_Door_Colonial_SJM_1820_Interior_Single_06

Table 4.5 – Complete Level 1 dataset (Roof)

Passport ID	IFC Class	Original Category	Current Use	Lifecycle State	Assessment Method
MP-SJM-2026-0063	Roofs	IfcCovering	IfcCovering	In Use	Disassembly_Potential
MP-SJM-2026-0080	Roofs	IfcCovering	IfcCovering	In Use	Disassembly_Potential
MP-SJM-2026-0085	Roofs	IfcCovering	IfcCovering	In Use	Disassembly_Potential
MP-SJM-2026-0086	Roofs	IfcCovering	IfcCovering	In Use	Disassembly_Potential
MP-SJM-2026-0077	Roofs	IfcCovering	IfcCovering	In Use	Disassembly_Potential
MP-SJM-2026-0087	Roofs	IfcCovering	IfcCovering	In Use	Disassembly_Potential
MP-SJM-2026-0088	Roofs	IfcCovering	IfcCovering	In Use	Disassembly_Potential
MP-SJM-2026-0089	Roofs	IfcCovering	IfcCovering	In Use	Disassembly_Potential
MP-SJM-2026-0090	Roofs	IfcCovering	IfcCovering	In Use	Disassembly_Potential
MP-SJM-2026-0083	Roofs	IfcCovering	IfcCovering	In Use	Disassembly_Potential
MP-SJM-2026-0084	Roofs			In Use	Disassembly_Potential
MP-SJM-2026-0070	Roofs	IfcCovering	IfcCovering	In Use	Disassembly_Potential
MP-SJM-2026-0069	Roofs	IfcCovering	IfcCovering	In Use	Disassembly_Potential
MP-SJM-2026-0068	Roofs	IfcCovering	IfcCovering	In Use	Disassembly_Potential
MP-SJM-2026-0067	Roofs	IfcCovering	IfcCovering	In Use	Disassembly_Potential
MP-SJM-2026-0066	Roofs	IfcCovering	IfcCovering	In Use	Disassembly_Potential
MP-SJM-2026-0065	Roofs	IfcCovering	IfcCovering	In Use	Disassembly_Potential

Table 4.6 – Complete Level 1 dataset (Roof)

Passport ID	IFC Class	Original Category	Current Use	Lifecycle State	Assessment Method
MP-SJM-2026-0064	Roofs	IfcCovering	IfcCovering	In Use	Disassembly_Potential
MP-SJM-2026-0081	Roofs	IfcCovering	IfcCovering	In Use	Disassembly_Potential
MP-SJM-2026-0082	Roofs	IfcCovering	IfcCovering	In Use	Disassembly_Potential

Table 4.7 – Complete Level 1 dataset (Roof)

Passport ID	Installation Date	Reuse Count	Project
MP-SJM-2026-0063	[c.1820] Initial installation - Fazenda SJM, Reused in 2010 at the same house	1	Fazenda São José de Mipibu - Field Survey 2025
MP-SJM-2026-0080	[c.1820] Initial installation - Fazenda SJM, Reused in 2010 at the same house	1	Fazenda São José de Mipibu - Field Survey 2025
MP-SJM-2026-0085	[c.2010] Initial installation - Fazenda SJM	0	Fazenda São José de Mipibu - Field Survey 2025
MP-SJM-2026-0086	[c.2010] Initial installation - Fazenda SJM	0	Fazenda São José de Mipibu - Field Survey 2025
MP-SJM-2026-0077	[c.2010] Initial installation - Fazenda SJM	0	Fazenda São José de Mipibu - Field Survey 2025
MP-SJM-2026-0087	[c.2010] Initial installation - Fazenda SJM	0	Fazenda São José de Mipibu - Field Survey 2025
MP-SJM-2026-0088	[c.2010] Initial installation - Fazenda SJM	0	Fazenda São José de Mipibu - Field Survey 2025
MP-SJM-2026-0089	[c.2010] Initial installation - Fazenda SJM	0	Fazenda São José de Mipibu - Field Survey 2025
MP-SJM-2026-0090	[c.2010] Initial installation - Fazenda SJM	0	Fazenda São José de Mipibu - Field Survey 2025
MP-SJM-2026-0083	[c.1820] Initial installation - Fazenda SJM, Reused in 2010 at the same house	1	Fazenda São José de Mipibu - Field Survey 2025
MP-SJM-2026-0084	[c.1820] Initial installation - Fazenda SJM, Reused in 2010 at the same house	0	Fazenda São José de Mipibu - Field Survey 2025
MP-SJM-2026-0070	[c.1820] Initial installation - Fazenda SJM, Reused in 2010 at the same house	1	Fazenda São José de Mipibu - Field Survey 2025
MP-SJM-2026-0069	[c.1820] Initial installation - Fazenda SJM, Reused in 2010 at the same house	1	Fazenda São José de Mipibu - Field Survey 2025
MP-SJM-2026-0068	[c.1820] Initial installation - Fazenda SJM, Reused in 2010 at the same house	0	Fazenda São José de Mipibu - Field Survey 2025
MP-SJM-2026-0067	[c.1820] Initial installation - Fazenda SJM, Reused in 2010 at the same house	0	Fazenda São José de Mipibu - Field Survey 2025
MP-SJM-2026-0066	[c.1820] Initial installation - Fazenda SJM, Reused in 2010 at the same house	1	Fazenda São José de Mipibu - Field Survey 2025
MP-SJM-2026-0065	[c.1820] Initial installation - Fazenda SJM, Reused in 2010 at the same house	1	Fazenda São José de Mipibu - Field Survey 2025

Table 4.8 – Complete Level 1 dataset (Roof)

Passport ID	Installation Date	Reuse Count	Project
MP-SJM-2026-0064	[c.2010] Initial installation - Fazenda SJM	0	Fazenda São José de Mipibu - Field Survey 2025
MP-SJM-2026-0081	[c.2010] Initial installation - Fazenda SJM	0	Fazenda São José de Mipibu - Field Survey 2025
MP-SJM-2026-0082	[c.1820] Initial installation - Fazenda SJM, Reused in 2010 at the same house	1	Fazenda São José de Mipibu - Field Survey 2025

Table 4.9 – Complete Level 1 dataset (Roof)

Ɗ BIM Library — Level 1 — Disassembly Potential — Roofs | Fazenda SJM 1820 | 20 element(s)					
Passport ID	Location	Lifecycle History	Expected Service Life	Connection Type	CT Score
MP-SJM-2026-0063	Main House	[c.1820] Initial installation - Fazenda SJM, Reused in 2010 at the same house	50+ years		0.5
MP-SJM-2026-0080	Main House	[c.1820] Initial installation - Fazenda SJM, Reused in 2010 at the same house	50+ years		0.5
MP-SJM-2026-0085	Main House - Veranda and kitchen	[c.2010] Initial installation - Fazenda SJM	50+ years	bolted	0.5
MP-SJM-2026-0086	Main House - Veranda and kitchen	[c.2010] Initial installation - Fazenda SJM	50+ years	bolted	0.5
MP-SJM-2026-0077	Main house	[c.2010] Initial installation - Fazenda SJM	+50 years		0.5
MP-SJM-2026-0087	Main House - Veranda and kitchen	[c.2010] Initial installation - Fazenda SJM	50+ years	bolted	0.5
MP-SJM-2026-0088	Main House - Veranda and kitchen	[c.2010] Initial installation - Fazenda SJM	50+ years	bolted	0.5
MP-SJM-2026-0089	Main House - Veranda and kitchen	[c.2010] Initial installation - Fazenda SJM	50+ years	bolted	0.5
MP-SJM-2026-0090	Main House - Veranda and kitchen	[c.2010] Initial installation - Fazenda SJM	50+ years	bolted	0.5
MP-SJM-2026-0083	Main House - Veranda and kitchen	[c.1820] Initial installation - Fazenda SJM, Reused in 2010 at the same house	200+ years	dry_click	1
MP-SJM-2026-0084	Main House - Veranda and kitchen		200+ years	dry_click	1
MP-SJM-2026-0070	Main House	[c.1820] Initial installation - Fazenda SJM, Reused in 2010 at the same house	50+ years		0.5
MP-SJM-2026-0069	Main House	[c.1820] Initial installation - Fazenda SJM, Reused in 2010 at the same house	50+ years		0.5
MP-SJM-2026-0068	Main House	[c.1820] Initial installation - Fazenda SJM, Reused in 2010 at the same house	50+ years		0.5
MP-SJM-2026-0067	Main House	[c.1820] Initial installation - Fazenda SJM, Reused in 2010 at the same house	50+ years		0.5
MP-SJM-2026-0066	Main House	[c.1820] Initial installation - Fazenda SJM, Reused in 2010 at the same house	200+ years		1
MP-SJM-2026-0065	Main House - Veranda and kitchen	[c.1820] Initial installation - Fazenda SJM, Reused in 2010 at the same house	200+ years		1

Table 4.10 – Complete Level 1 dataset (Roof)

Ɗ BIM Library — Level 1 — Disassembly Potential — Roofs | Fazenda SJM 1820 | 20 element(s)					
Passport ID	Location	Lifecycle History	Expected Service Life	Connection Type	CT Score
MP-SJM-2026-0064	Main House	[c.2010] Initial installation - Fazenda SJM	+50 years		0.5
MP-SJM-2026-0081	Main House	[c.2010] Initial installation - Fazenda SJM	50+ years		0.5
MP-SJM-2026-0082	Main House - Veranda and kitchen	[c.1820] Initial installation - Fazenda SJM, Reused in 2010 at the same house	200+ years		1

Table 4.11 – Complete Level 1 dataset (Roof)

Passport ID	CA Score	ID Score	GPE Score	Disassembly Score	Disassembly Class	Reusable	Repairable	Width (mm)	Height (mm)
MP-SJM-2026-0063	0.8	0.4	0.7	1	A — Excellent	Yes	Yes		
MP-SJM-2026-0080	0.8	0.4	0.7	1	A — Excellent	Yes	Yes		
MP-SJM-2026-0085	0.8	1	0.7	0.622	B — Good	Yes	Yes		
MP-SJM-2026-0086	0.8	1	0.7	0.622	B — Good	Yes	Yes		
MP-SJM-2026-0077	0.8	0.4	0.7	1	A — Excellent	Yes	Yes		
MP-SJM-2026-0087	0.8	1	0.7	0.622	B — Good	Yes	Yes		
MP-SJM-2026-0088	0.8	1	0.7	0.622	B — Good	Yes	Yes		
MP-SJM-2026-0089	0.8	1	0.7	0.622	B — Good	Yes	Yes		
MP-SJM-2026-0090	0.8	1	0.7	0.622	B — Good	Yes	Yes		
MP-SJM-2026-0083	1	1	1	1	A — Excellent	Yes	Yes		
MP-SJM-2026-0084	1	1	1	0.903	A — Excellent	Yes	Yes		
MP-SJM-2026-0070	0.8	0.4	0.7	1	A — Excellent	Yes	Yes		
MP-SJM-2026-0069	0.8	0.4	0.7	1	A — Excellent	Yes	Yes		
MP-SJM-2026-0068	0.8	0.4	0.7	1	A — Excellent	Yes	Yes		
MP-SJM-2026-0067	0.8	0.4	0.7	1	A — Excellent	Yes	Yes		
MP-SJM-2026-0066	1	1	1	1	A — Excellent	Yes	Yes		
MP-SJM-2026-0065	1	1	1	1	A — Excellent	Yes	Yes		

Table 4.12 – Complete Level 1 dataset (Roof)

Passport ID	CA Score	ID Score	GPE Score	Disassembly Score	Disassembly Class	Reusable	Repairable	Width (mm)	Height (mm)
MP-SJM-2026-0064	0.8	0.4	0.7	1	A — Excellent	Yes	Yes		
MP-SJM-2026-0081	0.8	0.4	0.7	1	A — Excellent	Yes	Yes		
MP-SJM-2026-0082	1	1	1	1	A — Excellent	Yes	Yes		

Table 4.13 – Complete Level 1 dataset (Roof)

Passport ID	IFC GUID	Element Name
MP-SJM-2026-0063	de19ff30-9a38-4030-b604-2dd12d745d3f-0005069a	DfD_Purlin_Colonial_SJM_1820_Structural_Longitudinal
MP-SJM-2026-0080	de19ff30-9a38-4030-b604-2dd12d745d3f-0005073f	DfD_Purlin_Colonial_SJM_1820_Structural_Longitudinal
MP-SJM-2026-0085	de19ff30-9a38-4030-b604-2dd12d745d3f-000509e0	DfD_Purlin_Colonial_SJM_1820_Structural_Longitudinal
MP-SJM-2026-0086	de19ff30-9a38-4030-b604-2dd12d745d3f-00050c04	DfD_Purlin_Colonial_SJM_1820_Structural_Longitudinal
MP-SJM-2026-0077	de19ff30-9a38-4030-b604-2dd12d745d3f-00051001	DfD_Purlin_Colonial_SJM_1820_Structural_Longitudinal
MP-SJM-2026-0087	5e225826-70f9-4ba2-ab53-03994de0e9f0-0009bce7	DfD_Rafter_Colonial_SJM_1820_Structural_Sloped
MP-SJM-2026-0088	5e225826-70f9-4ba2-ab53-03994de0e9f0-0009bced	DfD_Rafter_Colonial_SJM_1820_Structural_Sloped
MP-SJM-2026-0089	5e225826-70f9-4ba2-ab53-03994de0e9f0-0009bd08	DfD_Batten_Colonial_SJM_2010_Structural_Spaced
MP-SJM-2026-0090	5e225826-70f9-4ba2-ab53-03994de0e9f0-0009bd0e	DfD_Batten_Colonial_SJM_2010_Structural_Spaced
MP-SJM-2026-0083	5e225826-70f9-4ba2-ab53-03994de0e9f0-0009bd23	DfD_Tile_Colonial_SJM_1820_Covering_CapaCanal
MP-SJM-2026-0084	5e225826-70f9-4ba2-ab53-03994de0e9f0-0009bd29	DfD_Tile_Colonial_SJM_1820_Covering_CapaCanal
MP-SJM-2026-0070	5e225826-70f9-4ba2-ab53-03994de0e9f0-0009c562	DfD_Batten_Colonial_SJM_2010_Structural_Spaced
MP-SJM-2026-0069	5e225826-70f9-4ba2-ab53-03994de0e9f0-0009c569	DfD_Batten_Colonial_SJM_2010_Structural_Spaced
MP-SJM-2026-0068	5e225826-70f9-4ba2-ab53-03994de0e9f0-0009c57d	DfD_Rafter_Colonial_SJM_1820_Structural_Sloped
MP-SJM-2026-0067	5e225826-70f9-4ba2-ab53-03994de0e9f0-0009c584	DfD_Rafter_Colonial_SJM_1820_Structural_Sloped
MP-SJM-2026-0066	5e225826-70f9-4ba2-ab53-03994de0e9f0-0009c599	DfD_Tile_Colonial_SJM_1820_Covering_CapaCanal
MP-SJM-2026-0065	5e225826-70f9-4ba2-ab53-03994de0e9f0-0009c5a0	DfD_Tile_Colonial_SJM_1820_Covering_CapaCanal

Table 4.14 – Complete Level 1 dataset (Roof)

Passport ID	IFC GUID	Element Name
MP-SJM-2026-0064	5e225826-70f9-4ba2-ab53-03994de0e9f0-0009cf77	DfD_Rafter_Colonial_SJM_1820_Structural_Sloped
MP-SJM-2026-0081	5e225826-70f9-4ba2-ab53-03994de0e9f0-0009cf8a	DfD_Batten_Colonial_SJM_2010_Structural_Spaced
MP-SJM-2026-0082	5e225826-70f9-4ba2-ab53-03994de0e9f0-0009cf9d	DfD_Tile_Colonial_SJM_1820_Covering_CapaCanal

Table 4.15 – Complete Level 1 dataset (Window)

Passport ID	IFC Class	Original Category	Current Use	Lifecycle State	Assessment Method	Installation Date	Reuse Count
MP-SJM-2026-0014	Windows	IfcWindow	IfcWindow	In Use	DisassemblyPotential	c.1820	0
MP-SJM-2026-0015	Windows	IfcWindow	IfcWindow	In Use	DisassemblyPotential	c.1820	0
MP-SJM-2026-0016	Windows	IfcWindow	IfcWindow	In Use	DisassemblyPotential	c.1820	0
MP-SJM-2026-0017	Windows	IfcWindow	IfcWindow	In Use	DisassemblyPotential	c.1820	0
MP-SJM-2026-0018	Windows	IfcWindow	IfcWindow	In Use	DisassemblyPotential	c.1820	0
MP-SJM-2026-0019	Windows	IfcWindow	IfcWindow	In Use	DisassemblyPotential	c.1820	0
MP-SJM-2026-0020	Windows	IfcWindow	IfcWindow	In Use	DisassemblyPotential	c.1820	0
MP-SJM-2026-0021	Windows	IfcWindow	IfcWindow	In Use	DisassemblyPotential	c.1820	0
MP-SJM-2026-0022	Windows	IfcWindow	IfcWindow	In Use	DisassemblyPotential	c.1820	0

Table 4.16 – Complete Level 1 dataset (Window)

DfD BIM Library — Level 1 — Disasser			
Passport ID	Project	Location	Lifecycle History
MP-SJM-2026-0014	Fazenda São José de Mipibu — Field Survey 2025	Main House | Ground Floor | Main Entrance to Living Room	[c.1820] Initial installation — Fazenda SJM, [localização], Ground Floor
MP-SJM-2026-0015	Fazenda São José de Mipibu — Field Survey 2025	Main House | Ground Floor | Main Entrance to Living Room	[c.1820] Initial installation — Fazenda SJM, Main Entrance to Living Room, Ground Floor
MP-SJM-2026-0016	Fazenda São José de Mipibu — Field Survey 2025	Main House | Ground Floor | Side Entrance to Bedroom	[c.1820] Initial installation — Fazenda SJM, Side Entrance to Bedroom, Ground Floor
MP-SJM-2026-0017	Fazenda São José de Mipibu — Field Survey 2025	Main House | Ground Floor | Side Entrance to Bedroom	[c.1820] Initial installation — Fazenda SJM, Side Entrance to Bedroom, Ground Floor
MP-SJM-2026-0018	Fazenda São José de Mipibu — Field Survey 2025	Main House | Ground Floor | Side Entrance to Bedroom	[c.1820] Initial installation — Fazenda SJM, Side Entrance to Bedroom, Ground Floor
MP-SJM-2026-0019	Fazenda São José de Mipibu — Field Survey 2025	Main House | Ground Floor | Side Entrance to Bedroom	[c.1820] Initial installation — Fazenda SJM, Side Entrance to Bedroom, Ground Floor
MP-SJM-2026-0020	Fazenda São José de Mipibu — Field Survey 2025	Main House | Ground Floor | Side Entrance to Bedroom	[c.1820] Initial installation — Fazenda SJM, Side Entrance to Bedroom, Ground Floor
MP-SJM-2026-0021	Fazenda São José de Mipibu — Field Survey 2025	Main House | Ground Floor | Side Entrance to Kitchen	[c.1820] Initial installation — Fazenda SJM, Side Entrance to Kitchen, Ground Floor
MP-SJM-2026-0022	Fazenda São José de Mipibu — Field Survey 2025	Main House | Ground Floor | Back Façade to Kitchen	[c.1820] Initial installation — Fazenda SJM, Back Façade to Kitchen, Ground Floor

Table 4.17 – Complete Level 1 dataset (Window)

nbly Potential — Windows | Fazenda SJM 1820 | 9 element(s)								
Passport ID	Expected Service Life	Connection Type	CT Score	CA Score	ID Score	GPE Score	Disassembly Score	Disassembly Class
MP-SJM-2026-0014	200+ years (colonial window, c.1820, still in use 2025)	bolted	0.8	0.6	0.4	1	0.62337662337(	B
MP-SJM-2026-0015	200+ years (colonial window, c.1820, still in use 2025)	bolted	0.8	0.6	0.4	1	0.62337662337(	B
MP-SJM-2026-0016	200+ years (colonial window, c.1820, still in use 2025)	bolted	0.8	0.6	0.4	1	0.62337662337(	B
MP-SJM-2026-0017	200+ years (colonial window, c.1820, still in use 2025)	bolted	0.8	0.6	0.4	1	0.62337662337(	B
MP-SJM-2026-0018	200+ years (colonial window, c.1820, still in use 2025)	bolted	0.8	0.8	0.4	1	0.66666666666	B
MP-SJM-2026-0019	200+ years (colonial window, c.1820, still in use 2025)	bolted	0.8	0.6	0.4	1	0.62337662337(	B
MP-SJM-2026-0020	200+ years (colonial window, c.1820, still in use 2025)	bolted	0.8	0.8	0.4	1	0.66666666666	B
MP-SJM-2026-0021	200+ years (colonial window, c.1820, still in use 2025)	bolted	0.8	0.6	0.4	1	0.62337662337(	B
MP-SJM-2026-0022	200+ years (colonial window, c.1820, still in use 2025)	bolted	0.8	0.6	0.4	1	0.62337662337(	B

Table 4.18 – Complete Level 1 dataset (Window)

Passport ID	Reusable	Repairable	Width (mm)	Height (mm)	IFC GUID	Element Name
MP-SJM-2026-0014	Yes	Yes			c1404a24-b571-450f-9e4e-36514ec01964-0006afce	DfD_Window_Colonial_SJM_1820_Exterior_Single
MP-SJM-2026-0015	Yes	Yes			c1404a24-b571-450f-9e4e-36514ec01964-0006cd77	DfD_Window_Colonial_SJM_1820_Exterior_Single_02
MP-SJM-2026-0016	Yes	Yes			c1404a24-b571-450f-9e4e-36514ec01964-00070a8b	DfD_Window_Colonial_SJM_1820_Exterior_Single_03
MP-SJM-2026-0017	Yes	Yes			c1404a24-b571-450f-9e4e-36514ec01964-00071877	DfD_Window_Colonial_SJM_1820_Exterior_Single_04
MP-SJM-2026-0018	Yes	Yes			c1404a24-b571-450f-9e4e-36514ec01964-00073439	DfD_Window_Colonial_SJM_1820_Exterior_Single_05
MP-SJM-2026-0019	Yes	Yes			c1404a24-b571-450f-9e4e-36514ec01964-0007423c	DfD_Window_Colonial_SJM_1820_Exterior_Single_06
MP-SJM-2026-0020	Yes	Yes			c1404a24-b571-450f-9e4e-36514ec01964-0007500c	DfD_Window_Colonial_SJM_1820_Exterior_Single_07
MP-SJM-2026-0021	Yes	Yes			c1404a24-b571-450f-9e4e-36514ec01964-00075d9a	DfD_Window_Colonial_SJM_1820_Exterior_Single_08
MP-SJM-2026-0022	Yes	Yes			c1404a24-b571-450f-9e4e-36514ec01964-000779c5	DfD_Window_Colonial_SJM_1820_Exterior_Single_09

Table 4.19 – Complete Level 2 dataset (Column)

Passport ID	IFC Class	Original Category	Current Use	Lifecycle State	Assessment Method	Installation Date	Reuse Count
MP-SJM-2026-0029	Columns	IfcColumn	IfcColumn	In Use	TRACE_Protocol	c. 1820	0
MP-SJM-2026-0030	Columns	IfcColumn	IfcColumn	In Use	TRACE_Protocol	c. 1820	0
MP-SJM-2026-0024	Columns	IfcColumn	IfcColumn	In Use	TRACE_Protocol	c. 1820	0
MP-SJM-2026-0023	Columns	IfcColumn	IfcColumn	In Use	TRACE_Protocol	c. 1820	0
MP-SJM-2026-0025	Columns	IfcColumn	IfcColumn	In Use	TRACE_Protocol	c. 1820	0
MP-SJM-2026-0026	Columns	IfcColumn	IfcColumn	In Use	TRACE_Protocol	c. 1820	0
MP-SJM-2026-0027	Columns	IfcColumn	IfcColumn	In Use	TRACE_Protocol	c. 1820	0
MP-SJM-2026-0028	Columns	IfcColumn	IfcColumn	In Use	TRACE_Protocol	C. 1820	0

Table 4.20 – Complete Level 2 dataset (Column)

DfD BIM Library — Level 2 — TRACE Prot			
Passport ID	**Project**	**Location**	**Lifecycle History**
MP-SJM-2026-0029	Fazenda São José de Mipibu - Field Survey 2025	Main House | Ground Floor | Side Façade	[c.1820] Initial installation - Fazenda SJM, Side Façade
MP-SJM-2026-0030	Fazenda São José de Mipibu - Field Survey 2025	Main House | Ground Floor | Side Façade	[c.1820] Initial installation - Fazenda SJM, Side Façade
MP-SJM-2026-0024	Fazenda São José de Mipibu - Field Survey 2025	Main House | Ground Floor | Side Façade	[c.1820] Initial installation - Fazenda SJM, Side Façade
MP-SJM-2026-0023	Fazenda São José de Mipibu - Field Survey 2025	Main House | Ground Floor | Side Façade	[c.1820] Initial installation - Fazenda SJM, Side Façade
MP-SJM-2026-0025	Fazenda São José de Mipibu - Field Survey 2025	Main House | Ground Floor | Side Façade	[c.1820] Initial installation - Fazenda SJM, Side Façade
MP-SJM-2026-0026	Fazenda São José de Mipibu - Field Survey 2025	Main House | Ground Floor | Side Façade	[c.1820] Initial installation - Fazenda SJM, Side Façade
MP-SJM-2026-0027	Fazenda São José de Mipibu - Field Survey 2025	Main House | Ground Floor | Side Façade	[c.1820] Initial installation - Fazenda SJM, Side Façade
MP-SJM-2026-0028	Fazenda São José de Mipibu - Field Survey 2025	Main House | Ground Floor | Side Façade	[c.1820] Initial installation - Fazenda SJM, Side Façade

Table 4.21 – Complete Level 2 dataset (Column)

ɔcol — Columns | Fazenda SJM 1820 | 8 element(s)								
Passport ID	**Expected Service Life**	**Physical Integrity (0-2)**	**Recoverability (0-2)**	**Reuse Feasibility (0-2)**	**Information Confidence (0-2)**	**TRACE Score (0-8)**	**Recommendation**	**Reusable**
MP-SJM-2026-0029	50+ year (Fire-clay Brick mansory, 2010, still in use)	1	1	1	1	4	Conditional	Yes
MP-SJM-2026-0030	50+ year (Fire-clay Brick mansory, 2010, still in use)	1	1	1	1	4	Conditional	Yes
MP-SJM-2026-0024	50+ year (Fire-clay Brick mansory, 2010, still in use)	1	1	1	1	4	Conditional	Yes
MP-SJM-2026-0023	50+ year (Fire-clay Brick mansory, 2010, still in use)	1	1	1	1	4	Conditional	Yes
MP-SJM-2026-0025	200+ year (adobe column, c. 1820, still in use)	2	2	2	0	6	Material Upcycling	Yes
MP-SJM-2026-0026	50+ year (Fire-clay Brick mansory, 2010, still in use)	1	1	1	1	4	Conditional	Yes
MP-SJM-2026-0027	50+ year (Fire-clay Brick mansory, 2010, still in use)	1	1	1	1	4	Conditional	Yes
MP-SJM-2026-0028	50+ year (Fire-clay Brick mansory, 2010, still in use)	1	1	1	1	4	Conditional	Yes

Table 4.22 – Complete Level 2 dataset (Column)

Passport ID	**Repairable**	**Width (mm)**	**Height (mm)**	**IFC GUID**	**Element Name**
MP-SJM-2026-0029	Yes			de19ff30-9a38-4030-b604-2dd12d745d3f-000501b4	DfD_Column_Colonial_SJM_2010_Structural_Single
MP-SJM-2026-0030	Yes			de19ff30-9a38-4030-b604-2dd12d745d3f-00050284	DfD_Column_Colonial_SJM_2010_Structural_Single
MP-SJM-2026-0024	Yes			de19ff30-9a38-4030-b604-2dd12d745d3f-000502b4	DfD_Column_Colonial_SJM_2010_Structural_Single
MP-SJM-2026-0023	Yes			de19ff30-9a38-4030-b604-2dd12d745d3f-000502d2	DfD_Column_Colonial_SJM_2010_Structural_Single
MP-SJM-2026-0025	Yes			de19ff30-9a38-4030-b604-2dd12d745d3f-000502f7	DfD_Column_Colonial_SJM_2010_Structural_Single
MP-SJM-2026-0026	Yes			de19ff30-9a38-4030-b604-2dd12d745d3f-0005030f	DfD_Column_Colonial_SJM_2010_Structural_Single
MP-SJM-2026-0027	Yes			de19ff30-9a38-4030-b604-2dd12d745d3f-0005031b	DfD_Column_Colonial_SJM_2010_Structural_Single
MP-SJM-2026-0028	Yes			de19ff30-9a38-4030-b604-2dd12d745d3f-00050325	DfD_Column_Colonial_SJM_2010_Structural_Single

Table 7.23 – Complete Level 2 dataset (Floor)

Passport ID	IFC Class	Original Category	Current Use	Lifecycle State	Assessment Method	Installation Date	Reuse Count
MP-SJM-2026-0031	Floors	IfcFloor	IfcFloor	In Use	TRACE_Protocol	c.1820	0
MP-SJM-2026-0032	Floors	IfcFloor	IfcFloor	In Use	TRACE_Protocol	c.1820	0
MP-SJM-2026-0093	Floors	IfcFloor	IfcFloor	In Use	TRACE_Protocol	Unkown	0
MP-SJM-2026-0092	Floors	IfcFloor	IfcFloor	In Use	TRACE_Protocol	Unknown	0

Table 4.24 – Complete Level 2 dataset (Floor)

DfD BIM Library — Level 2 — TRACE Pro			
Passport ID	Project	Location	Lifecycle History
MP-SJM-2026-0031	Fazenda São José de Mipibu - Field Survey 2025	Main House | Ground Floor	[c.1820] Initial installation - Fazenda SJM
MP-SJM-2026-0032	Fazenda São José de Mipibu - Field Survey 2025	Main House | Ground Floor	[c.1820] Initial installation - Fazenda SJM
MP-SJM-2026-0093	Fazenda São José de Mipibu - Field Survey 2025	Main House | Ground Floor	[xxx] Initial installation - Fazenda SJM
MP-SJM-2026-0092	Fazenda São José de Mipibu - Field Survey 2025	Main House | Ground Floor	[xxx] Initial installation - Fazenda SJM

Table4C.25 – Complete Level 2 dataset (Floor)

tocol — Floors | Fazenda SJM 1820 | 4 element(s)									
Passport ID	Expected Service Life	Physical Integrity (0-2)	Recoverability (0-2)	Reuse Feasibility (0-2)	Information Confidence (0-2)	TRACE Score (0-8)	Recommendation	Reusable	Repairable
MP-SJM-2026-0031	200+ years (clay brick, c.1820, still in use 2025)	1	1	1	1	4	Conditional	Yes	Yes
MP-SJM-2026-0032	200+ years (clay brick, c.1820, still in use 2025)	1	1	1	1	4	Conditional	Yes	Yes
MP-SJM-2026-0093	200+ years (stained tile paving, c.1820, still in use 2025)	1	0	1	1	3	End of Life	Yes	Yes
MP-SJM-2026-0092	200+ years (stained tile paving, c.1820, still in use 2025)	1	0	1	1	3	End of Life	Yes	Yes

Table 4.26 – Complete Level 2 dataset (Floor)

Passport ID	Width (mm)	Height (mm)	IFC GUID	Element Name
MP-SJM-2026-0031			de19ff30-9a38-4030-b604-2dd12d745d3f-00050f3b	DfD_Floor_Colonial_SJM_XXXX_Ground_Rammed
MP-SJM-2026-0032			de19ff30-9a38-4030-b604-2dd12d745d3f-00050f9e	DfD_Floor_Colonial_SJM_XXXX_Ground_Rammmed
MP-SJM-2026-0093			4366c131-2fee-4a7a-a878-abbc01b15194-000b1edd	DfD_Floor_Colonial_SJM_XXXX_Ground_Rammed
MP-SJM-2026-0092			4366c131-2fee-4a7a-a878-abbc01b15194-000b1f16	DfD_Floor_Colonial_SJM_XXXX_Ground_Rammmed

Table 4.27 – Complete Level 2 dataset (Stair)

Passport ID	IFC Class	Original Category	Current Use	Lifecycle State	Assessment Method	Installation Date	Reuse Count
MP-SJM-2026-0095	Stairs	IfcStair	IfcStair	In Use	TRACE_Protocol	Unknown	0
MP-SJM-2026-0040	Stairs	IfcDoor	IfcDoor	In Use	TRACE_Protocol	Unkown	0
MP-SJM-2026-0096	Stairs	IfcStair	IfcStair	In Use	TRACE_Protocol	Unknown	0
MP-SJM-2026-0097	Stairs	IfcStair	IfcStair	In Use	TRACE_Protocol	Unknown	0
MP-SJM-2026-0098	Stairs	IfcStair	IfcStair	In Use	TRACE_Protocol	Unknown	0

Table 4.28 – Complete Level 2 dataset (Stair)

DfD BIM Library — Level 2 — TRACE Pro			
Passport ID	Project	Location	Lifecycle History
MP-SJM-2026-0095	Fazenda São José de Mipibu - Field Survey 2025	Main House | Ground Floor	[xxx] Initial installation - Fazenda SJM
MP-SJM-2026-0040	Fazenda São José de Mipibu - Field Survey 2025	Main House | Ground Floor	[xxx] Initial installation - Fazenda SJM
MP-SJM-2026-0096	Fazenda São José de Mipibu - Field Survey 2025	Main House | Ground Floor	[xxx] Initial installation - Fazenda SJM
MP-SJM-2026-0097	Fazenda São José de Mipibu - Field Survey 2025	Main House | Ground Floor	[xxx] Initial installation - Fazenda SJM
MP-SJM-2026-0098	Fazenda São José de Mipibu - Field Survey 2025	Main House | Ground Floor	[xxx] Initial installation - Fazenda SJM

Table 4.29 – Complete Level 2 dataset (Stair)

ɪtocol — Stairs | Fazenda SJM 1820 | 5 element(s)									
Passport ID	Expected Service Life	Physical Integrity (0-2)	Recoverability (0-2)	Reuse Feasibility (0-2)	Information Confidence (0-2)	TRACE Score (0-8)	Recommendation	Reusable	Repairable
MP-SJM-2026-0095	200+ years (stained tile paving, c.1820, still in use 2025)	1	0	1	1	3	End of Life	Yes	Yes
MP-SJM-2026-0040	200+ years (stained tile paving, c.1820, still in use 2025)	1	0	1	1	3	End of Life	Yes	Yes
MP-SJM-2026-0096	200+ years (stained tile paving, c.1820, still in use 2025)	1	0	1	1	3	End of Life	Yes	Yes
MP-SJM-2026-0097	200+ years (stained tile paving, c.1820, still in use 2025)	1	0	1	1	3	End of Life	Yes	Yes
MP-SJM-2026-0098	200+ years (stained tile paving, c.1820, still in use 2025)	1	0	1	1	3	End of Life	Yes	Yes

Table 4.30 – Complete Level 2 dataset (Stair)

Passport ID	Width (mm)	Height (mm)	IFC GUID	Element Name
MP-SJM-2026-0095			de19ff30-9a38-4030-b604-2dd12d745d3f-00051277	DfD_Stair_SJM_xxxx_Ground_Rammed
MP-SJM-2026-0040			de19ff30-9a38-4030-b604-2dd12d745d3f-000514cb	DfD_Stair_SJM_xxxx_Ground_Rammed
MP-SJM-2026-0096			1fd71949-cb75-42a7-9afa-cb959cb3ec8f-00080bad	DfD_Stair_SJM_xxxx_Ground_Rammed
MP-SJM-2026-0097			1fd71949-cb75-42a7-9afa-cb959cb3ec8f-00080d49	DfD_Stair_SJM_xxxx_Ground_Rammed
MP-SJM-2026-0098			dc1f43d7-bed3-4b65-a991-4e95bb23a045-0009a702	DfD_Stair_SJM_xxxx_Ground_Rammed

Table 4.31 – Complete Level 2 dataset (Wall)

Passport ID	IFC Class	Original Category	Current Use	Lifecycle State	Assessment Method	Installation Date	Reuse Count
MP-SJM-2026-0062	Walls	IfcWall	IfcWall	In Use	TRACE_Protocol	c.1820	0
MP-SJM-2026-0043	Walls	IfcWall	IfcWall	In Use	TRACE_Protocol	c.1820	0
MP-SJM-2026-0045	Walls	IfcWall	IfcWall	In Use	TRACE_Protocol	c.1820	0
MP-SJM-2026-0046	Walls	IfcWall	IfcWall	In Use	TRACE_Protocol	c. 1820	0
MP-SJM-2026-0047	Walls	IfcWall	IfcWall	In Use	TRACE_Protocol	c. 1820	0
MP-SJM-2026-0048	Walls	IfcWall	IfcWall	In Use	TRACE_Protocol	c. 1820	0
MP-SJM-2026-0049	Walls	IfcWall	IfcWall	In Use	TRACE_Protocol	c. 1820	0
MP-SJM-2026-0050	Walls	IfcWall	IfcWall	In Use	TRACE_Protocol	c. 1820	0
MP-SJM-2026-0053	Walls	IfcWall	IfcWall	In Use	TRACE_Protocol	c.1820	0
MP-SJM-2026-0054	Walls	IfcWall	IfcWall	In Use	TRACE_Protocol	c. 1820	0
MP-SJM-2026-0057	Walls	IfcWall	IfcWall	In Use	TRACE_Protocol	c. 1820	0
MP-SJM-2026-0058	Walls	IfcWall	IfcWall	In Use	TRACE_Protocol	c. 1820	0
MP-SJM-2026-0059	Walls	IfcWall	IfcWall	In Use	TRACE_Protocol	c. 1820	0
MP-SJM-2026-0060	Walls	IfcWall	IfcWall	In Use	TRACE_Protocol	c. 1820	0
MP-SJM-2026-0042	Walls	IfcWall	IfcWall	In Use	TRACE_Protocol	c. 1820	0
MP-SJM-2026-0051	Walls	IfcWall	IfcWall	In Use	TRACE_Protocol	c. 1820	0
MP-SJM-2026-0056	Walls	IfcWall	IfcWall	In Use	TRACE_Protocol	c. 1820	0

Table 4.32 – Complete Level 2 dataset (Wall)

Passport ID	IFC Class	Original Category	Current Use	Lifecycle State	Assessment Method	Installation Date	Reuse Count
MP-SJM-2026-0055	Walls	IfcWall	IfcWall	In Use	TRACE_Protocol	c.1820	0
MP-SJM-2026-0061	Walls	IfcWall	IfcWall	In Use	TRACE_Protocol	c. 1820	0
MP-SJM-2026-0052	Walls	IfcWall	IfcWall	In Use	TRACE_Protocol	c. 1820	0
MP-SJM-2026-0044	Walls	IfcWall	IfcWall	In Use	TRACE_Protocol	c. 1820	0

Table 4.33 – Complete Level 2 dataset (Wall)

DfD BIM Library — Level 2 — TRACE Prot			
Passport ID	**Project**	**Location**	**Lifecycle History**
MP-SJM-2026-0062	Fazenda São José de Mipibu - Field Survey 2025	Main House | Ground Floor| Façade	[c.1820] Initial installation - Fazenda SJM, Façade
MP-SJM-2026-0043	Fazenda São José de Mipibu - Field Survey 2025	Main House | Ground Floor | Side Façade	[c.1820] Initial installation - Fazenda SJM, Side Façade
MP-SJM-2026-0045	Fazenda São José de Mipibu - Field Survey 2025	Main House | Ground Floor | Back	[c.1820] Initial installation - Fazenda SJM, Back
MP-SJM-2026-0046	200+ year (adobe wall, c. 1820, still in use)	Main House | Ground Floor | Back	[c.1820] Initial installation - Fazenda SJM, Back
MP-SJM-2026-0047	Fazenda São José de Mipibu - Field Survey 2025	Main House | Ground Floor | Back	[c.1820] Initial installation - Fazenda SJM, Back
MP-SJM-2026-0048	Fazenda São José de Mipibu - Field Survey 2025	Main House | Ground Floor | Back	[c.1820] Initial installation - Fazenda SJM, Back
MP-SJM-2026-0049	Fazenda São José de Mipibu - Field Survey 2025	Main House | Ground Floor | Back	[c.1820] Initial installation - Fazenda SJM, Back
MP-SJM-2026-0050	Fazenda São José de Mipibu - Field Survey 2025	Main House | Ground Floor | Back	[c.1820] Initial installation - Fazenda SJM, Back
MP-SJM-2026-0053	Fazenda São José de Mipibu - Field Survey 2025	Main House | Ground Floor | Side Façade	[c.1820] Initial installation - Fazenda SJM, Side Façade
MP-SJM-2026-0054	Fazenda São José de Mipibu - Field Survey 2025	Main House | Ground Floor | Interior	[c.1820] Initial installation - Fazenda SJM, Interior
MP-SJM-2026-0057	Fazenda São José de Mipibu - Field Survey 2025	Main House | Ground Floor | Interior	[c.1820] Initial installation - Fazenda SJM, Interior
MP-SJM-2026-0058	Fazenda São José de Mipibu - Field Survey 2025	Main House | Ground Floor | Interior	[c.1820] Initial installation - Fazenda SJM, Interior
MP-SJM-2026-0059	Fazenda São José de Mipibu - Field Survey 2025	Main House | Ground Floor | Interior	[c.1820] Initial installation - Fazenda SJM, Interior
MP-SJM-2026-0060	Fazenda São José de Mipibu - Field Survey 2025	Main House | Ground Floor | Interior	[c.1820] Initial installation - Fazenda SJM, Interior
MP-SJM-2026-0042	Fazenda São José de Mipibu - Field Survey 2025	Main House | Ground Floor | Interior	[c.1820] Initial installation - Fazenda SJM, Interior
MP-SJM-2026-0051	Fazenda São José de Mipibu - Field Survey 2025	Main House | Ground Floor | Interior	[c.1820] Initial installation - Fazenda SJM, Interior
MP-SJM-2026-0056	Fazenda São José de Mipibu - Field Survey 2025	Main House | Ground Floor | Side Façade	[c.1820] Initial installation - Fazenda SJM, Side Façade

Table 4.34 – Complete Level 2 dataset (Wall)

DfD BIM Library — Level 2 — TRACE Prot			
Passport ID	**Project**	**Location**	**Lifecycle History**
MP-SJM-2026-0055	Fazenda São José de Mipibu - Field Survey 2025	Main House | Ground Floor | Side Façade	[c.1820] Initial installation - Fazenda SJM, Side Façade
MP-SJM-2026-0061	Fazenda São José de Mipibu - Field Survey 2025	Main House | Ground Floor | Low wall	[c.1820] Initial installation - Fazenda SJM, Low wall
MP-SJM-2026-0052	Fazenda São José de Mipibu - Field Survey 2025	Main House | Ground Floor | Low wall	[c.1820] Initial installation - Fazenda SJM, Low wall
MP-SJM-2026-0044	Fazenda São José de Mipibu - Field Survey 2025	Main House | Ground Floor | Low wall	[c.1820] Initial installation - Fazenda SJM, Low wall

Table 4.35 – Complete Level 2 dataset (Wall)

tocol — Walls | Fazenda SJM 1820 | 21 element(s)									
Passport ID	Expected Service Life	Physical Integrity (0-2)	Recoverability (0-2)	Reuse Feasibility (0-2)	Information Confidence (0-2)	TRACE Score (0-8)	Recommendation	Reusable	Repairable
MP-SJM-2026-0062	200+ years (adobe wall, c.1820, still in use 2025)	1	1	1	1	4	Conditional	Yes	Yes
MP-SJM-2026-0043	200+ years (adobe wall, c. 1820, still in use 2025)	1	1	1	1	4	Conditional	Yes	Yes
MP-SJM-2026-0045	200+ year (adobe wall, c. 1820, still in use)	1	1	1	1	4	Conditional	No	Yes
MP-SJM-2026-0046	100+ year (Fire clay brick masonry, c. 2010, still in use)	1	1	1	1	4	Conditional	Yes	Yes
MP-SJM-2026-0047	100+ year (Fire clay brick masonry, c. 2010, still in use)	1	1	1	1	4	Conditional	Yes	Yes
MP-SJM-2026-0048	100+ year (Fire clay brick masonry, c. 2010, still in use)	1	1	1	1	4	Conditional	Yes	Yes
MP-SJM-2026-0049	200+ year (adobe wall, c. 1820, still in use)	1	1	1	1	4	Conditional	Yes	Yes
MP-SJM-2026-0050	200+ year (adobe wall, c. 1820, still in use)	1	1	1	1	4	Conditional	Yes	Yes
MP-SJM-2026-0053	200+ year (adobe wall, c. 1820, still in use)	1	1	1	1	4	Conditional	Yes	Yes
MP-SJM-2026-0054	200+ year (adobe wall, c. 1820, still in use)	1	1	1	1	4	Conditional	Yes	Yes
MP-SJM-2026-0057	200+ year (adobe wall, c. 1820, still in use)	1	1	1	1	4	Conditional	Yes	Yes
MP-SJM-2026-0058	200+ year (adobe wall, c. 1820, still in use)	1	1	1	1	4	Conditional	Yes	Yes
MP-SJM-2026-0059	200+ year (adobe wall, c. 1820, still in use)	1	1	1	1	4	Conditional	Yes	Yes
MP-SJM-2026-0060	200+ year (adobe wall, c. 1820, still in use)	1	1	1	1	4	Conditional	Yes	Yes
MP-SJM-2026-0042	200+ year (adobe wall, c. 1820, still in use)	1	1	1	1	4	Conditional	Yes	Yes
MP-SJM-2026-0051	200+ year (adobe wall, c. 1820, still in use)	1	1	1	1	4	Conditional	Yes	Yes
MP-SJM-2026-0056	200+ year (adobe wall, c. 1820, still in use)	1	1	1	1	4	Conditional	Yes	Yes

Table 4.36 – Complete Level 2 dataset (Wall)

tocol — Walls | Fazenda SJM 1820 | 21 element(s)									
Passport ID	Expected Service Life	Physical Integrity (0-2)	Recoverability (0-2)	Reuse Feasibility (0-2)	Information Confidence (0-2)	TRACE Score (0-8)	Recommendation	Reusable	Repairable
MP-SJM-2026-0055	200+ years (Adobe wall, c.1820, still in use 2025)	1	1	1	1	4	Conditional	Yes	Yes
MP-SJM-2026-0061	100+ year (Fire clay brick masonry, c. 2010, still in use)	1	1	1	1	4	Conditional	Yes	Yes
MP-SJM-2026-0052	200+ year (adobe wall, c. 1820, still in use)	1	1	1	1	4	Conditional	Yes	Yes
MP-SJM-2026-0044	100+ year (Fire clay brick masonry, c. 2010, still in use)	1	1	1	1	4	Conditional	Yes	Yes

Table 4.37 – Complete Level 2 dataset (Wall)

Passport ID	Width (mm)	Height (mm)	IFC GUID	Element Name
MP-SJM-2026-0062			de19ff30-9a38-4030-b604-2dd12d745d3f-0004f743	DfD_Wall_Colonial_SJM_1820_Structural_Solid
MP-SJM-2026-0043			de19ff30-9a38-4030-b604-2dd12d745d3f-0004f7ad	DfD_Wall_Colonial_SJM_1820_Structural_Solid
MP-SJM-2026-0045			de19ff30-9a38-4030-b604-2dd12d745d3f-0004f7cb	DfD_Wall_Colonial_SJM_1820_Structural_Solid
MP-SJM-2026-0046			de19ff30-9a38-4030-b604-2dd12d745d3f-0004f7ed	DfD_Wall_FireClayBrick_SJM_2010_Structural_Solid
MP-SJM-2026-0047			de19ff30-9a38-4030-b604-2dd12d745d3f-0004f82f	DfD_Wall_FireClayBrick_SJM_2010_Structural_Solid
MP-SJM-2026-0048			de19ff30-9a38-4030-b604-2dd12d745d3f-0004f865	DfD_Wall_FireClayBrick_SJM_2010_Structural_Solid
MP-SJM-2026-0049			de19ff30-9a38-4030-b604-2dd12d745d3f-0004f928	DfD_Wall_Colonial_SJM_1820_Structural_Solid
MP-SJM-2026-0050			de19ff30-9a38-4030-b604-2dd12d745d3f-0004f958	DfD_Wall_Colonial_SJM_1820_Structural_Solid
MP-SJM-2026-0053			de19ff30-9a38-4030-b604-2dd12d745d3f-0004f9ef	DfD_Wall_Colonial_SJM_1820_Structural_Solid
MP-SJM-2026-0054			de19ff30-9a38-4030-b604-2dd12d745d3f-0004fba2	DfD_Wall_Colonial_SJM_1820_Structural_Solid
MP-SJM-2026-0057			de19ff30-9a38-4030-b604-2dd12d745d3f-0004fbdd	DfD_Wall_Colonial_SJM_1820_Structural_Solid
MP-SJM-2026-0058			de19ff30-9a38-4030-b604-2dd12d745d3f-0004fcbf	DfD_Wall_Colonial_SJM_1820_Structural_Solid
MP-SJM-2026-0059			de19ff30-9a38-4030-b604-2dd12d745d3f-0004fcc9	DfD_Wall_Colonial_SJM_1820_Structural_Solid
MP-SJM-2026-0060			de19ff30-9a38-4030-b604-2dd12d745d3f-0004fe48	DfD_Wall_Colonial_SJM_1820_Structural_Solid
MP-SJM-2026-0042			de19ff30-9a38-4030-b604-2dd12d745d3f-0004fe83	DfD_Wall_Colonial_SJM_1820_Structural_Solid
MP-SJM-2026-0051			de19ff30-9a38-4030-b604-2dd12d745d3f-00050000	DfD_Wall_Colonial_SJM_1820_Structural_Solid
MP-SJM-2026-0056			de19ff30-9a38-4030-b604-2dd12d745d3f-000505b9	DfD_Wall_Colonial_SJM_1820_Structural_Solid

Table 4.38 – Complete Level 2 dataset (Wall)

Passport ID	Width (mm)	Height (mm)	IFC GUID	Element Name
MP-SJM-2026-0055			de19ff30-9a38-4030-b604-2dd12d745d3f-000505c0	DfD_Wall_Colonial_SJM_1820_Structural_Solid
MP-SJM-2026-0061			de19ff30-9a38-4030-b604-2dd12d745d3f-000508b2	DfD_Wall_FireClayBrick_SJM_2010_Structural_Solid
MP-SJM-2026-0052			de19ff30-9a38-4030-b604-2dd12d745d3f-00050937	DfD_Wall_FireClayBrick_SJM_2010_Structural_Solid
MP-SJM-2026-0044			de19ff30-9a38-4030-b604-2dd12d745d3f-00051311	DfD_Wall_FireClayBrick_SJM_2010_Structural_Solid

APPENDIX 5: COMPLETE EXPORTED DATASET (JSON)

LISTING 5.1 – Top-level structure of the exported JSON dataset


```
"dfd_library": {
  "schema_version": "3.0",
  "generated": "2026-08-29T13:40",
  "author": "Marcos Batista",
  "programme": "European Master in BIM A+ (Erasmus+)",
  "methodology": "Two-level DfD framework — Level 1: Disassembly Potential (4 Design Determining Factors) | Level 2: TRACE Protocol
  "total_elements": 80,
  "level_1_disassembly_potential": {
    "count": 42,
    "elements": [
```


LISTING 5.2 – JSON record for door MP-SJM-2026-0001 (Level 1, Disassembly Potential)


```
"element_name": "DfD_Door_Colonial_SJM_1820_Exterior_Double",
"ifc_guid": "5aa8b0fd-9eeb-4020-b703-4d216e8cea49-0005c0a6",
"ifc_class": "Doors",
"DfD_MaterialPassportID": "MP-SJM-2026-0001",
"DfD_OriginalCategory": "IfcDoor",
"DfD_CurrentUse": "IfcDoor",
"DfD_LifeCycleState": "In Use",
"DfD_InstallationDate": "c.1820",
"DfD_ReassemblyCount": "0",
"DfD_CurrentProject": "Fazenda São José de Mipibu — Field Survey 2025",
"DfD_CurrentLocation": "Main House | Ground Floor | Main Entrance to Living Room",
"DfD_LifecycleHistory": "[c.1820] Initial installation — Fazenda SJM, Main Entrance to Living Room, Ground Floor",
"DfD_ExpectedServiceLife": "200+ years (colonial door, c.1820, still in use 2025)",
"DfD_IsReusable": "Yes",
"DfD_IsRepairable": "Yes",
"DfD_UseTraceProtocol": "No",
"DfD_AssessmentMethod": "DisassemblyPotential",
"DfD_ConnectionType": "bolted",
"DfD_CT_Score": "0.8",
"DfD_CA_Score": "0.8",
"DfD_ID_Score": "1",
"DfD_GPE_Score": "0.4",
"DfD_DisassemblyScore": "0.6666666666666666",
"DfD_DisassemblyClass": "B"
```


LISTING 5.3 – JSON record for wall MP-SJM-2026-0062 (Level 2, TRACE Protocol)


```
"element_name": "DfD_Purlin_Colonial_SJM_1820_Structural_Longitudinal",
"ifc_guid": "de19ff30-9a38-4030-b604-2dd12d745d3f-0005069a",
"ifc_class": "Roofs",
"DfD_MaterialPassportID": "MP-SJM-2026-0063",
"DfD_OriginalCategory": "IfcCovering",
"DfD_CurrentUse": "IfcCovering",
"DfD_LifeCycleState": "In Use",
"DfD_InstallationDate": "[c.1820] Initial installation - Fazenda SJM, Reused in 2010 at the same house",
"DfD_ReassemblyCount": "1",
"DfD_CurrentProject": "Fazenda São José de Mipibu - Field Survey 2025",
"DfD_CurrentLocation": "Main House",
"DfD_LifecycleHistory": "[c.1820] Initial installation - Fazenda SJM, Reused in 2010 at the same house",
"DfD_ExpectedServiceLife": "50+ years",
"DfD_IsReusable": "Yes",
"DfD_IsRepairable": "Yes",
"DfD_UseTraceProtocol": "No",
"DfD_AssessmentMethod": "Disassembly_Potential",
"DfD_CT_Score": "0.5",
"DfD_CA_Score": "0.8",
"DfD_ID_Score": "0.4",
"DfD_GPE_Score": "0.7",
"DfD_DisassemblyScore": "1",
"DfD_DisassemblyClass": "A — Excellent"
```

APPENDIX 6: ONLINE COMPONENT LIBRARY

Table 6.1 – Assessment results (Door)



Table 6.2 – Assessment results (Door)

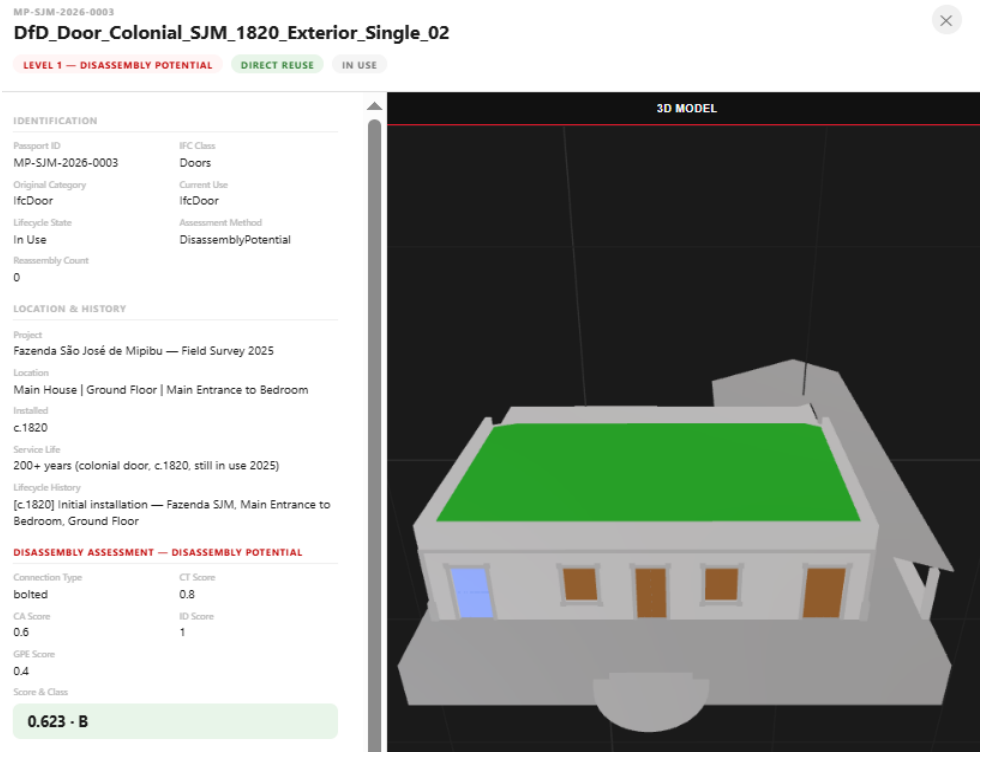


Table 6.3 – Assessment results (Door)

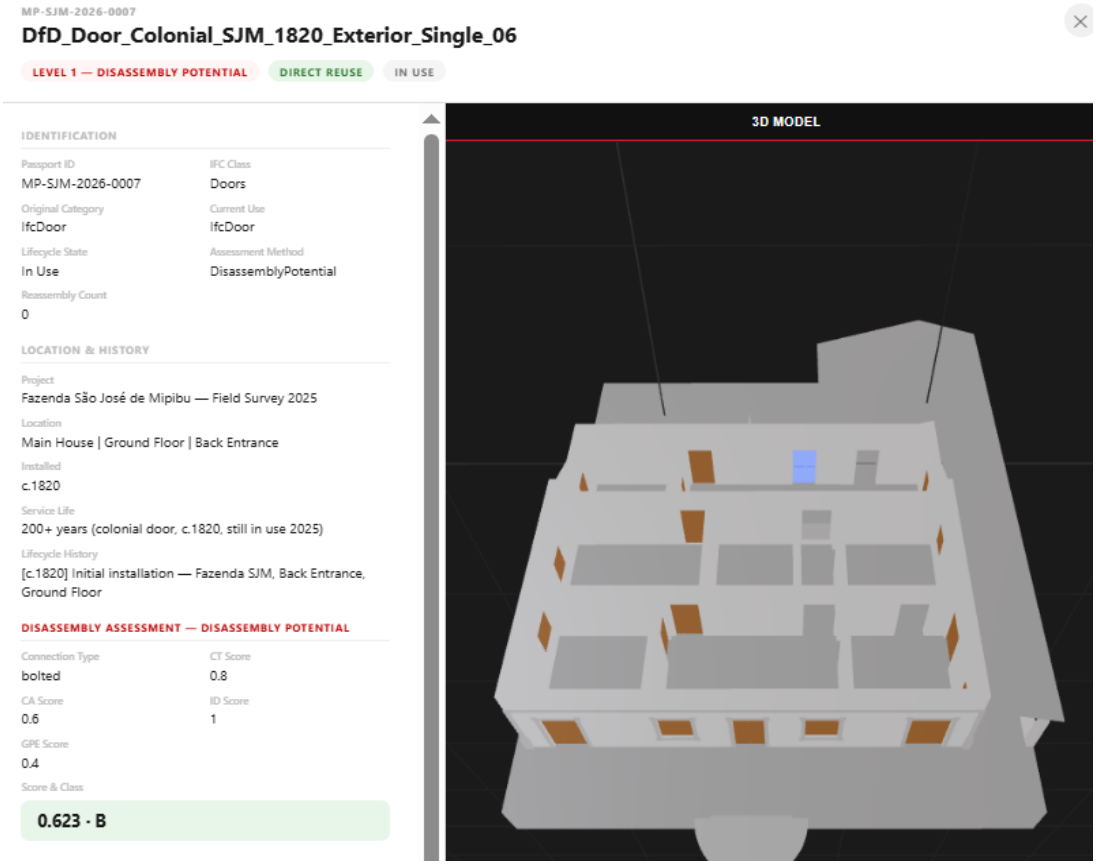


Table 6.4 – Assessment results (Door)

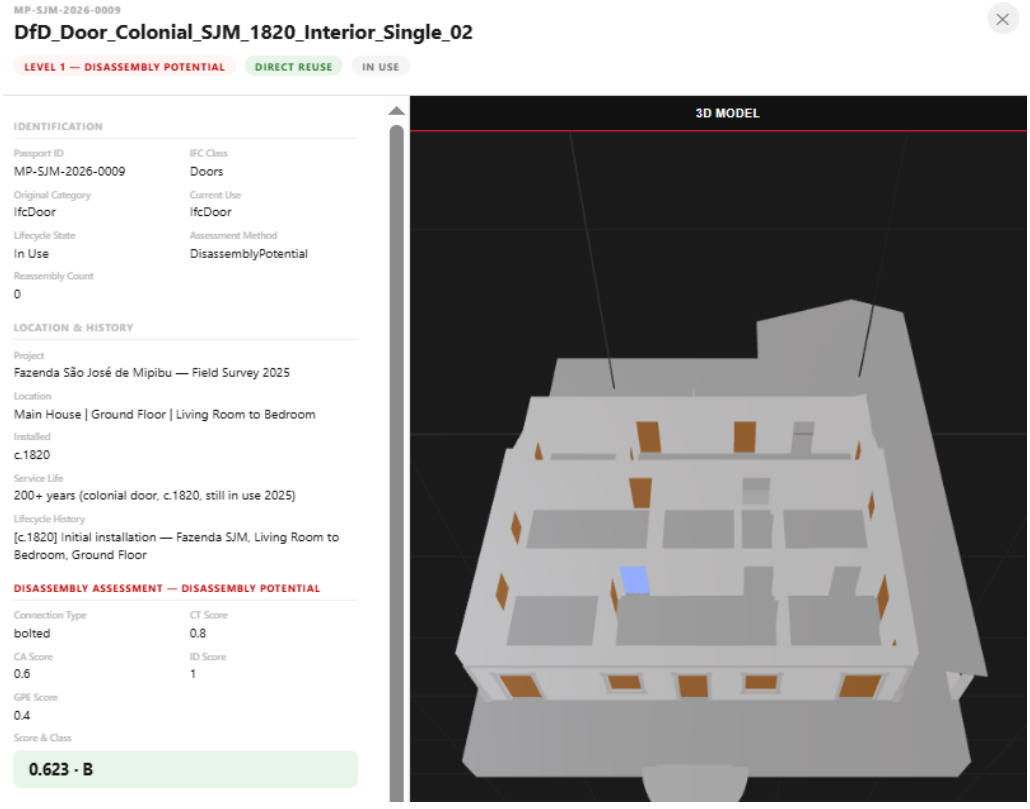


Table 6.5 – Assessment results (Door)

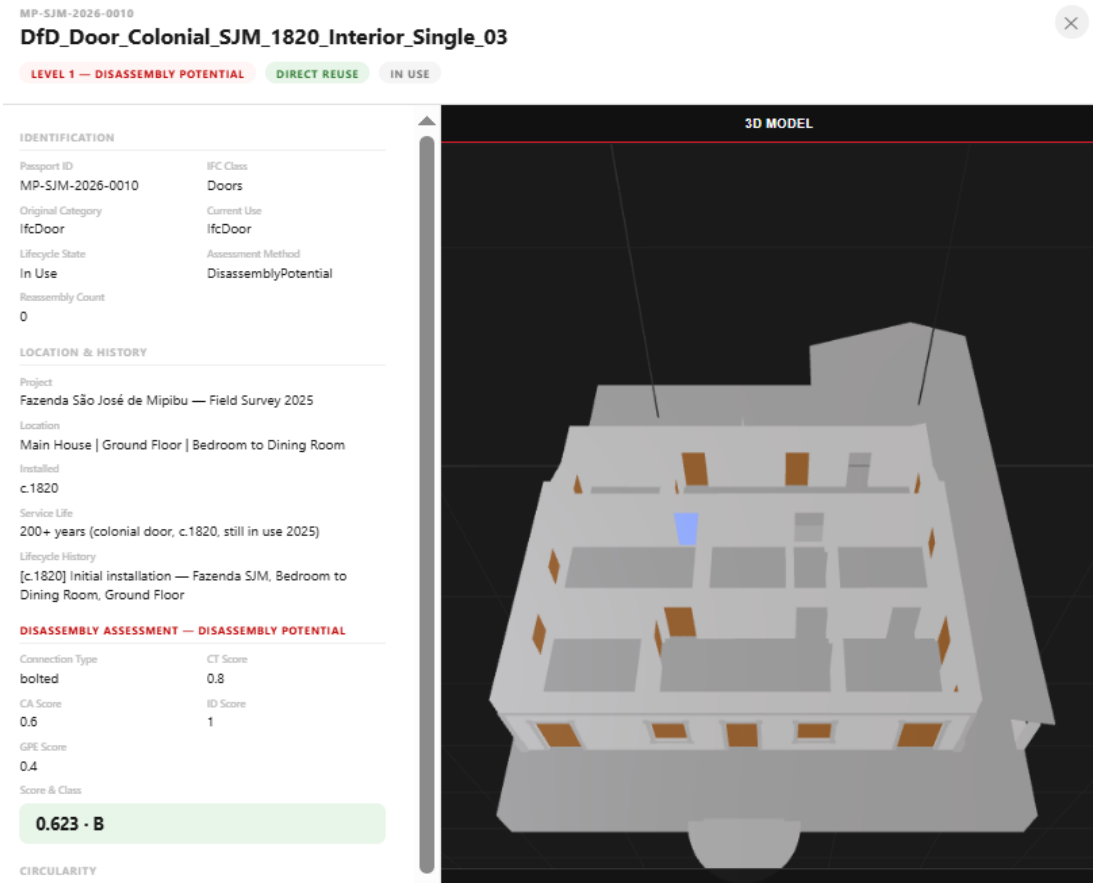


Table 6.6 – Assessment results (Window)

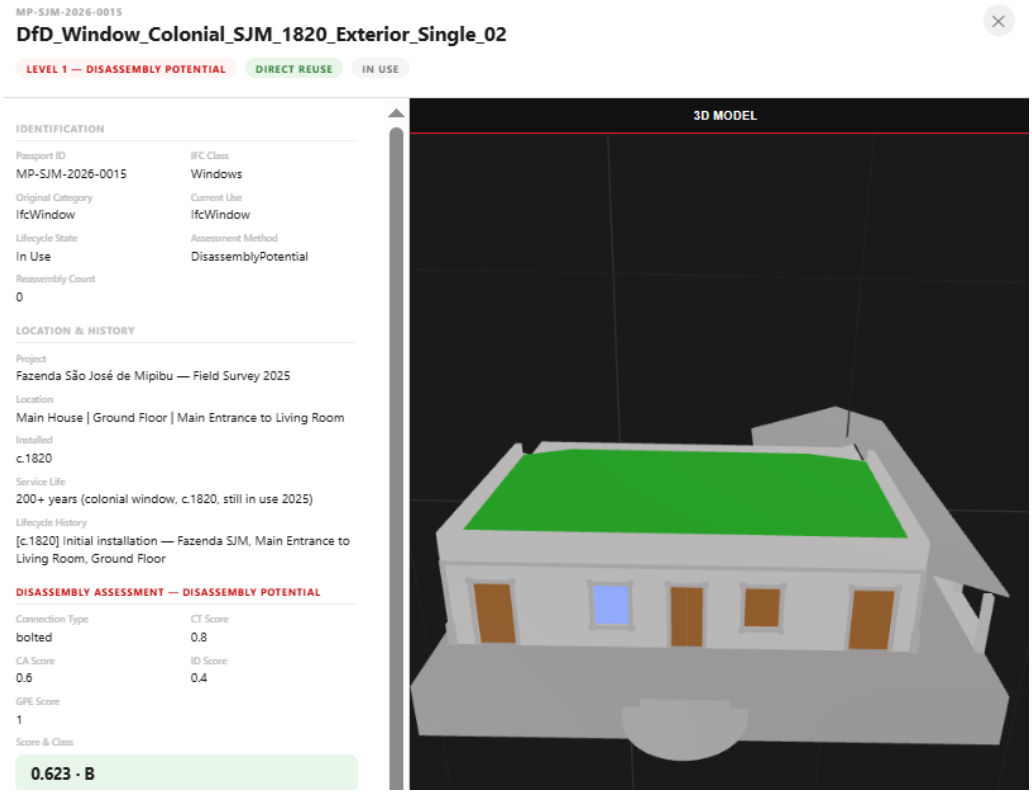


Table 6.7 – Assessment results (Window)

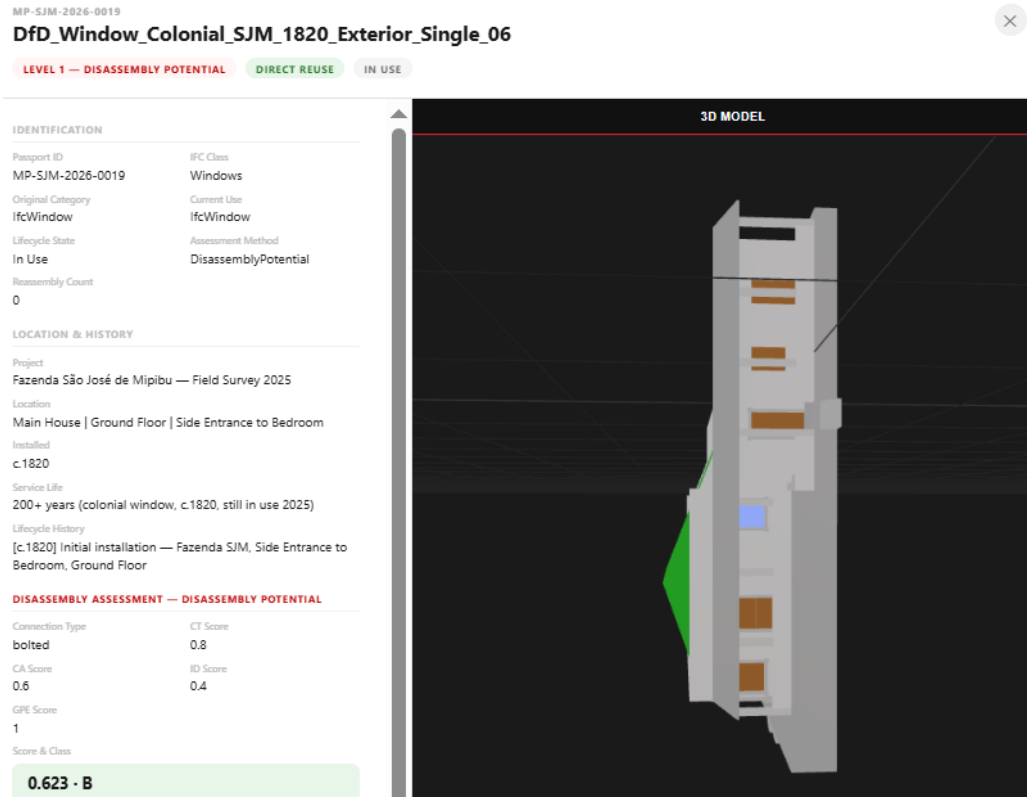


Table 6.8 – Assessment results (Window)

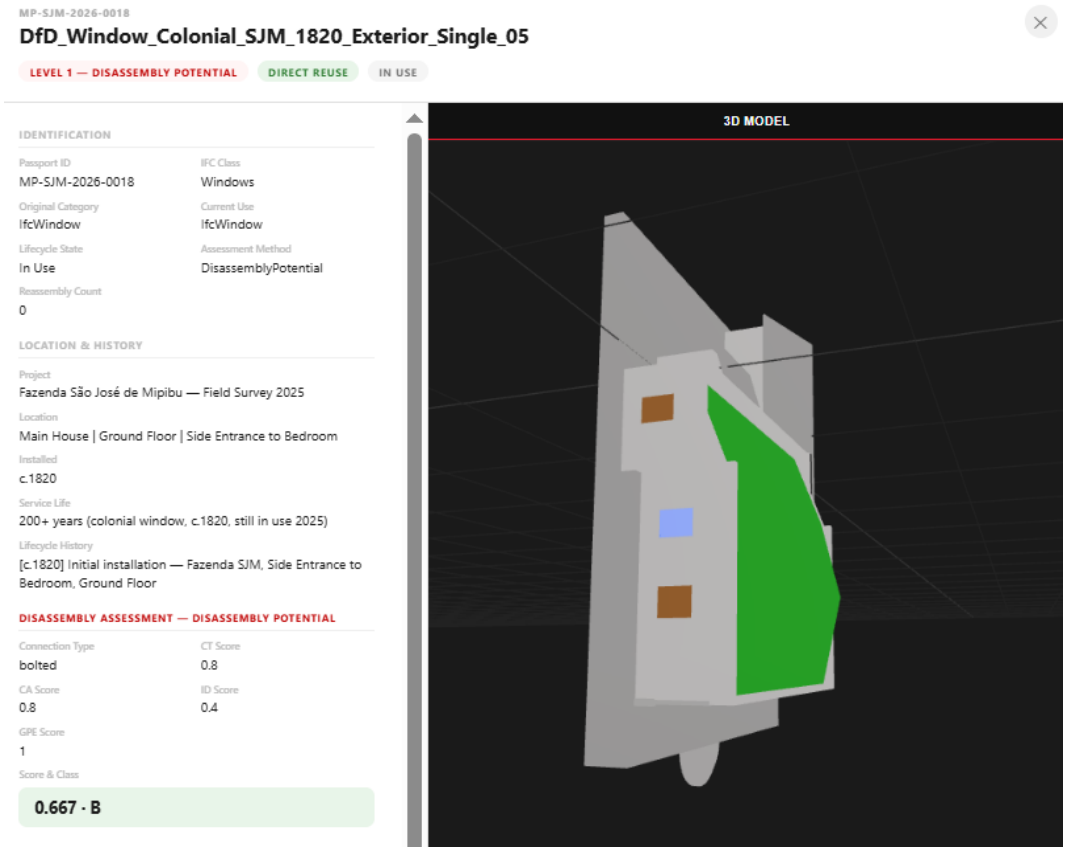


Table 6.9 – Assessment results (Window)

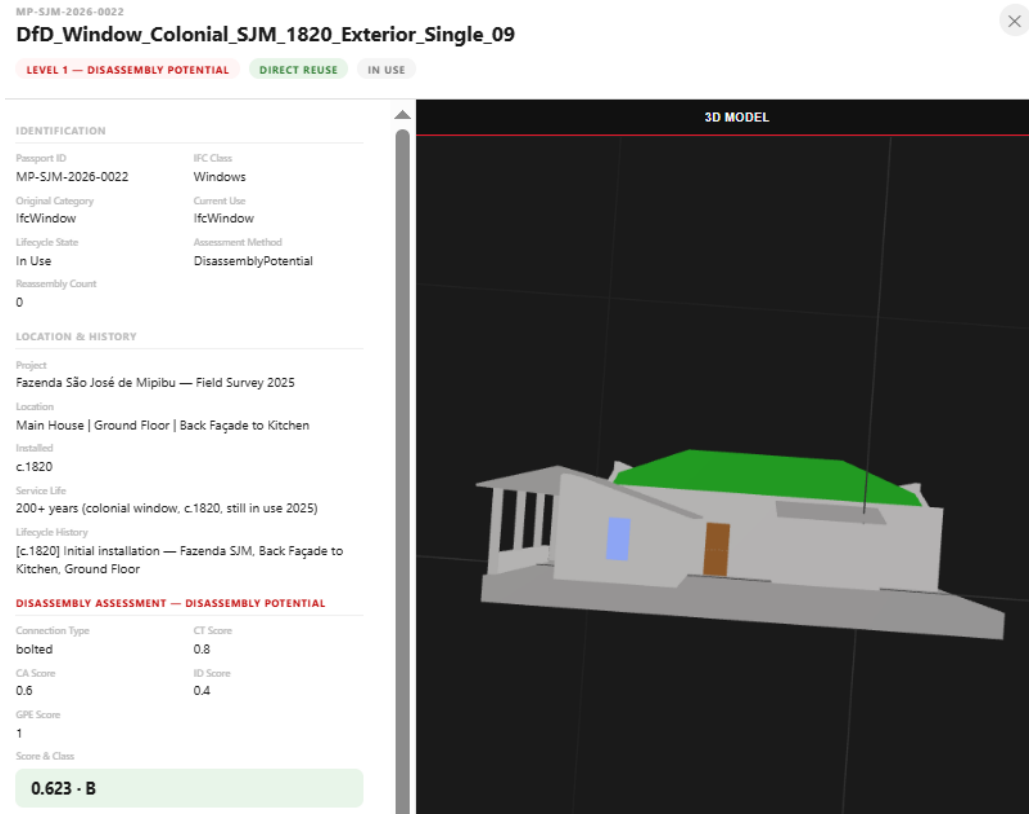


Table 6.10 – Assessment results (Window)

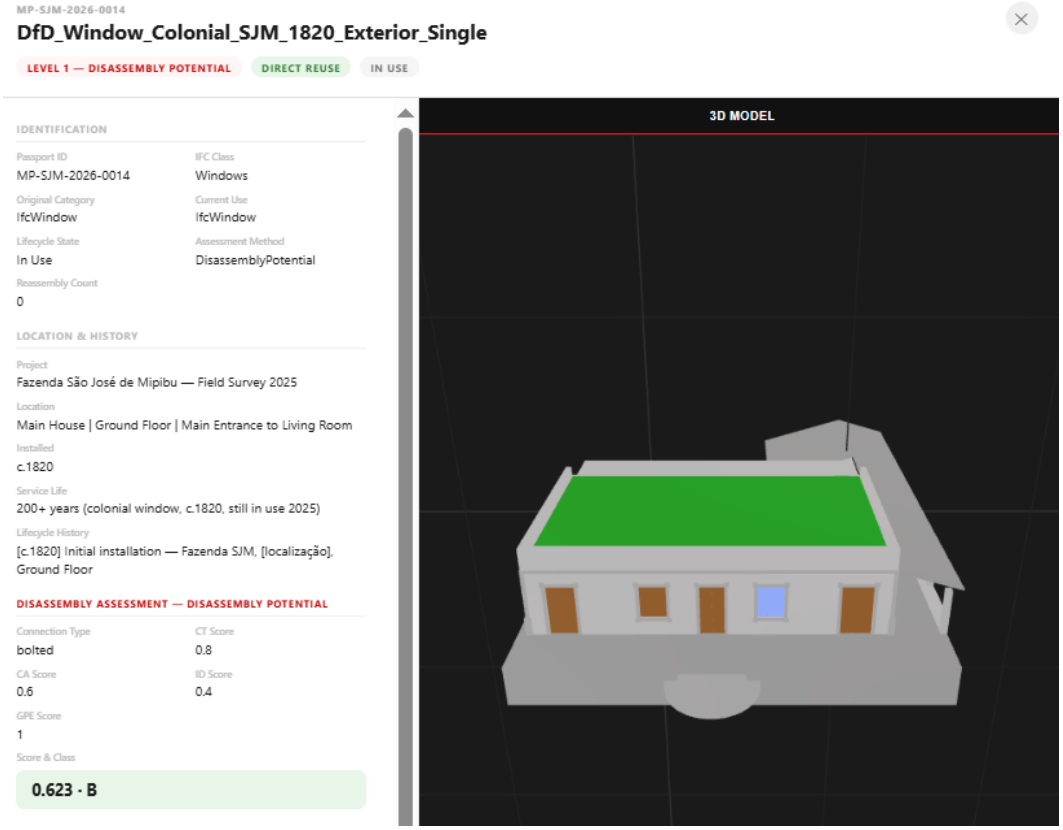


Table 6.11 – Assessment results (Roof)

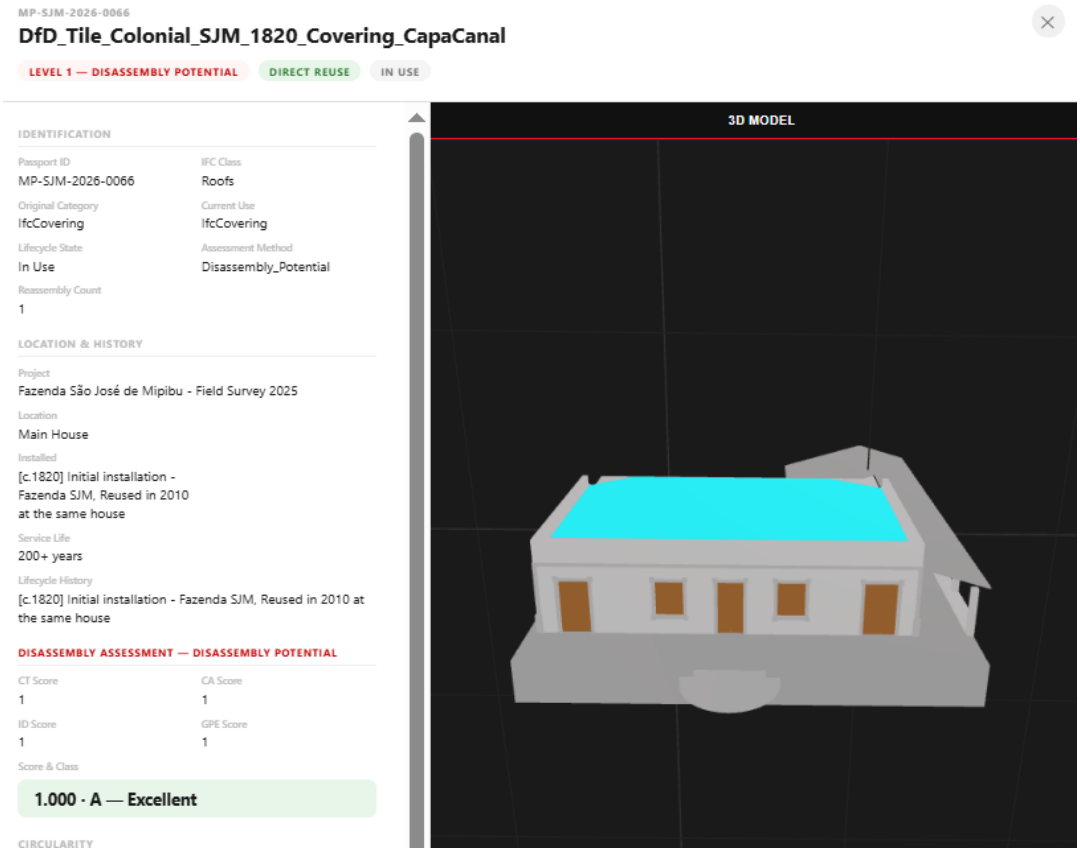


Table 6.12 – Assessment results (Wall)

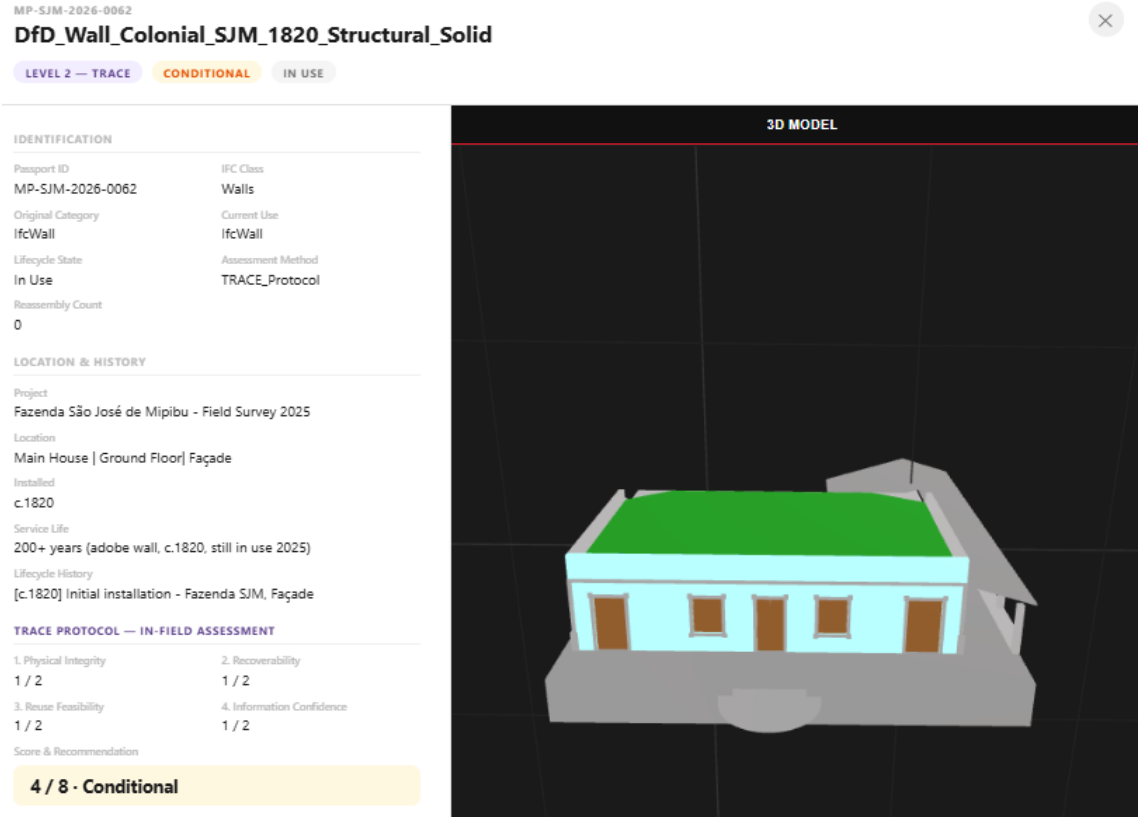


Table 6.13 – Assessment results (Wall)

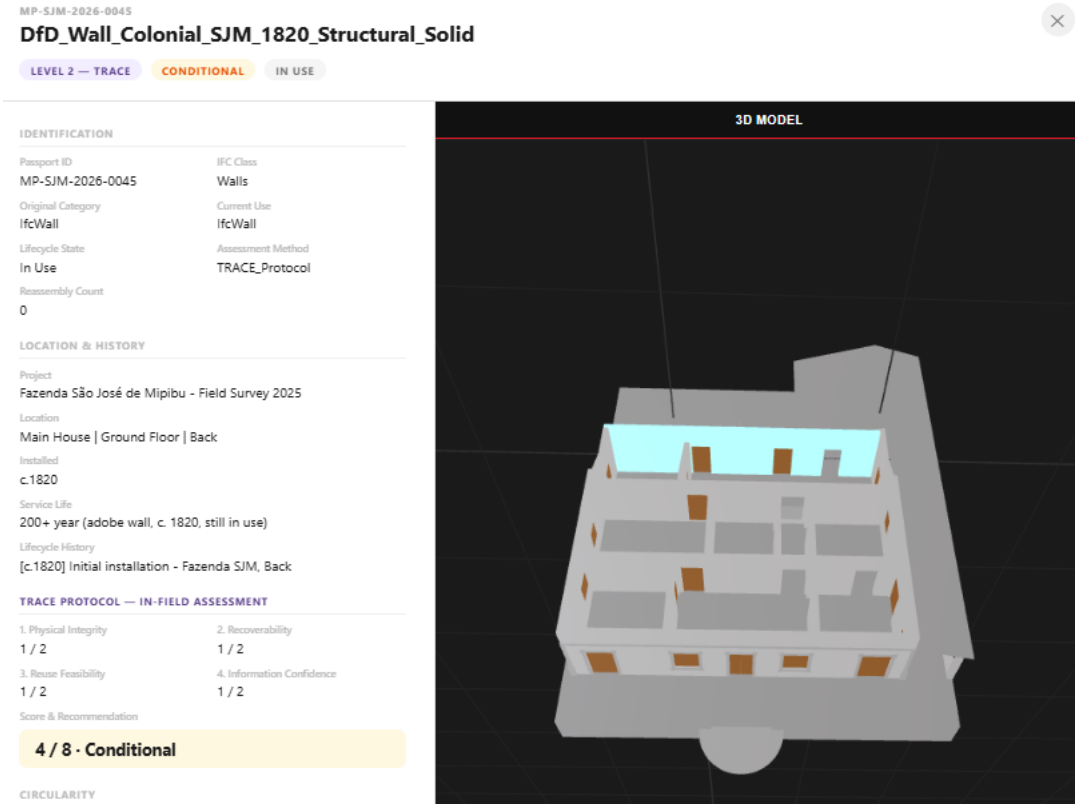


Table 6.14 – Assessment results (Wall)

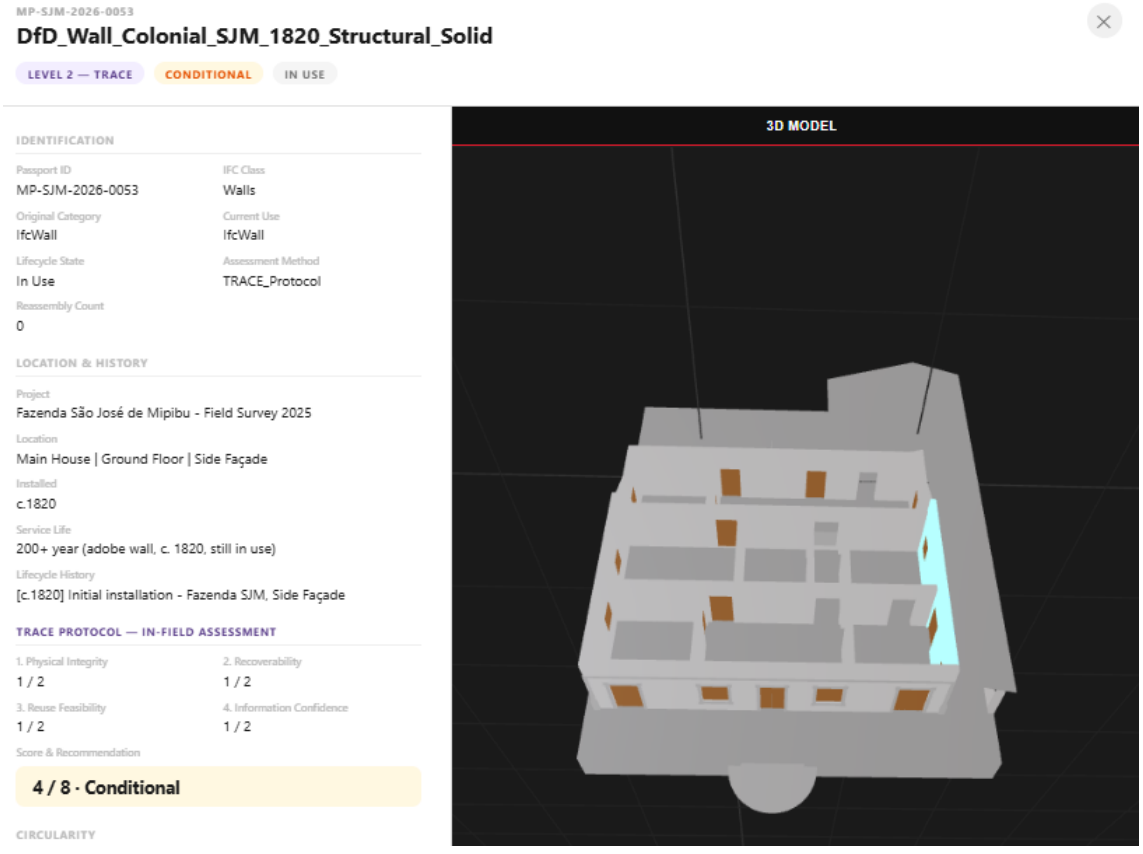


Table 6.15 – Assessment results (Wall)

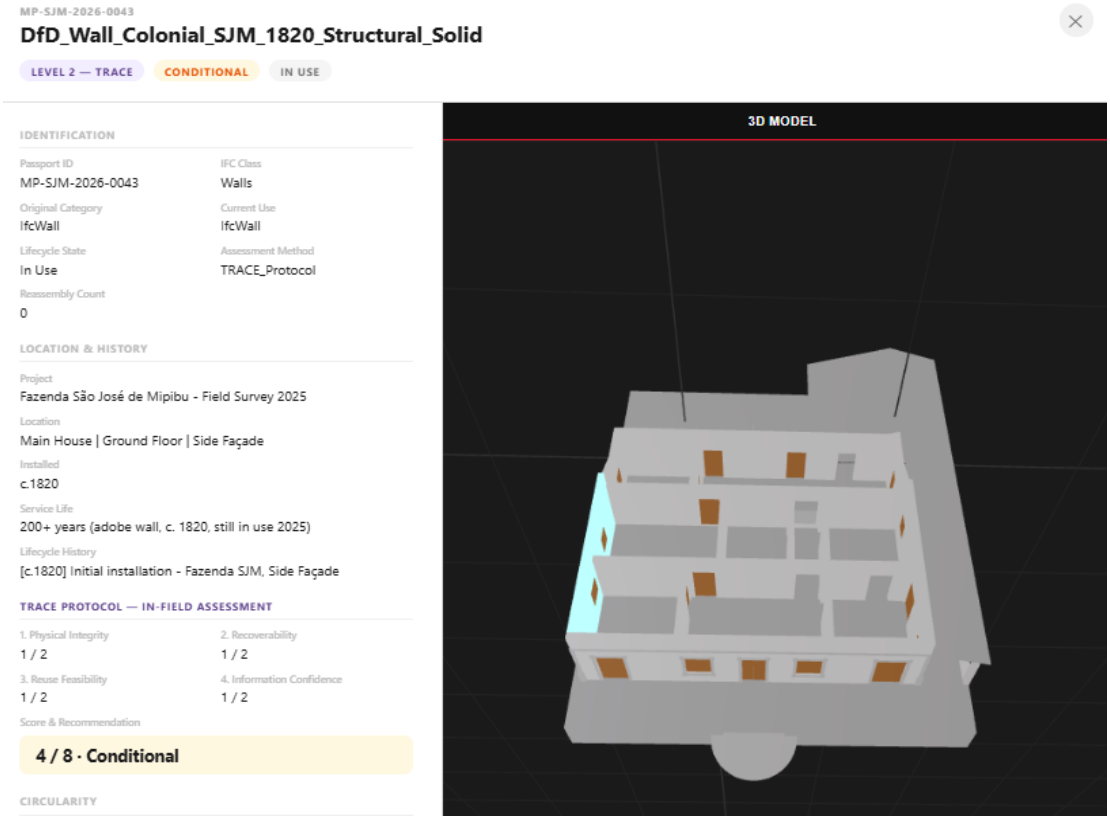


Table 6.16 – Assessment results (Wall)

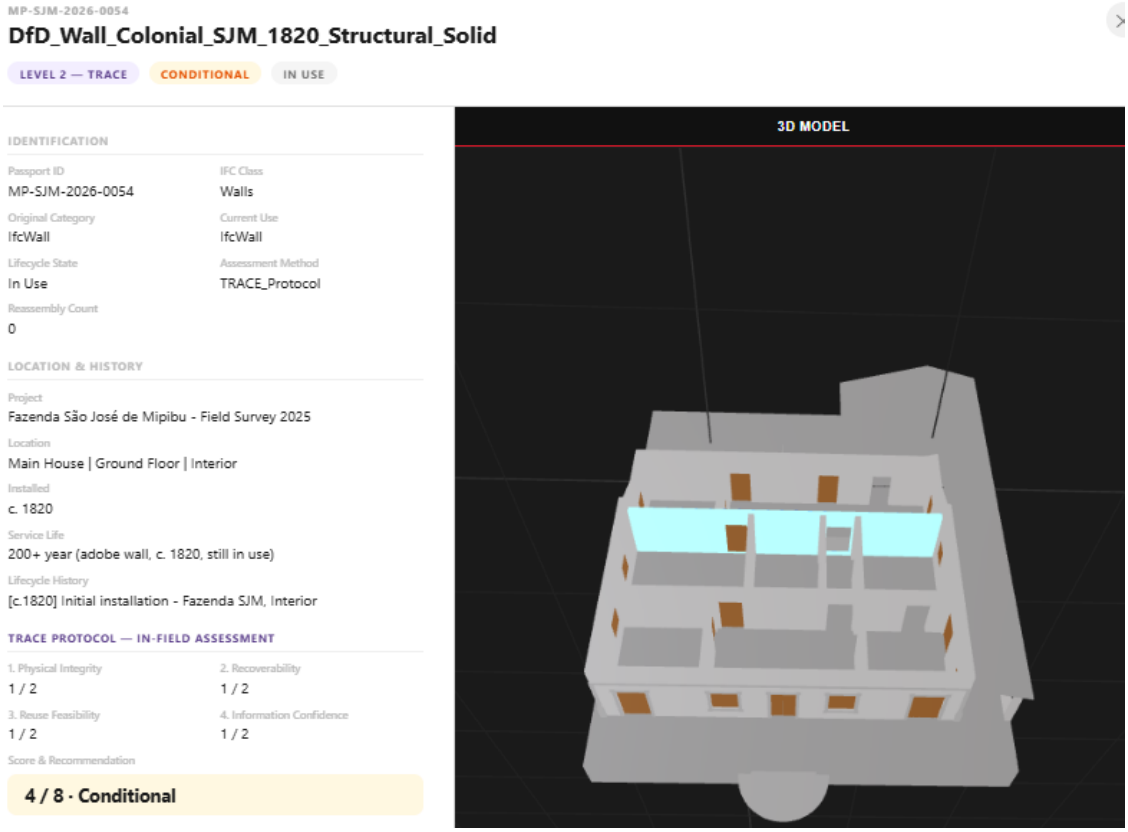


Table 6.17 – Assessment results (Column)

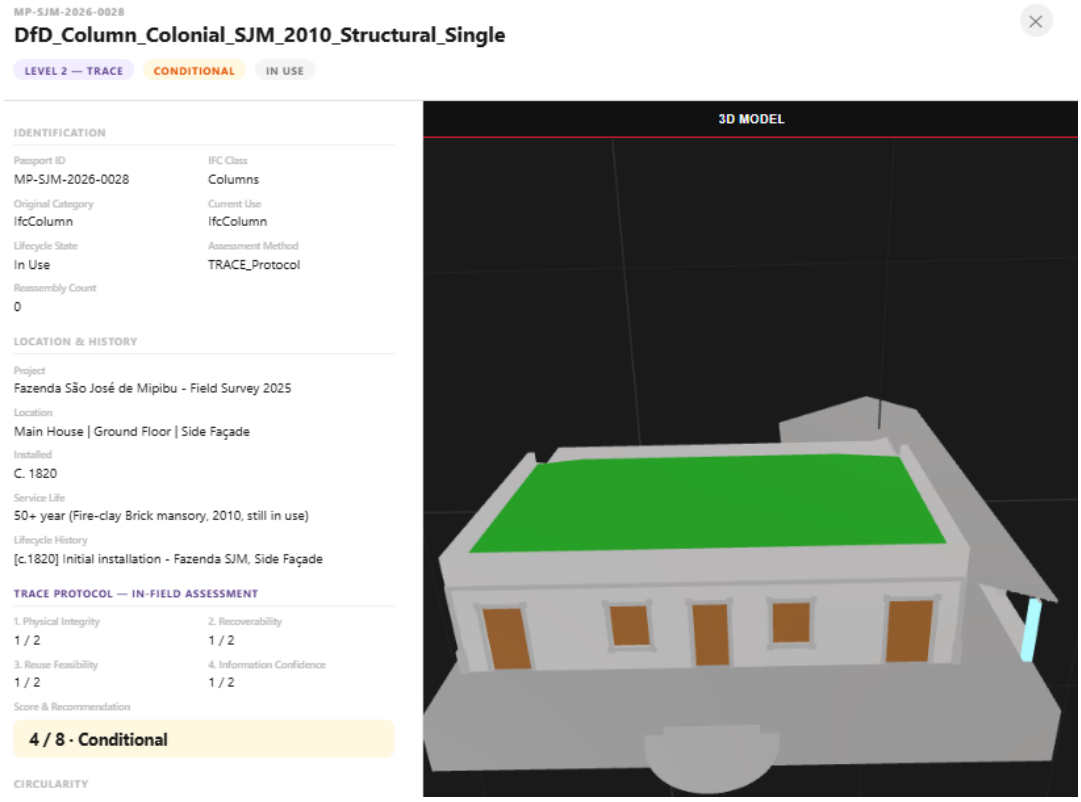


Table 6.18 – Assessment results (Stair)

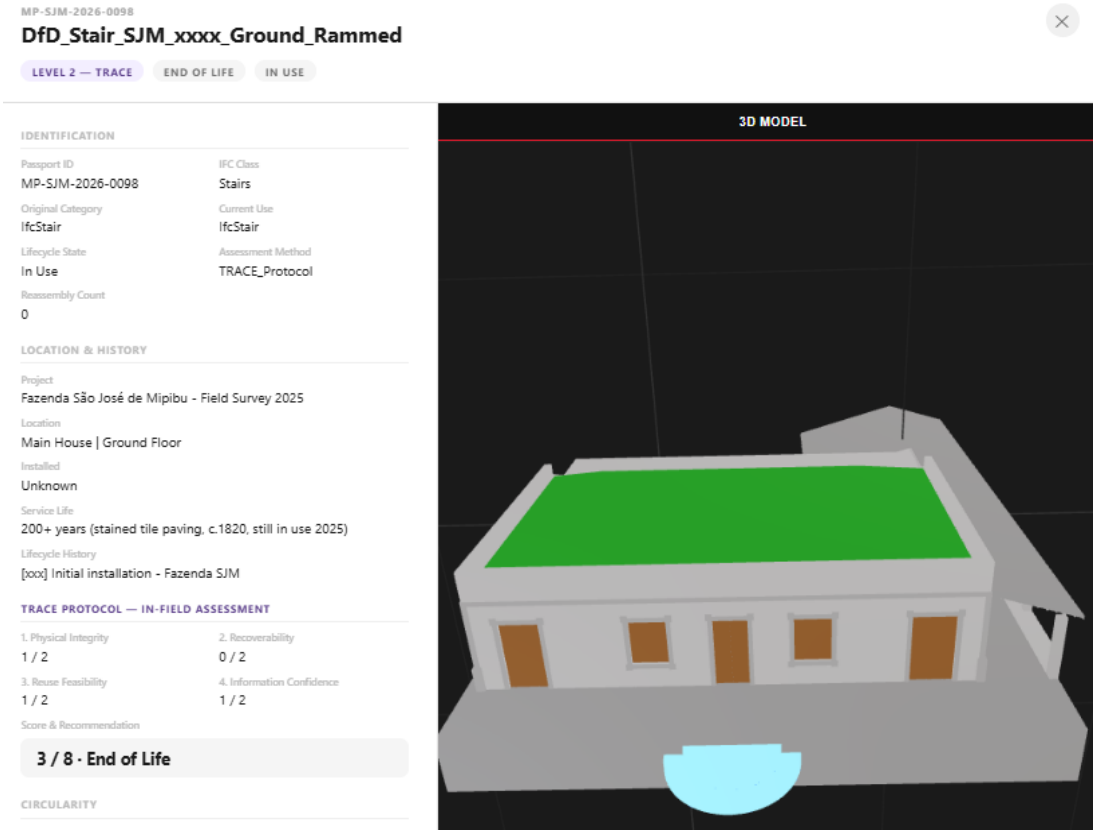


Table 6.19 – Assessment results (Floor)

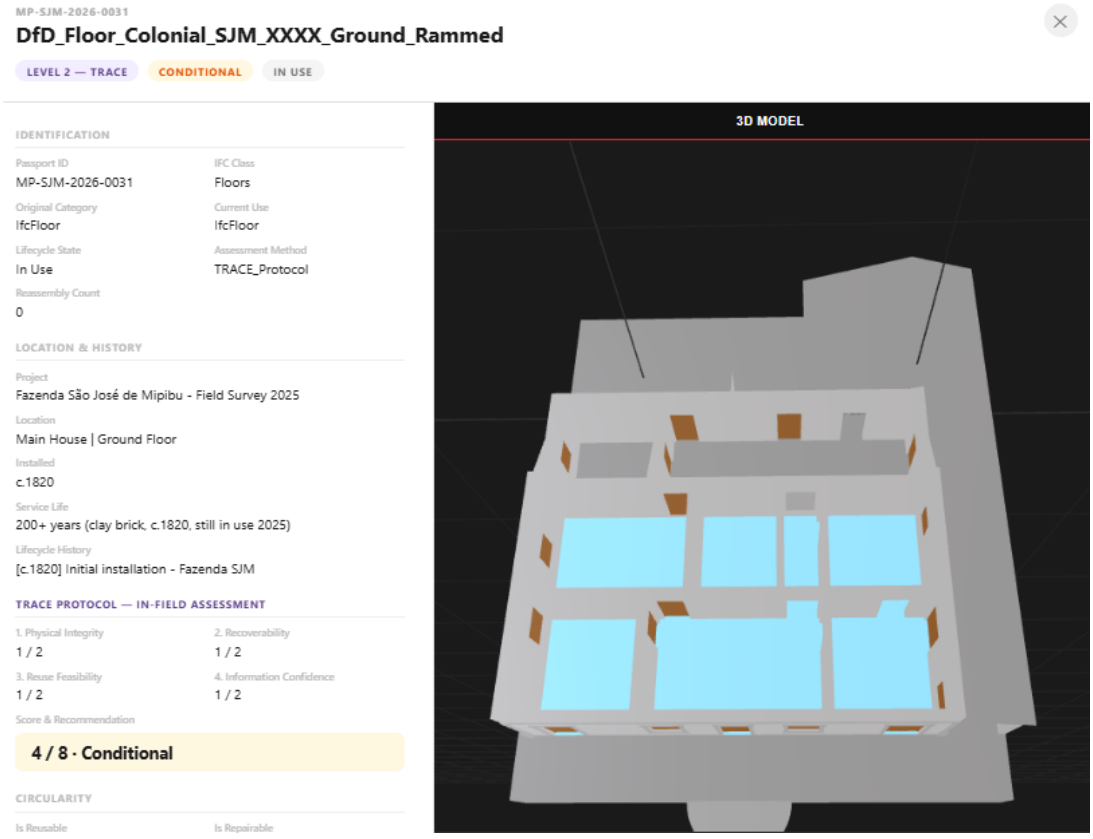


Table 6.20 – Assessment results (Floor)

