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Retrofitting Heritage Buildings: Aligning Heritage Building Information Management with DIN Standards

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Abstract

Heritage buildings require continuous maintenance and adaptation to modern needs. However, decision-making processes for their retrofitting are often hindered by fragmented documentation and inaccessible data. This paper proposes integrating the information requirements provided by the DIN standards for conservation, sustainability, energy efficiency, condition assessment, and risk management in heritage buildings into Heritage Building Information Management (HBIM) models. The goal is to improve the availability and exchange of information between stakeholders to streamline decision-making processes. To this end, four DIN standards are analyzed to identify key attributes required. The objective is to explore how to incorporate these attributes into HBIM models to serve as structured repositories for preventive documentation. Integrating these standards into the Industry Foundation Classes (IFC) schema, which structures the information in the HBIM models, allows for a more proactive approach to retrofitting and maintaining heritage buildings, balancing sustainability with the preservation of their historical significance.
The study reveals that the existing IFC schema lacks sufficient properties to capture the granularity and specificity required by these DIN standards in the context of heritage buildings. Therefore, some new properties and property sets are proposed to be added to the IFC schema to fill these gaps and enhance interoperability.

1. Introduction

Heritage buildings are an integral part of our cultural and historical identity. They require continuous maintenance and adaptation to modern needs (Yazdani Mehr, 2019). These structures not only serve as a testament to our past but also play an important role in shaping our present and future. However, fragmented and inaccessible documentation often hinders the management, conservation, and retrofitting of these buildings (Rebec et al., 2022), leading to inefficient decision-making processes and potential losses in cultural and historical significance (Korro Bañuelos et al., 2021).

Retrofitting heritage buildings involves balancing sustainability with preservation. The decision-making process is complex and requires information about historical construction techniques, material conditions, energy performance, and prior interventions (Ruggeri et al., 2020). DIN standards, such as DIN EN 16853, DIN EN 16883, DIN EN 17680, and DIN EN 16247-2, provide guidelines on the information needed for energy efficiency, conservation planning, and sustainability assessments. However, their practical integration into digital workflows is limited. These standards also include clauses that depend on data availability, making documentation optional and resulting in inconsistent documentation practices. These inconsistencies highlight the need for a more structured and standardized approach to preventive documentation, which Heritage Building Information Management (HBIM) can provide.

Despite the theoretical advantages of Building Information Management (BIM) methodologies, their application in heritage buildings faces multiple challenges (Penjor et al., 2024). Complex geometries, heterogeneous material compositions, and the need for precise historical documentation complicate BIM adoption in this context (Khalil and Stravoravdis, 2019).

Furthermore, the Industry Foundation Classes (IFC) schema, designed primarily for new construction (Diara and Rinaudo, 2020), has restricted adaptability for historic structures and lacks predefined properties for specific conservation information, historical materiality, previous interventions, and certain heritage-adapted sustainability criteria. These limitations hinder the effective representation and management of heritage buildings, constraining the potential of BIM-based workflows to support informed and sustainable conservation practices.

This paper explores the potential of HBIM as a structured repository for preventive documentation, ensuring that essential data is available when interventions become necessary. By leveraging HBIM, heritage buildings can benefit from a more efficient and effective management process, enabling better decision-making and preserving their cultural and historical significance.

To achieve this goal, an analysis of how the processes described in DIN standards relevant to the retrofitting of heritage buildings can be integrated into HBIM models is carried out, identifying key attributes required and their possible location within the entities of the IFC schema. This seeks to support conservation processes and facilitate interdisciplinary communication. By analyzing relevant regulations and standards in conservation, sustainability, and energy efficiency, this research examines how sustainability considerations set out in these regulations can be embedded within the HBIM framework, enabling more effective decision-making for retrofit interventions. The study also investigates the challenges and limitations associated with the use of the IFC schema for conservation and rehabilitation, highlighting the need for a more comprehensive and structured approach to documentation and management.

2. DIN standards for sustainable retrofitting of heritage buildings

DIN standards are developed or adopted by the DIN (Deutsches Institut für Normung e. V.), which is the German Standards

Institute. Often, DIN standards are German national versions of European standards (EN), in which case they are designated DIN EN. They are standardization tools to define what information is needed and how certain processes and assessments (such as conservation, energy audits, and sustainability assessments) should be carried out in a structured manner and with clear methodologies, with the ultimate aim of supporting informed decision-making and facilitating management.

For this study, four DIN standards have been selected based on their direct relevance to the context of sustainable retrofitting of heritage buildings. Together, they cover the fundamental informational pillars of heritage conservation, energy performance, comprehensive sustainability, as well as technical condition, adaptability, usability, and indoor environmental quality, which guide decisions in the conservation and retrofitting of historic buildings. The analysis of these standards allows the identification of necessary information that is not explicitly present or adequately structured in the existing IFC schema.

2.1 DIN EN 16853:2017-07 (Conservation of cultural heritage - Conservation process - Decision making, planning and implementation)

DIN EN 16853 is a standard that provides a structured approach to cultural heritage conservation, encompassing decision-making, planning, and implementation. This standard guides conservation professionals in developing a thorough and well-planned conservation process, which includes a range of steps. Firstly, it requires the documentation of the cultural heritage item, including its condition and significance, as well as the characterization of its materials and potential risks. Next, a risk assessment is conducted to identify potential threats to the item’s integrity, followed by the identification and diagnosis of its constituent elements and materials. The standard then emphasizes the importance of stakeholder collaboration and communication, ensuring that all parties involved in the conservation process are aware of the plans and goals. By recording and analyzing this information, conservation professionals can develop a comprehensive conservation plan that takes into account the item’s unique characteristics, its cultural and historical significance, and the potential risks associated with its conservation.

2.2 DIN EN 16883:2017-08 (Conservation of cultural heritage - Guidelines for improving the energy performance of historic buildings)

DIN EN 16883 is a standard for the conservation of cultural heritage, providing a comprehensive framework for improving the energy performance of historic buildings while preserving their unique character and integrity. This standard offers a structured approach to balancing the need for energy efficiency with the need to conserve the building’s cultural and historical significance. To achieve this balance, it requires a thorough and systematic evaluation of the building, taking into account its technical, heritage, and economic aspects. This involves gathering and documenting a wide range of information, including the building’s identification, legal protection, and description, as well as its condition, history of interventions, and technical elements and systems. Additionally, the standard requires a detailed analysis of the building’s energy performance, including the identification of areas for improvement and the development of strategies for reducing energy consumption. Furthermore, it emphasizes the importance of documenting all interventions carried out and elements discovered during the evaluation process, ensuring that the building’s history and significance are preserved for future generations.

2.3 DIN EN 17680:2023-12 (Sustainability of construction works - Evaluation of the potential for sustainable refurbishment of buildings)

DIN EN 17680 is a standard that provides a comprehensive methodology for evaluating the potential for sustainable refurbishment of buildings, enabling construction professionals to assess the sustainability of renovation projects, identify areas for improvement, prioritize interventions, and develop strategies for reducing the environmental impact of buildings. This standard establishes a structured approach to assessing sustainability in renovations, integrating aspects such as technical adaptability, energy efficiency, and climate resilience. By considering a wide range of performance categories, including technical, adaptability, usability, social, energy and water, indoor environment and health, economic viability, climate resilience, and embodied environmental impacts, it provides a holistic evaluation of a building’s sustainability potential. To facilitate this assessment, the standard introduces a system of indicators and ratings, with classes ranging from 0 to 3, as well as a ”Not Implemented” (NI) category, allowing for a nuanced evaluation of a building’s performance. A fundamental aspect of this assessment is a detailed condition assessment of the building, which involves a thorough examination of its current state, including its technical systems, materials, and environmental conditions.

2.4 DIN EN 16247-2:2022-11 (Energy audits - Buildings)

DIN EN 16247-2 is a standard that provides a detailed framework for conducting energy audits in buildings, enabling professionals to identify areas for improvement, prioritize energy-saving measures, and develop strategies for reducing energy consumption while informing decision-making. This standard specifies methodologies for energy audits, emphasizing the importance of metering, operational data, and environmental conditions in evaluating a building’s energy performance. Conducting a thorough energy audit requires the collection and analysis of a wide range of data, including energy consumption patterns, technical system diagrams, and environmental conditions. The standard also emphasizes the importance of reviewing relevant documents, such as building drawings, technical specifications, and consumption data, as well as considering the potential inclusion of BIM models to enhance the accuracy and comprehensiveness of the audit. Furthermore, it outlines the requirements and methodology for energy use analysis, including the calculation of energy performance indicators, which provide a quantitative measure of a building’s energy efficiency. The standard also specifies the content and structure of the audit report, ensuring that the results and recommendations are presented in a clear and actionable manner.

3. The IFC schema

The IFC schema is an open data standard for the exchange of building information, developed by buildingSMART International (bSI). IFC is a data model that enables the creation, exchange, and management of building information in a standardized and interoperable way. It is widely used in the construction industry for BIM and has become a de facto standard for data exchange between different software applications.

IFC 4.3.2.0 (also known as IFC 4.3 ADD2 or IFC 4.3) is the current official version of the IFC standard, released in 2024 (buildingSMART Technical, 2024). It has been formally approved and published as an international standard by ISO 16739-1:2024, and introduces significant enhancements over the previous official release, IFC 4.0.2.1 (IFC4 ADD2 TC1), particularly in supporting infrastructure projects, refining the schema architecture, and refining interoperability. These enhancements facilitate data management and interoperability across various disciplines.

The research focuses on IFC 4.3 since it is the current approved version of the IFC standard, and its new features and improvements make it more suitable for the needs of heritage buildings. While the enhancements in IFC 4.3 are not exclusively aimed at heritage buildings, some of them offer valuable tools for modeling and managing historic structures. One relevant addition is the IsLandmarked property within the Pset_BuildingCommon property set (Pset). This Boolean attribute indicates whether a building is officially recognized as a historic or protected structure (TRUE), not recognized (FALSE), or if the status is unknown.

The introduction of Pset_Uncertainty within IfcProduct and IfcTypeProduct, represents another significant improvement. This Pset is designed to capture geometric uncertainty regarding measurements, including how that uncertainty was assessed, something very useful for heritage buildings, where complex geometries and heterogeneous material compositions often complicate the achievement of accurate documentation. Additionally, the refined schema architecture, organized into Resource, Core, Interoperability, and Domain layers, improves modularity and clarity, enabling the detailed representation of complex architectural elements and their relationships, important for conservation and retrofit projects.

The implementation of IFC 4.3 in software applications is a gradual process, and it’s not yet fully widespread. While some software vendors have already implemented IFC 4.3, others are still in the process of updating their products to support the new standard. It’s worth noting that even if a software vendor has implemented IFC 4.3, it’s not guaranteed that all of their products will support the new standard. Additionally, some vendors may have implemented IFC 4.3 in a limited capacity, such as only supporting a subset of the new entities and attributes.

4. Aligning IFC with DIN standards

To address the limitations previously mentioned, one step to be taken is to align the IFC schema with different regulations and standards. The DIN standards described above provide guidelines on the information needed for energy efficiency, conservation planning, and sustainability assessments. By aligning the IFC schema with them, it is possible to create a more comprehensive and structured approach to documentation and management.

Some of the specific issues that need to be addressed when integrating DIN standards within the IFC schema include:

- The standards emphasize conservation-specific properties, cultural value assessment, or sustainability indicators, not explicitly present in the IFC schema.
- IFC schema lacks predefined properties for historical significance, material aging, previous interventions, and conservation history.
- While the IFC schema supports environmental performance data, it does not natively accommodate heritage-adapted sustainability criteria, which integrates cultural and historical factors into sustainability assessments.
- The standards highlight risk evaluation, decay mechanisms, and conservation strategies, but the IFC schema does not inherently provide properties to document structural vulnerabilities or degradation processes over time.
- The standards include detailed material stratigraphy and layered historical interventions, while the IFC schema typically represents materials without comprehensive historical layering.
- The IFC schema does not effectively incorporate adaptive reuse principles, conservation-oriented maintenance planning, or traditional construction techniques specified in heritage standards.

Finding solutions to address these issues will enable more effective decision-making and preservation of cultural and historical significance.

5. Methodology

In the framework of the research with the aim of integrating the DIN standards relevant for the retrofitting of heritage buildings into the HBIM models, a mapping between the information requirements arising from the application of the mentioned DIN standards and the existing capabilities within the IFC 4.3 schema has been performed. The objective is to improve decision-making in the conservation and retrofitting of heritage buildings, a process often complicated due to fragmented documentation in these types of buildings.

DIN EN 16853, DIN EN 16883, DIN EN 17680, and DIN EN 16247-2 provide guidelines on the information required for conservation, sustainability, energy efficiency, condition assessment, and risk management in buildings, including heritage buildings. These requirements (or the categories of information derived from them) can potentially be represented using entities and Psets from the IFC 4.3 schema.

By analyzing the four DIN standards chosen, the general categories of requirements or areas of assessment that are important in the context of the rehabilitation and conservation of historic buildings have been identified, in line with the type of information that the DIN standards aim to document. Each of these DIN standards contributes to several of these categories, as the processes they describe require multidisciplinary information about the building.

DIN EN 16853 guides conservation planning, including risk assessment and stakeholder collaboration. It requires information on identification, characterization of materials and construction, significance of the object and its material, condition assessment, environmental assessment and recording, conservation history, diagnosis, and risk.

DIN EN 16883 focuses on balancing energy improvements with conservation needs. It requires general building information, including heritage designation and heritage significance, and requests a description of the building, including construction details, elements, materials, and finishes. It also requires an assessment of the condition of the building elements and technical systems, and emphasizes the evaluation of energy performance and the assessment of the indoor environment, involving risk assessment when evaluating improvement measures.

DIN EN 17680 defines a methodology for assessing sustainability in renovations. It involves a comprehensive assessment of the building covering technical and functional condition, considering aspects such as adaptability, usability, social aspects, energy and water (operational impacts), indoor environment quality (health), economic viability, resilience to climate change, and embodied environmental impacts. It requires the assessment of the condition of building elements and technical systems, and considers cultural value as part of the social and heritage aspects to consider in the initial assessment.

DIN EN 16247-2 requires information on the characteristics of the building, specifies the methodology for evaluating the technical systems of the building, emphasizes the role of measurement and operational data in assessing energy performance, and considers indoor environmental conditions. It also emphasizes the importance of the information on the building envelope for energy performance.

As a result of the analysis of the four DIN standards, nine main categories were identified that serve to classify the various types of information required in these standards. These categories correspond to the fundamental areas of assessment in the context of the rehabilitation and conservation of historic buildings, and are as follows:

1. General building and spatial information: refers to basic identification data, location, use, and spatial characteristics.
2. Construction elements (envelope, structure, etc.): covers detailed information on the physical components of the building, its materials, and geometry.
3. Technical building systems: includes systems such as HVAC, electrical, and plumbing
4. Condition assessment and management: relates to the current physical condition of elements and systems, including damage, wear and tear, and maintenance history.
5. Indoor environment and health assessment: addresses air quality, temperature, humidity, lighting, noise, and presence of hazardous substances.
6. Energy, water, and sustainability: covers energy and water consumption, energy performance, environmental indicators, and sustainability aspects.
7. Heritage and conservation: refers to specific information on historical significance, cultural value, past interventions, and conservation priorities.
8. Risk and decision-making: includes risk assessment (structural, environmental, etc.) and information necessary for informed decision-making processes.
9. Performance and efficiency assessment: measures how well the elements and systems function, particularly in terms of energy and functionality.

In order to meet the information needs posed by the requirements of the standards, certain IFC entities that already have associated Psets containing relevant properties can be used. For example, if it is required to document the physical condition of a wall (category 4), the IfcWall entity is appropriate, and the Pset_Condition associated with it contains specific properties such as AssessmentDescription and AssessmentDate, which are necessary to meet that requirement.

Similarly, to document the indoor environment and health assessment (category 5), the IfcSpace entity contains Pset_SpaceHVACDesign and Pset_SpaceLightingDesign, with properties such as TemperatureSetPoint, HumiditySetPoint, and Illuminance. These properties allow the capture of relevant information on thermal and visual comfort, humidity management, and lighting energy efficiency.

In the comparative study between IFC 4.3 and the DIN standards analyzed, it was concluded that the existing properties are not sufficient to capture the granularity and specificity required by the DIN standards in the context of heritage buildings. The scope of this paper is not to show the existing properties that can be currently used to cover the requirements of these DIN standards, but to understand the limitations of IFC 4.3 to document specific aspects of heritage that the DIN standards require, and to propose possible property additions and Psets to fill those gaps. These properties are necessary to fully support conservation processes and facilitate interdisciplinary communication in an HBIM context.

6. Results

There is an existing information gap between the detailed, multidisciplinary requirements of the DIN standards for heritage building management and modernization, and the native data modeling capabilities of the IFC 4.3 schema. This paper proposes some properties for an HBIM model to effectively serve as a structured digital repository that complies with the information requirements of the relevant standards for sustainable conservation and rehabilitation.

Properties identified as missing fall into the following areas:

- Cultural and historical value.
- Heritage designation and significance.
- Legal protection status.
- References to historical survey documents and past interventions.
- Summary of conservation and maintenance history.
- Classification and description of types and causes of deterioration.
- Description of structural vulnerabilities.
- References to detailed condition reports of elements and systems (complementing existing basic condition properties).
- Long-term conservation strategy.
- References to conservation-oriented maintenance planning documents.
- Performance classes (0-3) and structured evaluation criteria for various categories (technical, adaptability, usability).
- Detailed indoor environment assessment results, including a full range of air quality indicators such as radon, VOCs, formaldehyde, particulates/fibers, as well as lighting and acoustics results according to specific methodologies.
- Detailed results and summaries of economic viability, social and climate resilience assessment, including sustainability criteria tailored to the estate.
- Detailed indicators and references to evaluations of the deconstruction process, such as reuse potential and waste management.

- References and management of documentation of the commissioning and use phases ("as built", manuals, test reports, user feedback, etc.).
- Complex indicators of the use phase (aesthetics, ecology, etc.).
- Reference to the full energy audit report.
- References to documents or graphs detailing the disaggregation of energy use and energy performance indicators used.
- Ability to record results of specific non-standard measurements.

Table 1 presents a structured proposal for adding to the IFC schema specific information that has been identified as missing in the IFC 4.3 schema but is required by the analyzed DIN standards that are relevant to building management and retrofitting, particularly in the heritage context (HBIM).

Property	Type	Data type
Pset_Commissioning *in IfcBuilding and IfcDistributionElement*		
CommissioningReport	Reference	Document
FunctionalTesting	Reference	Document
Pset_ConservationStrategy *in IfcBuilding, IfcBuildingStorey, IfcSpace and IfcBuiltElement*		
StrategyDescription	Single	Text
MaintenancePlan	Reference	Document
Pset_EnergyAudit *in IfcBuilding, IfcSite, IfcSpace, IfcZone and IfcDistributionElement*		
AuditReport	Reference	Document
BreakdownReport	Reference	Document
PerformanceIndicators	Reference	Document
SpecificMeasurement	Reference	Document
Pset_HeritageCommon *in IfcBuilding, IfcSite and IfcBuiltElement*		
CulturalValue	Single	Text
HeritageProtectionStatus	Single	Label
HistoricalStudy	Reference	Document
Pset_HeritageCondition *in IfcBuiltElement and IfcBuildingElementPart*		
DeteriorationType	Single	Label
DeteriorationCause	Single	Text
StructuralVulnerability	Single	Text
ConditionSurvey	Reference	Document
Pset_IndoorEnvironmentAssessment *in IfcSpace and IfcZone*		
RadonConcentration	Single	Real
FormaldehydeConcentration	Single	Real
TVOCConcentration	Single	Real
ParticulatesConcentration	Single	Real
DaylightingAssessment	Enumerated	Label
AcousticAssessment	Enumerated	Label

Continued on next column

Table 1. Proposed properties, Psets, and the entities in which they are located.

The proposal specifies how to integrate the properties within the IFC schema. For this purpose, a name is proposed for each identified property. It also indicates to which IFC entities these properties would apply, which assigns the information of the

Property	Type	Data type
Pset_InterventionHistory *in IfcBuilding, IfcBuildingStorey, IfcSpace and IfcBuiltElement*		
PreviousInterventions	Single	Text
InterventionRecord	Reference	Document
ConservationHistory	Single	Text
Pset_ProjectDocumentation *in IfcBuilding*		
AsBuiltDocumentation	Reference	Document
OperationMaintenanceManual	Reference	Document
UserManual	Reference	Document
Pset_SustainabilityAssessment *in IfcBuilding, IfcSite, IfcBuildingStorey and IfcSpace*		
SustainabilityAssessment	Reference	Document
OverallPerformanceClass	Enumerated	Label
TechnicalPerformanceClass	Enumerated	Label
AdaptabilityPerformanceClass	Enumerated	Label
UsabilityPerformanceClass	Enumerated	Label
SocialPerformance	Enumerated	Label
EconomicViability	Enumerated	Label
ClimateResilience	Enumerated	Label
Pset_SustainableDeconstruction *in IfcBuilding, IfcSite, IfcSpace, IfcZone, IfcBuiltElement and IfcDistributionElement*		
DeconstructionAssessment	Reference	Document
ReusePotentialAssessment	Enumerated	Label
WasteManagementPlan	Reference	Document
EmbodiedEnvironmentalImpact	Table	Text/Real
Pset_UsagePhase *in IfcBuilding, IfcSpace and IfcDistributionElement*		
UserFeedback	Single	Text
MaintenanceLog	Reference	Document

Table 1. Proposed properties, Psets, and the entities in which they are located. (Continued)

properties to the appropriate building element or space. Psets or groups of properties are also proposed to organize the information, providing a logical infrastructure for the data within the HBIM model. These Psets seek to organize the missing information thematically to group related properties. Finally, a definition of how the property value would be represented within the IFC schema and the data type is defined, ensuring interoperability and understanding of the type of information.

The Psets Commissioning, ProjectDocumentation, and UsagePhase are related to documentation and process. Pset_Commissioning includes information about the start-up phase. Pset_ProjectDocumentation refers to general project documentation. Pset_UsagePhase covers information relevant to the usage phase, complementing the information stored in the existing IfcPerformanceHistory entity.

The Psets ConservationStrategy, HeritageCommon, HeritageCondition, and InventoryHistory are related to heritage and conservation. Pset_ConservationStrategy proposes a description of the long-term conservation strategy. Pset_HeritageCommon captures the cultural value and historical significance, and the legal protection status in more detail than the existing boolean property IsLandmarked. Pset_HeritageCondition documents the physical condition of the building. Pset_InterventionHistory documents the conservation process.

Pset_EnergyAudit records the information required by energy audits and indoor environment assessments, in addition to existing properties such as CO2Content and Illuminance. Pset_IndoorEnvironmentAssessment covers aspects of indoor environment quality. Pset_SustainabilityAssessment records the information for assessing sustainability in refurbishments, considering multiple aspects, since the existing property PerformanceClasses is just mapped for electrical circuit's protective devices, and complementing other existing properties such as ProjectInvestmentEstimate and ROI. Pset_SustainableDeconstruction relates to the relevant information on sustainable deconstruction.

The property HeritageProtectionStatus, although marked as type Single (IfcPropertySingleValue), could be Enumerated (IfcPropertyEnumeratedValue) with potential legal protection levels, such as "national", "regional", or "local".

The property DeteriorationType, although defined as Single, could potentially be Enumerated, with values such as "Erosion", "Salinization", "Biological Attack", etc. A complete list of possible types is not defined in the DIN standards, but the enumeration could standardly categorize deterioration types.

The properties DaylightingAssessment and AcousticAssessment are marked as Enumerated, and their possible values could be aligned with the performance classes defined in DIN EN 17680 (0, 1, 2, 3, NI), although they are not defined in this way in the DIN standards. A property of type Single could also be used.

The properties OverallPerformanceClass, TechnicalPerformanceClass, AdaptabilityPerformanceClass, and UsabilityPerformanceClass are defined as type Enumerated. DIN EN 17680 establishes an evaluation methodology based on a system of indicators and classification by performance levels. The values are: "Class 0", "Class 1", "Class 2", "Class 3", and "NI" (not investigated).

The properties SocialPerformance, EconomicViability, ClimateResilience, and ReusePotentialAssessment are defined as Enumerated types, and in all of them, options are inferred as a scale. "High", "Medium", "Low", "No" viability or potential could be used for all of them, but as an alternative, they could also be aligned with the classes already used in other properties (0-3, NI).

The property EmbodiedEnvironmentalImpact is defined as a Table (IfcPropertyTableValue). This allows representing the data in the form of a table, where each row associates an expression value with definition values. The expression column could contain the name of the environmental indicator (e.g., "Global Warming Potential", "Acidification Potential") using Text (IfcText) data type, or even Label (IfcLabel). The definition column should contain the corresponding numeric value for that indicator, using Real (IfcReal) data type.

The purpose of the Document (IfcDocumentReference) data type within properties of type Reference (IfcPropertyReferenceValue) is to provide a link or reference to an external document relevant to an entity in the HBIM model. This is useful because much of the detailed information, such as reports, plans, records, or manuals, exists as separate documents (PDFs, text files, etc.) rather than being fully embedded in the model. This implies that the property in the model does not store the content of the document, but rather a reference pointing to the external document file or location. This allows software applications that read the model file in IFC format to know where to find documents that complement the alphanumeric information included directly as properties.

7. Discussion

The analysis of the four DIN standards revealed that they provide guidelines on the information needed for conservation, sustainability, energy efficiency, condition assessment, and risk management in heritage buildings. These requirements have the potential to be represented using the entities and Psets in the IFC schema.

However, the existing properties in the IFC 4.3 schema are not sufficient to capture the granularity and specificity required by the DIN standards in the context of heritage buildings. Therefore, the addition of new properties and Psets to the IFC schema can fill the gaps. This addition can enhance interoperability and understanding of the type of information needed, supporting conservation processes and facilitating interdisciplinary communication.

The integration of DIN standards into HBIM models, as proposed in this paper, offers a structured approach to the documentation and management of heritage buildings. By aligning the IFC schema with DIN standards, a more comprehensive and standardized framework for conservation and retrofitting processes is created. This approach enables more effective decision-making and preservation strategies of cultural and historical significance.

Future research should include exploring the possibilities of standardizing the requirements of norms and standards as properties, and the regulated use of these properties to standardize the digital processes. The proposal included in this paper is just a small example that shows that there is room for improvement in this direction. To make this possible, a collaborative effort must be undertaken among stakeholders in the field of BIM, heritage conservation, and standardization, including leaders, research institutions, government agencies, international organizations, and professional associations.

8. Conclusion

Heritage Building Information Management (HBIM) has great potential as a structured repository for preventive documentation and can become a key tool for information management in the rehabilitation of historic buildings. By leveraging its potential and integrating requirements from norms and standards related to historic heritage conservation, a more efficient and effective management process can be achieved.

The proposal presented in this paper acts as a bridge between the need for detailed information for HBIM and sustainable rehabilitation, the specific requirements defined by DIN standards for conservation, energy and sustainability (DIN EN 16853, DIN EN 16883, DIN EN 17680 and DIN EN 16247-2), the list of missing properties that are not covered by the IFC 4.3 schema, and the formal structuring of how this information can be added or mapped into the IFC 4.3 schema. It seeks to make IFC-based HBIM models more semantically rich and capable of complying with relevant standards, allowing the digital model to truly function as a structured repository for the integrated management of heritage buildings.

This approach facilitates better data management, improves interoperability and understanding of the type of information needed, supports interdisciplinary conservation planning, and enables more informed and effective decision-making for rehabilitation interventions.

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