Level of Information Need in Heritage Building Management: a case study in Morocco

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Abstract
This paper investigates the symbiotic relationship between Heritage Building Information Modeling (HBIM) and Level of Information Need (LOIN) in the realm of heritage building management. Recognizing the generic nature of Level of Development (LOD) standards in HBIM, we underscore the significance of defining specific information requirements tailored to architects' needs. Employing the ISO 7817-1 standard as a guiding framework, our study focuses on the implementation of LOIN principles in a Moroccan heritage building for pathology diagnosis. First, a literature review on HBIM and LOIN is presented, a case study is illustrated and later results of a survey and interviews are analyzed and discussed. The paper is one of the first publications that shows how LOIN can be applied in HBIM for the erosion aspect of pathology analysis. Despite the current implementation of HBIM among architects in Morocco is very limited, the majority of interviews believes that the LOIN approach can improve effective definition of deliverables to drive more accurate conservation activities. To increase the HBIM maturity in the country, more training and fundings should be provided as well as collaboration between academia, industry and heritage organizations.

Keywords: Preservation, Cultural Heritage, Historical Building Information Modeling, Level of Information Need, Pathology Diagnosis

1 Introduction

Nowadays Building Information Modelling (BIM) has been implemented in the cultural heritage to support different uses (Piaia et al 2020). However, one of the main issues in the development of BIM remains the definition of precise information requirements (Tsay et al 2023) to enable a machine-readable approach supporting semi-automatic checking of deliverables.

In addition, in some countries as Morocco, there has been growing awareness about the preservation and valorization of cultural heritage. Several historical sites are listed as World Heritage by UNESCO in cities such as Rabat, Fes and Figuig. However, the status of BIM in Morocco is still in its infancy, and its implementation in client organizations and architectural practices remains a significant challenge.

This work seeks to address this gap by investigating the current adoption of HBIM in Morocco and how clients and professionals can define more accurate information requirements to support a data-driven approach.

2 Methodology

A mixed methodology has been used to undertake this study. A specific case study related to pathology diagnosis has been selected to evaluate the research questions. Firstly, a selection of papers on HBIM and definition of information requirements has been undertaken. Papers were selected using Scopus by searching the keywords “BIM”, “building information modelling”, “heritage”, “HBIM”, “information requirements”, “LOD” “level of information need” and “LOIN”. A total of 36 papers were found and analyzed but just 13 were considered relevant for this study because of their accuracy discussing HBIM and information requirements. Secondly, the LOIN framework included in the standard ISO 7817-1 (replacing EN 17412-1) has been implemented in the case study of Ksar Loudaghir in Figuig, Morocco. The study area represents the Jewish district that was demolished due to disrepair. A house in ruins that will undergo a restoration intervention has been selected for the case study. Renovation usually starts with a diagnostic study during feasibility. This step involves identifying the various pathologies affecting the project. Based on the results of this diagnosis, the architect recommends the types of interventions to be carried out during the restoration phase, hence the relevance of our choice.
Later, a structured survey was sent to stakeholders in cultural heritage in Morocco to investigate the adoption of HBIM and the potential of the LOIN approach. The survey was sent mainly to architects as they are the main actors for the initial phase of pathology analysis. The stakeholders have been selected for their crucial role to intervene directly in cultural heritage projects. We have selected 20 Moroccan architects who are experts in heritage, with experience ranging from 2 to 10 years in the field and they are working for the main Moroccan clients organizations for heritage sites.
After the survey was completed, participants were asked to attend in person interviews to discuss the answers of the survey and expand on challenges, opportunities, and potential pathways for leveraging LOIN framework in the Moroccan heritage preservation. Interviews were recorded and analyzed using qualitative content analysis. Finally, results have been presented and discussed.

3 Literature review

BIM is a methodology that represents a significant advancement in the world of AECO (Architecture, Engineering, Construction and Operations). Several studies have demonstrated the effectiveness of this methodology for new assets as well as existing ones, including heritage assets (HBIM) (Lovell et al 2023). BIM facilitates the reconstruction, documentation, management, and maintenance of cultural heritage (Colucci et al 2023). Several emerging technologies now allow the exploitation of information by translating it from the real world to the virtual world, also by using machine learning techniques (Belhi et al 2020). Malinverni et al (2019) emphasized the development of the Scan to BIM method, which involves using deep learning approaches to automate the transformation of point clouds into parametric objects. Another example is photogrammetry, which allows the representation of a structure or prominent elements of a building through the amplification of a succession of high-resolution images (Ch’ng et al 2018, Di Giulio et al 2017, Alshawabkeh et Baik 2023). The produced point clouds offer flexibility of use, ranging from 3D representation to textured orthophoto representation, enabling better analysis of materials and pathologies in various forms (Banfi, 2017).
However, one challenge in implementing BIM is defining machine-readable requirements (Bolpagni and Ciribini, 2016). Numerous solutions exist for structuring data such as Information Container for linked Document Delivery (ICDD). Within a Common Data Environment (CDE), the potential of ICDD in linked data management, interoperability and metadata querying is interesting (Senthilvel et al 2021). Also, using web ontologies and Linked Data principles can provide a valuable knowledge-based approach to assess construction damages. By linking data from multiple ontologies and integrating information models, it enables comprehensive damage evaluation (Al-Hakam et Raimar 2019, Bonduel et al 2019).
The LOD (Level of Definition) concept and its variations (level of geometry, level of information, level of detail etc.) provide a reference to describe the progressive development of information,

especially the modeling aspects (Bolpagni and Ciribini 2016). These concepts have been applied also in HBIM expanding or modifying LOD scales for heritage. For example, in Italy specific LOD were added to consider information requirements for restoration in the UNI 11337-4:2017 (LOD F-G). However, the application of this approach lacks precision, leading to interpretation and lack of direct implementation in authoring tools. According to Santoni et al (2020), in an HBIM methodology, the use of LOD in the management of restoration and preservation delays the understanding of geometry, state of the art, and structural behavior. This results in increased costs, poor time management, and limits the ability to undertake coherent restoration or renovation solutions (Brumana et al 2018). These issues can lead to irreversible damage, misallocated resources and failure to meet conservation standards.

To overcome those issues, the level of information need (LOIN) framework was introduced in the standard ISO 19650-1:2018 and later further detailed in EN 17412-1:2020 that became an international standard in 2024 as ISO 7817-1. LOIN allows clients to define precise information requirements and allow a machine-readable approach (Oliveira et al 2024). However its adoption in HBIM is still very limited and there are few published articles on this topic that mention LOIN (Lovell et al 2023; Argasiński & Kuroczyński 2023). However, Lovell et al 2023 do not mention the standard EN 17412-1 and they just refer to "ISO 19650", mentioning incorrectly that LOIN "is composed of the level of model detail and level of associated information. In addition, Argasiński & Kuroczyński (2023) do not follow the LOIN framework presented in EN 17412-1, but they use traditional labels as "LOIN 1". For these reasons, there is a gap in the current literature on applications of LOIN for HBIM according to the published standard ISO 7817-1:2024 (that replaces EN 17412-1:2020).

4 Case study: Ksar Loudaghir in Figuig – Morocco

A Moroccan case study has been identified to investigate the application of the LOIN framework. The case study is situated in Figuig, a palm oasis town located in eastern Morocco, near the border with Algeria. This town is characterized by its unique cultural heritage and it has been listed as a UNESCO World Heritage Site since 2011. Figuig represents a testament to the ingenuity of its predecessors in using a perfect blend of raw stone and earth.

The case study focuses on Ksar Loudaghir area, the Mellah district, known as the Jewish quarter (Figure 1). This case study selected a Jewish house that has undergone degradation both structurally and architecturally (Figure 2).

Figure 1. Project situated in Mellah district which is the Jewish house zone

Figure 2. Panoramic view taken from the North gallery of the upper floor. Source: Study "Testimony of Degradations of the Mellah"

Loin implementation for pathology diagnosis: This following section shows how the LOIN framework can be implemented by the client to specify how to conduct a pathology diagnosis for the Jewish house within the Mellah quarter in Ksar Loudaghir in Morocco. The LOIN has been defined using a traditional approach with written text and tables in word to communicate with local stakeholders who are not familiar with HBIM.

4.1 Prerequisits

To define the LOIN, the first step deals with identification of the prerequisits. For this case study the following prerequisites have been identified:

- **Purpose:** pathology diagnosis;
- **Information delivery milestone:** feasibility;
- **Actor - information receiver:** public client;
- **Actor - information provider:** architect;
- **Objects:** wall, column, slab, roof, stair, door, window, terrain, landscaping and site accessories (see Table 1).

Table 1. Objects breakdown for pathologis diagnosis displaying IFC entities and types

Object	IFC Entity	IFC Type
	Group 1 Architectural and structural element	
Architectural walls	IfcWall	STANDARD
Structural walls	IfcWall	STANDARD
Columns	IfcColumn	COLUMN
Slab	IfcSlab	FLOOR
Roofs	IfcRoof	WOODEN_ROOF
Stairs	Ifcstair	DOUBLE_L-SHAPED STAIRS
	Group 2 Interior elements	
Doors	IfcDoor	DOOR

Windows	IfcWindow	WINDOW
	Group 3 Site element	
Terrain	IfcGeographicalElement	TERRAIN
Landscaping	IfcGeographicalElement	LANDSCAPE
Site Accessories	IfcBuildingElementProxy	SITE_ACCESSORY

When dealing with pathology diagnosis the following sub-purposes have been identified: erosion, cracks, dampness, structural deformation, material decay (relative to stone and wood), staining and discoloration. All those sub-purposes were analyzed as part of our study; in this paper just the erosion of the wall is presented as an example.

4.2 Geometrical information

4.2.1 Detail

The detail needed for pathology diagnosis of a door is symbolic. Just the perimeter of the erosion should be represented (Figure 3).

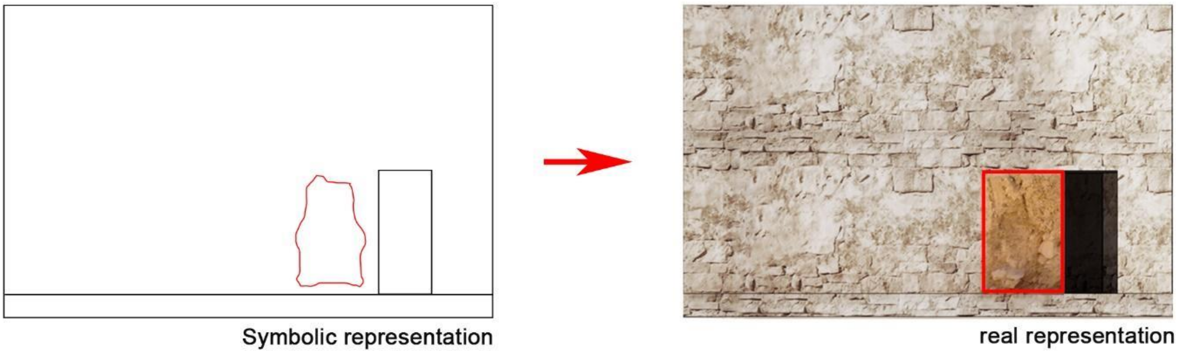


Figure 3. Detail aspect of geometrical information for a wall relative to pathology diagnosis

4.2.2 Dimensionality

Dimensionality represents the dimension of the needed representation. In this case study a 3D dimensionality is required (Figure 4) because it provides comprehensive visualization, accurate assessment, and detailed representation of the heritage structure, capturing intricate details crucial for understanding and addressing erosion. They enable simulation and prediction of future erosion patterns, enhancing preventive measures and intervention strategies. Additionally, 3D representation improves communication among project stakeholders and integrates with advanced technologies as point cloud and geographic information system (GIS). This ensures historical accuracy and supports effective decision-making, preserving the structure's integrity and historical significance.

Figure 4. 3D modeling of the study project

4.2.3 Location

Location allows to place the erosion pathology in the geometrical representation. It can be absolute or relative. In this case study, the location is absolute because it is important to ensure precise geolocation of erosion areas. Absolute localization provides exact coordinates, enabling accurate tracking and monitoring of the erosion over time. This precision is crucial for planning targeted interventions, assessing the effectiveness of restoration efforts, and maintaining the historical integrity of the heritage structure (Figure 5).

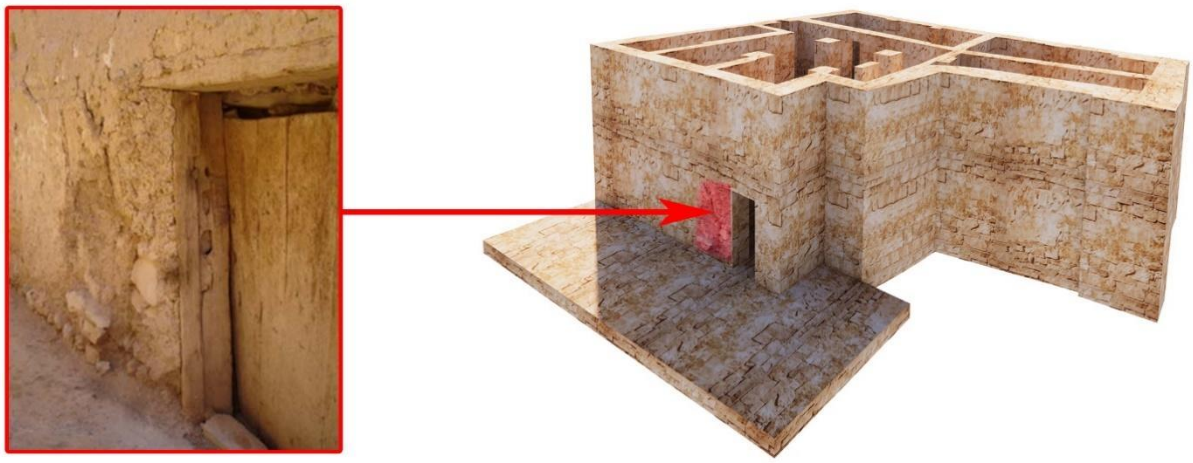


Figure 5. Location of the erosion pathology. Source image: Study "Testimony of Degradations of the Mellah"

4.2.4 Appearance

This section describes the needed appearance for erosion. In this context the real texture of material is required because it provides insights of the condition of the material and the extent of the damage. The texture can reveal signs of wear, erosion patterns, biological growth, and other forms of degradation that might not be visible through other means. Accurate representation of the material's texture helps in diagnosing the specific types of pathology, planning appropriate interventions, and ensuring that the restoration efforts preserve the history of material and the aesthetic integrity.

4.2.5 Parametric behavior

In this case, the parametric behavior is required because it allows the client to dynamically adjust and optimize the design later on based on various parameters and conditions. This flexibility enables the client to evaluate multiple scenarios, predict the impact of different interventions, and make informed decisions. By understanding how changes in parameters affect the accuracy of pathology diagnosis, the client can develop more effective and tailored solutions, ensuring that the future interventions address the specific needs and conditions of the heritage project.

4.3 Alphanumerical information

4.3.1 Identification

To allow identification of objects within a breakdown structure, the IFC schema was used (see Table 1).

4.3.2 Information content

This section allows for grouping properties to facilitate the management of alphanumeric information (see Table 2).

In addition, as part of this study, we added the information content in the authoring tool (Autodesk Revit) to show later to the architects how information requirements can be answered in the information model. After entering all the information needed to identify the erosion pathology and localizing it into the model, the use of a viewer (DDScad Viewer) was crucial to interpret the data gathered (Figure 6). The viewer allowed to read inside the IFC schema all the properties related to the erosion pathology (Table 2) simplifying the management of alphanumeric information.

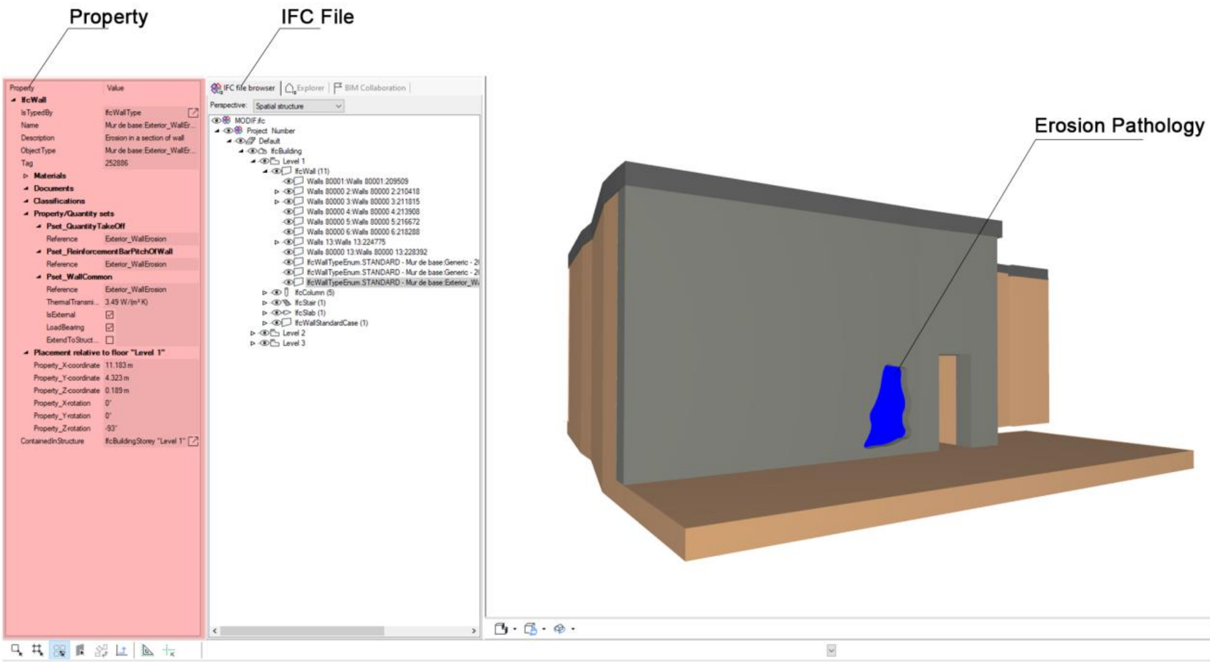


Figure 6. DDScad Viewer showing the alphanumerical information for the erosion pathology of a wall

Table 2. Required Properties for IfcWall for "Erosion Assessment" purpose

Property Name	Description	Data Type	Instance or Type	Unit
	IfcWall			
Name	Common Wall: Exterior_WallErosion	Character	I	n/a
IsTypedBy	IfcWallType	Character	I	n/a
Description	Erosion in a section of wall	Character	I	n/a
Tag	252886 (ID of the infected wall)	Integer	I	-
Materials	Stone (Type of material the wall can be made by concrete, stone, brick, earth,…)	Character	T	mm

	Pset_WallErosion			
Reference	Exterior_WallErosion	Character	I	n/a
IsExternal	= TRUE (It can either = FALSE if it was Interior wall who was infected by erosion)	Boolean	I	n/a
LoadBearing	= TRUE (It can either = FALSE if it wasn't a structural wall)	Boolean	I	n/a
Area	1.48 m^2 (Represent the area of the erosion)	Decimal	T	m^2
Width	20 cm (Represent the width of the erosion)	Decimal	T	cm
Height	1.7 m (Represent the height of the erosion)	Decimal	T	m

4.4 Documentation

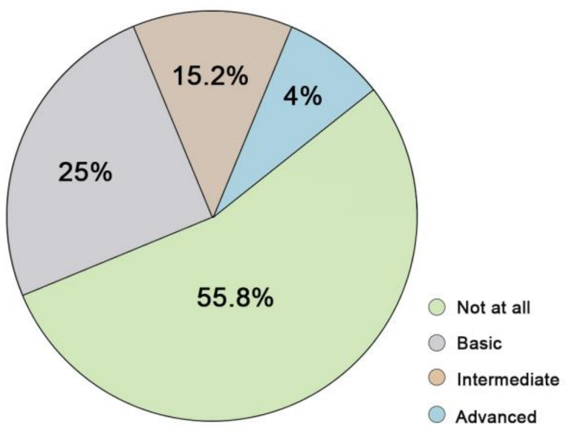
This part allows for grouping all possible information about the erosion phenomenon. In this case study, several documents are needed to conduct proper interventions and address the erosion phenomenon. First, site plans must be provided, showing the location and context of the heritage project. If available, architectural drawings from previous investigations that illustrate the damage and degradation, might be required to allow a comparison with the actual situation. Topographical surveys are also needed, as they illustrate the site and any relevant geographical features affecting erosion.

In addition, condition assessment reports with detail of the current state of the structure, including visual inspections, are required. Additionally, structural and material analysis reports might be useful to assess the main structure's behavior in relation to materials that can cause erosion, cracks, and all the phenomena listed in the prerequisites section.

To manage and reference these documents effectively, we utilize relevant IFC entities. IfcDocumentInformation stores metadata for previously cited external documents, including identification, description, and other details, while providing access to the document content through its Location attribute (Atazadeh et al 2021). This entity also includes additional metadata elements such as document owner, purpose, editors, scope, electronic format, intended use, confidentiality, and status, which are crucial for maintaining organized and comprehensive documentation. On the other hand, IfcDocumentReference facilitates referencing specific components of IfcDocumentInformation, such as particular chapters or paragraphs. This capability ensures easy access to relevant sections related to the erosion phenomenon, promoting precise and efficient document management.

5 Survey on implementation of HBIM in Morocco

This section presents survey and interview results undertaken among 20 Moroccan practitioners, with focus on architects specializing in heritage. The survey was divided into three key areas: understanding of HBIM, understanding of LOIN, current state and future perspectives of both.



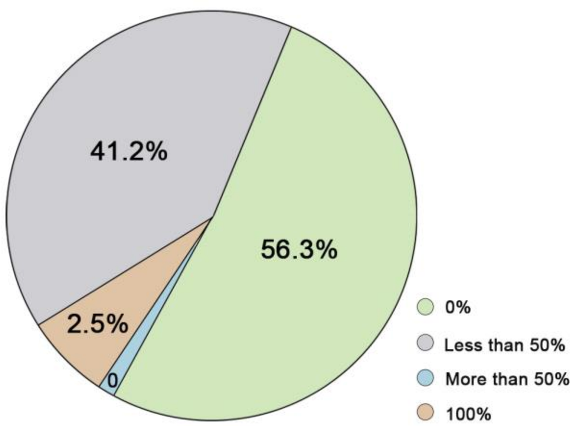


Figure 7. Level of familiarity with HBIM Projects

Figure 8. Utilization of HBIM in Moroccan heritage

Regarding the level of familiarity with the HBIM, we observe that 55.8% of the architects have no knowledge of HBIM, and 25% have only a basic understanding (Figure7). Conversely, 19.2% are at an intermediate to advanced level. 56.3% of participants have never experienced or heard of HBIM in the heritage field (Figure 8). Moreover, 41.2% of architects consider utilizing HBIM in heritage projects less than 50%.

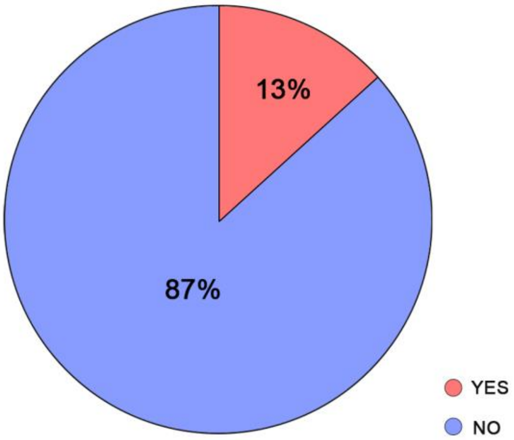


Figure 9. Utilizing a standard to specify a requirement for heritage preservation using BIM

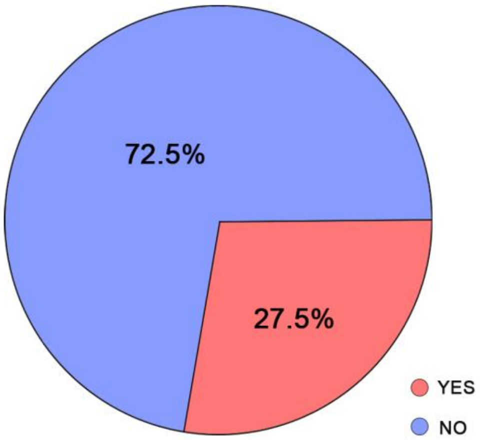


Figure 10. Knowledge about the concept of LOIN in heritage preservation

Figure 9 shows that just 13% of heritage projects using this methodology adhere to a standard and 27.5% are familiar with the LOIN framework.

6 Discussion of survey results and interviews

The survey shows that the knowledge of BIM for HBIM is very limited among Moroccan architects working for heritage projects, and usually they do not follow any type of standards for defining information requirements and modeling.

After the survey, interviews were performed with same participants to delve into the benefits and challenges in using HBIM. The majority of responses emphasized that HBIM allows preservation and conservation of data as well its organization and accuracy as usually information is spread in documents and it is not easy to find causing delays and issues. Having a precise schedule can drastically improve workflows and enhance interventions in various forms such as providing the right information to the right specialist in a timely manner. Additionally, HBIM could allow for better-detailed recording of the architectural and technical components of heritage relics, leading to better future management (maintenance, renovation, rehabilitation) and more precise and refined architectural interventions for requalification or enhancement.

The majority of interviewees mentioned that the main challenge in using HBIM in Morocco, deals with lack of expertise. A good mastery of the HBIM requires considerable on-site experience and a strong command of various types of interventions in the field of heritage as well as experience in using BIM methodology. Furthermore, some interviewees mentioned that another challens is related to lack of tools to represent the complexity of structures with irregular surfaces and shapes. In addition, another issue is the lack of interdisciplinary collaboration between historians, architects, and technologists. Finally, cost and resources can be prohibitive for clients, leading to the abandonment of HBIM.

During the interviews, the case study illustrated in section 4 (Ksar Loudaghir in Figuig) was discussed to show the possibilities of implementing the LOIN framework. Practitioners mentioned that for pathology diagnosis, the majority of studies are conducted in site, in the form of traditional surveys in handwritten form without a detailed brief from clients. This practice has been criticized by most architects who complained about uncertainty of quantity and quality of deliverables as well as loss of information and lack of precision.

The use of a standard such as LOIN can drastically enhance the quality of information k requirements created by clients to be issued to architects for a more effective and precise response. It was mentioned during the interviews that LOIN offers several opportunities, including more accurate offers, knowing what the client really needs, enabling architects to easily work on their targeted tasks, and increasing the manageability and interoperability of the information model. All interviewees mentioned that the main limitations are lack of stakeholders' knowledge about LOIN, lack of funds from public authorities or professional bodies, to start implementing the basics of HBIM as a strategy.

7 Conclusion

This paper shows an example of how the LOIN framework can be used for HBIM, especially for the erosion aspect of pathology analysis. This is the first application of LOIN for HBIM as previous publications discussed in the literature review did not cover the heritage sector. The LOIN framework has been defined using a traditional approach (text and tables) due to the novelty of the topic in Morocco.

The research also shows that HBIM is still not widely used in Morocco and standards are rarely applied. Interviewees see potential in using BIM for the heritage sector and the majority believes that the LOIN framework can support them in receiving a more accurate brief. LOIN enables the definition of needed amount of information for specific tasks, enhancing efficiency in opposition of the “LOD” approach that is open to interpretation and potential legal claims. The ‘LOD’ approach is indicative, especially for HBIM where very often there are not extensive guidelines that define the meaning of generic labels as “LOD 200” or “LOG B”. Thanks to precise requirements, instead, experts can focus on conservation efforts, optimizing resources while preserving the integrity of cultural heritage sites.

Implementing HBIM and LOIN requires significant effort at frontend. Dedicated funding for research and development, as well as training programs to upskill professionals in heritage conservation and digital modeling are essential in Morocco. The definition of LOIN for HBIM should be a joint effort between academia, industry, and heritage organizations.

Future work might include the definition of LOIN for pathology analysis using a database to allow more effective machine-readable approach and automatic checking. In addition, the survey can be repeated to monitor maturity progress and by involving a wider range of stakeholders active on heritage in Morocco.

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