Knowledge and Decision Systems with Applications

www.kadsa.org
eISSN: 3079-6318

A BIM-Enabled Framework for Design Continuity and Lifecycle Decision-Making

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ARTICLE INFO

Article history:
Received 20 March 2026
Received in revised form 10 May 2026
Accepted 26 May 2026
Available online 03 June 2026

Keywords:
Building Information Modelling; Facilities Management; Design Framework; Decision-Making

ABSTRACT

Building Information Modelling (BIM) has evolved into a fundamental platform for lifecycle information management within the Architecture, Engineering, Construction, and Facilities Management (AEC-FM) sector. Despite its effectiveness in supporting technical coordination and information exchange, BIM remains limited in preserving Architectural Design Intent (ADI), particularly the spatial, material, functional, and experiential rationale underpinning design decisions. Consequently, critical design knowledge is often fragmented or lost during transitions between design, construction, and facility management phases, undermining design continuity and lifecycle decision-making. This study investigates how ADI is represented, transferred, and preserved within BIM-enabled workflows and proposes a structured mechanism for maintaining design continuity throughout the building lifecycle. A mixed-methods approach was adopted, combining a systematic literature review, comparative analysis of four documented BIM case studies, and a questionnaire survey involving architects, BIM managers, contractors, and facility managers. The findings reveal that ADI loss occurs predominantly during design-to-construction and construction-to-facility-management transitions. Key causes include inadequate documentation of design rationale, model simplification during handovers, fragmented stakeholder communication, and the absence of structured metadata for capturing qualitative design knowledge. Three principal dimensions of vulnerability were identified: spatial layout, materiality, and functionality. Survey results further demonstrate strong industry recognition of the importance of preserving ADI while highlighting practical implementation barriers, including unclear responsibilities, time constraints, and limited client requirements. To address these challenges, this study proposes a Design Intent Preservation Framework (DIPF) integrating rationale annotation, metadata tagging, design constraint recording, and lifecycle coordination triggers within BIM environments. The framework contributes to lifecycle-oriented BIM research by extending information management beyond technical interoperability toward the preservation of design knowledge, thereby supporting informed decision-making and long-term design continuity.

1. Introduction

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https://doi.org/10.59543/rgq78c34

1.1 Digital Transformation and Lifecycle-Oriented BIM in the Built Environment

The built environment sector is currently undergoing a profound transformation driven by rapid technological advancement, accelerating urbanisation, and the global demand for sustainable and intelligent infrastructure. Despite contributing approximately 13% to global Gross Domestic Product (GDP), the construction industry remains one of the least digitised sectors compared with manufacturing, finance, and logistics [1]. This persistent digitalisation gap has intensified the need for integrated information management approaches capable of improving productivity, reducing fragmentation, and enabling more informed decision-making across the building lifecycle [2].

Building Information Modelling (BIM) has emerged as a key response to these challenges. BIM facilitates the creation, management, and exchange of digital representations of built assets, allowing stakeholders to coordinate information across design, construction, handover, and operation. Initially developed as a tool for improving 3D design coordination, BIM has evolved into a multidisciplinary information management system supporting spatial coordination, clash detection, scheduling, cost estimation, performance analysis, and Facilities Management (FM) [3]. The institutionalisation of BIM has been reinforced by international standards and policy frameworks, including the UK Government's BIM Level 2 mandate, ISO 19650, the Construction Playbook [4], and the Net Zero Strategy [5]. These initiatives reflect a broader transition from project-based delivery efficiency toward lifecycle performance and whole-life value. Buildings are no longer evaluated solely according to cost or delivery speed, but by how they perform, adapt, and age over time.

This lifecycle-oriented shift is further accelerated by the emergence of Digital Twin (DT), IoT-integrated systems, and data-driven FM. These technologies rely heavily on structured and transferable BIM data. However, if BIM is to support long-term lifecycle intelligence, it must preserve not only technical and operational information but also the design intelligence embedded during early architectural stages.

1.2 Architectural Design Intent (ADI) and the Challenge of Knowledge Continuity

ADI refers to the spatial, aesthetic, cultural, experiential, and contextual reasoning embedded within architectural decisions. It captures not only what is designed, but also why specific forms, spatial configurations, materials, and user experiences are selected. ADI therefore constitutes a critical component of a building's architectural identity and design coherence throughout its lifecycle [6].

The early design stage forms the conceptual foundation of architectural projects. During this phase, architects engage in iterative processes of abstraction, exploration, negotiation, and synthesis before design concepts are translated into formal documentation and construction logic [7]. ADI encompasses both explicit and implicit forms of design knowledge. Explicit elements include geometry, material palettes, circulation systems, and spatial organisation, while implicit dimensions include atmosphere, symbolism, sensory experience, and anticipated user behaviour [8]. As Sherif [9] notes, ADI is not merely a static design outcome, but a dynamic process shaped by stakeholder dialogue, contextual conditions, cultural influences, and evolving design reasoning.

Traditionally, this knowledge was communicated through sketches, physical models, drawings, annotations, and tacit understanding retained by architects. With the increasing adoption of BIM, however, design knowledge is progressively encoded within parametric models and associated metadata. BIM enables design alternatives to be modelled and evaluated in real time, improving communication, coordination, and design optimisation. Nevertheless, much of the underlying rationale behind architectural decisions remains undocumented within BIM environments.

1.3 BIM and the Limitations of Design Knowledge Representation

Although BIM is frequently promoted as a lifecycle-enabling methodology, existing literature suggests that current BIM workflows remain heavily oriented toward technical coordination rather than conceptual continuity. BIM effectively records geometric, technical, and performance-related information, but it often fails to capture the narrative, interpretive, and experiential dimensions of architectural reasoning. This limitation has been widely discussed in the literature. Coates *et al.,* [8] describe BIM as closer to “digital Lego” than “digital clay”, arguing that BIM lacks the openness and fluidity necessary for conceptually rich architectural exploration. Similarly, Martin *et al.,* [10] argue that BIM tools may restrict design freedom and reduce opportunities for bespoke architectural outcomes. These critiques reveal a shared concern that while BIM enhances technical coordination, it may simultaneously undermine design imagination and qualitative reasoning.

In current practice, ADI is often only partially represented through textual comments, linked documents, or informal annotations, many of which become disconnected, obsolete, or removed during later project phases [11]. Interoperability schemas such as Interconnected Facility Management (IFC) and Construction Operations Building information exchange (COBie) support structured data exchange, particularly for FM, but they frequently reduce complex design narratives into simplified technical data formats [12]. Consequently, unless design intent is embedded through structured metadata or decision-capture mechanisms, it becomes vulnerable to semantic drift and eventual loss during lifecycle transitions [13,14].

Abdelalim *et al.,* [15] further argue that ADI ranges from explicit model content to implicit stakeholder knowledge, and that without formal encoding strategies, tacit design reasoning is unlikely to survive successive project transitions. This suggests that BIM requires not only technical interoperability but also mechanisms capable of preserving qualitative design knowledge.

1.4 Lifecycle Fragmentation and the Loss of ADI

The fragmentation of ADI becomes particularly evident during transitions from design to construction and from construction to FM. During construction, BIM models are commonly re-authored to prioritise constructability, sequencing, quantity take-offs, and technical coordination. While these modifications improve delivery efficiency, they may also alter spatial arrangements, material specifications, and architectural details without preserving the rationale behind the original decisions [16].

Similarly, in FM, BIM primarily functions as a repository of operational metadata, including maintenance schedules, system specifications, and asset identifiers. Although BIM has significant potential for lifecycle management [3], construction and FM professionals are often insufficiently involved during early design stages, resulting in models that fail to fully reflect architectural intent, operational priorities, or construction constraints [17]. This disconnect can lead to inefficient layouts, inappropriate material substitutions, and costly post-handover interventions [18].

The literature increasingly identifies these transitions as points of information fragmentation and “data inheritance” breakdown [19]. Each project stage introduces new stakeholders, priorities, and modelling protocols, often resulting in the filtering, overwriting, or simplification of design-layer metadata [20]. Hu *et al.,* [21] demonstrate that even relatively minor discrepancies between as-designed and as-built models can generate significant misalignment with the original ADI.

Importantly, this erosion of design fidelity is not merely a technical issue but a systemic one. Existing BIM standards such as ISO 19650, IFC, COBie, and BS EN 17412-1 primarily focus on interoperability, asset information exchange, and operational data management. Although these standards improve structured information delivery, they provide limited mechanisms for preserving qualitative design reasoning, experiential logic, or contextual architectural knowledge. As a result, BIM workflows continue to privilege technical efficiency over conceptual continuity. The reviewed literature consistently highlights a critical gap in how ADI is embedded, transferred, and maintained within BIM-enabled lifecycle workflows. Existing BIM research has made considerable progress in interoperability, lifecycle integration, and technical information management; however, it has largely prioritised geometric accuracy, coordination efficiency, and operational performance over the preservation of qualitative design reasoning.

Current BIM standards and workflows support the exchange of technical information but inadequately preserve the architectural “why” behind spatial organisation, material selection, and experiential design decisions. The loss of ADI is especially evident during transitions from design to construction and from construction to FM, where model reauthoring, role-specific filtering, and fragmented data practices contribute to semantic drift and knowledge discontinuity. Furthermore, while substantial literature exists on BIM implementation and lifecycle management independently, comparatively little research has explored the intersection of BIM, ADI, and lifecycle continuity as an integrated process. Existing approaches to decision capture and narrative BIM remain underdeveloped and inconsistently applied in industry practice.

This reveals a clear research opportunity to investigate systematic methods for preserving ADI throughout the BIM lifecycle through structured metadata, rationale annotation, and lifecycle coordination mechanisms.

Based on the identified research gap, this study is guided by the following research questions:

How is ADI currently represented within BIM-enabled workflows?

At which stages of the building lifecycle is ADI most vulnerable to fragmentation or loss?

How do architects, BIM professionals, and facility managers perceive the value and usability of ADI in downstream lifecycle decision-making?

How can BIM workflows be enhanced to support the systematic preservation and transfer of ADI throughout the building lifecycle?

To address these questions, the study pursues the following objectives:

1. To examine how ADI is currently captured and represented within BIM environments.
2. To identify where and why ADI is lost during transitions from design to construction and FM.
3. To investigate stakeholder perceptions regarding the value and practical use of ADI in lifecycle BIM workflows.
4. To develop a Design Intent Preservation Framework (DIPF) incorporating metadata tagging, rationale annotation, and lifecycle coordination triggers to support design continuity across the building lifecycle.

2. Methodology

This study adopts a mixed-methods research approach, integrating both qualitative and quantitative methodologies to comprehensively investigate the challenges associated with sustaining ADI throughout BIM processes. The study recognises that ADI extends beyond purely quantitative metrics, as it also encompasses intangible design attributes and qualitative architectural values. The research is grounded in a constructivist framework, acknowledging that ADI is shaped by diverse stakeholder perspectives and contextual influences across the design and construction process. The mixed-methods approach enhances the comprehensiveness and reliability of the findings by enabling the triangulation of literature, empirical case studies, and industry perspectives. Consequently, the study is able to examine not only measurable trends but also the nuanced interpretations and perceptions of ADI.

To address the four research objectives systematically (Figure 1), different but interconnected methodologies are employed. Objective 1 is achieved through a comprehensive literature review. Objective 2 is addressed through the examination of real-world case studies. Objective 3 is investigated using a questionnaire survey to evaluate stakeholder attitudes and perceptions. Finally, Objective 4 is achieved through the synthesis of all findings into a conceptual theoretical framework. This multi-phase methodological approach ensures that the research not only identifies the issue of ADI loss within BIM processes but also provides theoretically informed explanations and practically relevant solutions applicable to real-world contexts.

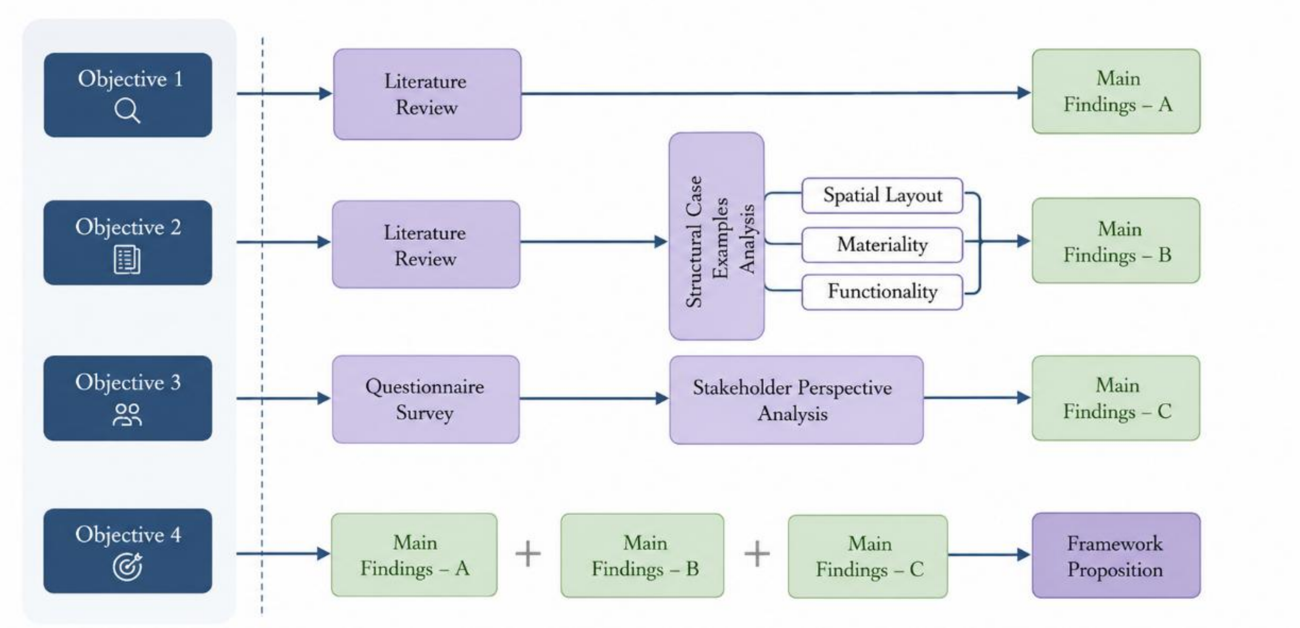


Fig. 1. Research methodologies

2.1 Defining and Integrating ADI within BIM Workflows

A comprehensive literature review was undertaken to address this objective. The review established the theoretical foundation of the study by critically examining existing academic and professional discourse related to BIM, FM, and ADI. The findings revealed that three principal dimensions spatial layout, materiality, and functionality constitute the primary aspects through which ADI degradation occurs throughout a building's lifecycle. These dimensions provide an analytical lens for evaluating the discrepancies between intended and realised design outcomes. In addition, a secondary layer of operational and regulatory influences was identified as contributing to ADI deterioration, including factors such as safety requirements, cost constraints, energy efficiency targets, maintainability considerations, and construction logistics.

2.2 Identifying ADI Gains, Losses, and Priority Shifts during BIM Transitions

This objective seeks to investigate the contexts and mechanisms through which ADI is frequently compromised during BIM-enabled project transitions. Rather than focusing exclusively on in-depth case studies of individual projects, the study draws upon a broad range of examples derived from academic literature and industry documentation. This approach enables the identification of recurring real-world scenarios in which ADI was diminished as a result of project phase transitions, stakeholder reconfiguration, or performance-driven modifications.

The analysis provides a comprehensive understanding of ADI loss throughout the entire building lifecycle, encompassing the design, construction, and operational stages. The examined examples include educational buildings, healthcare facilities, museums, governmental buildings, mechanical spaces, and several other building typologies. Each case illustrates how and why specific modifications undermined the integrity of the original design intent. To support Objective 1, these findings are explicitly connected to the three core dimensions of ADI.

Spatial layout refers to the organisation and relational logic of interior spaces, including circulation patterns, adjacencies, proportions, and zoning arrangements. Alterations to the original design, such as repositioned walls or widened corridors, may disrupt spatial orientation, natural lighting conditions, and overall circulation efficiency within the built environment [22]. Materiality encompasses the sensory, symbolic, and environmental qualities of architectural materials, including texture, reflectivity, thermal performance, and colour. Inadequate documentation of the rationale behind material substitutions or procurement-related changes may negatively affect both environmental quality and building performance [23].

Functionality refers to the intended use, adaptability, and contextual responsiveness of a space. According to Bąkowski [24], the repurposing of spaces for example, converting communal areas into storage or technical rooms may adversely affect user experience, natural lighting, ventilation, and acoustic performance.

The findings further indicate that BIM models rarely contain structured and accessible explanations of the rationale underlying design decisions. Without embedded reasoning or integrated design knowledge, subsequent stakeholders are often unable to evaluate the long-term implications of modifications introduced during later project stages. Accordingly, the study examines targeted mitigation strategies for these challenges where appropriate. Collectively, these approaches emphasise the necessity for a more systematic method of capturing and preserving ADI within BIM workflows, thereby establishing the conceptual foundation for the DIPF proposed in objective 4.

2.3 Evaluating Stakeholder Perceptions of BIM for Lifecycle Design Continuity

To strengthen and validate the findings derived from the literature review and case study analysis, a questionnaire survey was conducted involving architects, BIM managers, construction professionals, and facilities managers. Participants were selected through purposive sampling to ensure balanced representation across design and operational responsibilities. Invitations were distributed through academic channels, professional networks, and LinkedIn to reach individuals with direct experience in BIM-related processes.

The survey aimed to capture stakeholder perspectives regarding the current state of ADI preservation within BIM workflows, the challenges associated with recording and accessing design rationale, and the extent to which operational priorities influence design integrity. The questionnaire consisted of both multiple-choice and open-ended questions and was distributed through digital platforms and professional networks. The collected responses were analysed using a combination of statistical analysis and thematic analysis. Inductive coding of open-ended responses revealed several overarching themes, including “communication breakdown,” “loss through simplification,” and the “value of narrative metadata.” Although the sample size limits broader generalisability, thematic saturation was achieved following the analysis of 14 valid responses. Potential limitations considered within the study include sample bias, such as the overrepresentation of design professionals relative to FM practitioners, regional differences in BIM practices, and variations in the interpretation of ADI terminology. Nevertheless, triangulating qualitative insights with quantitative trends contributed to enhancing the credibility and reliability of the findings.

2.4 Developing a DIPF for Tracking Design Decision Rationales

This objective seeks to synthesise the findings derived from the literature review, case studies, and stakeholder survey into an integrated framework capable of supporting the embedding and preservation of ADI throughout BIM processes. The proposed DIPF aims to provide a clearer definition of ADI components, identify critical points of vulnerability, and establish structured mechanisms for encoding and maintaining design rationale within BIM workflows.

The framework further outlines stakeholder responsibilities at different project stages, potential approaches to data architecture, and policy alignments required to support lifecycle continuity. Designed to be adaptable across varying project types and BIM maturity levels, the proposed framework seeks to provide practical value for both academia and industry within the Architecture, Engineering, Construction, and Facilities Management (AEC-FM) sectors.

2.5 Ethical Considerations

Ethical approval for this study was obtained through the university’s formal research ethics review process prior to data collection. All participants were provided with a detailed participant information statement explaining the purpose of the research, the voluntary nature of participation, data usage procedures, and their right to withdraw from the study at any stage without penalty. Informed consent was obtained electronically through the online survey platform before participants were permitted to proceed with the questionnaire. To ensure confidentiality and participant privacy, all collected data were fully anonymised prior to analysis, and no personally identifiable information was retained. Data were securely stored on password-protected institutional servers accessible only to the research team and managed in accordance with the university’s data protection and information security policies. Furthermore, all research procedures were designed to minimise potential psychological, social, or professional risks to participants, ensuring that participation posed no foreseeable harm. The findings are reported in aggregate form to further protect participant anonymity and maintain ethical integrity throughout the research process.

3. Results

3.1 Assessment of Literature Review

The literature reveals substantial limitations in current approaches to the definition, integration, and transfer of ADI throughout BIM processes. ADI encompasses not only the geometric and functional specifications of a design but also the underlying architectural narratives, intentions, and decision-making rationales that shape the built environment [25]. Although BIM has significantly advanced the digital management and coordination of architectural and construction information, existing BIM practices remain limited in their capacity to communicate the qualitative and interpretive dimensions that inform design decisions [26]. Contemporary BIM models predominantly rely on object-based representations that prioritise measurable and quantitative information over value-driven, experiential, and interpretive aspects of design [6,8]. As projects progress through different lifecycle stages and involve an increasing number of stakeholders, critical design rationale and contextual knowledge are often diluted, fragmented, or entirely lost during information transfer processes. Consequently, the continuity and integrity of ADI become increasingly vulnerable throughout BIM-enabled project delivery.

3.2 Summary of Case Studies

This section presents a curated collection of real-world scenarios derived from the literature to examine how ADI is modified, compromised, or diminished throughout project development. The analysis applies the three previously established ADI dimensions functionality, spatial arrangement, and materiality to identify which aspects of design intent were affected and to investigate the underlying causes of such changes. Across the examined cases, architectural decisions were frequently altered, overridden, or disregarded due to competing priorities, operational constraints, or project-specific pressures. Each case study documents the identified issue, specifies the affected ADI component, analyses the resulting compromise, and proposes targeted recommendations for improving BIM-related processes and information continuity.

To support this analysis, a taxonomy derived from the literature is presented in Table 1, categorising design features and their associated sub-factors relevant to ADI preservation.

This framework demonstrates how a single modification may simultaneously influence multiple dimensions of architectural experience and highlights the complex and interconnected factors that shape architectural decision-making processes [27].

Table 1
ADI factors, sub-factors, and their corresponding definitions

ADI Factor	Sub-Factor	Definition
Spatial Layout	Circulation and zoning	Logical organisation of spaces for movement, access, and adjacency.
	Privacy and visual control	Spatial planning for seclusion, openness, or controlled visual access.
	Wayfinding or navigation	Layout clarity to help users orient and move through the space easily.
	Monumental or framed views	Spatial positioning to capture views (natural, urban, monumental).
	Lighting and Ventilation	Placement of openings for required direct/indirect/natural lighting & ventilation
	Scale and proportion	Sense of space based on height, width, and overall geometric harmony.
	Cultural / Contextual Layout	Spatial configuration reflecting traditions, rituals, or local norms.
Materiality	Physical Properties	Tactility, temperature, weight, and resilience of materials.
	Colour / Texture / Finish	Visual and tactile surface qualities influencing mood and perception.
	Acoustic Performance	Material contribution to sound control, reverberation, and privacy.
	Thermal Properties	Material impact on insulation, heat retention/loss, and user comfort.
	Durability / Maintenance Logic	Ease of upkeep and long-term integrity of selected finishes.
	Cultural / Symbolic Meaning	Materials selected for regional, historical, or cultural relevance.
Functionality	Intended Use and Flexibility	Core purpose of a space and its ability to adapt to changing needs.
	Thermal Comfort	Ability to maintain a temperature conducive to human comfort.
	Visual Comfort	Avoiding glare, ensuring balanced natural or artificial light for comfort.
	Access & Inclusivity	Universal design features enabling mobility and cognitive access.
	Sensory Experience	The emotional/spatial impact (light, sound, scale) on user's experiences.
	Environmental Responsiveness	Design driven by solar orientation, wind flow, daylighting, and other ecological factors.

3.2.1 *Case study one Northumbria university*

A comprehensive case study of 32 non-residential buildings at Northumbria University's city campus revealed several ADI compromises at various stages along the design-to-FM transition [28]. The most troublesome discrepancies between the BIM model and the as-built environment were in room proportions, door placements, and circulation pathways (Figure 2). Kassem *et al.,* [29] identified that the primary causes of these inconsistencies were ambiguous BIM models and the limited use of BIM drawings. Circulation and zoning, wayfinding and navigation, as well as size and proportion were significantly impaired as a consequence. For instance, both students and staff, particularly those with mobility impairments, have difficulties traversing the facility owing to the corridor widths being narrower than intended. Interruptions to the campus's planned sequential flow compromised the architectural plan's objectives of creating a coherent and rhythmic environment.

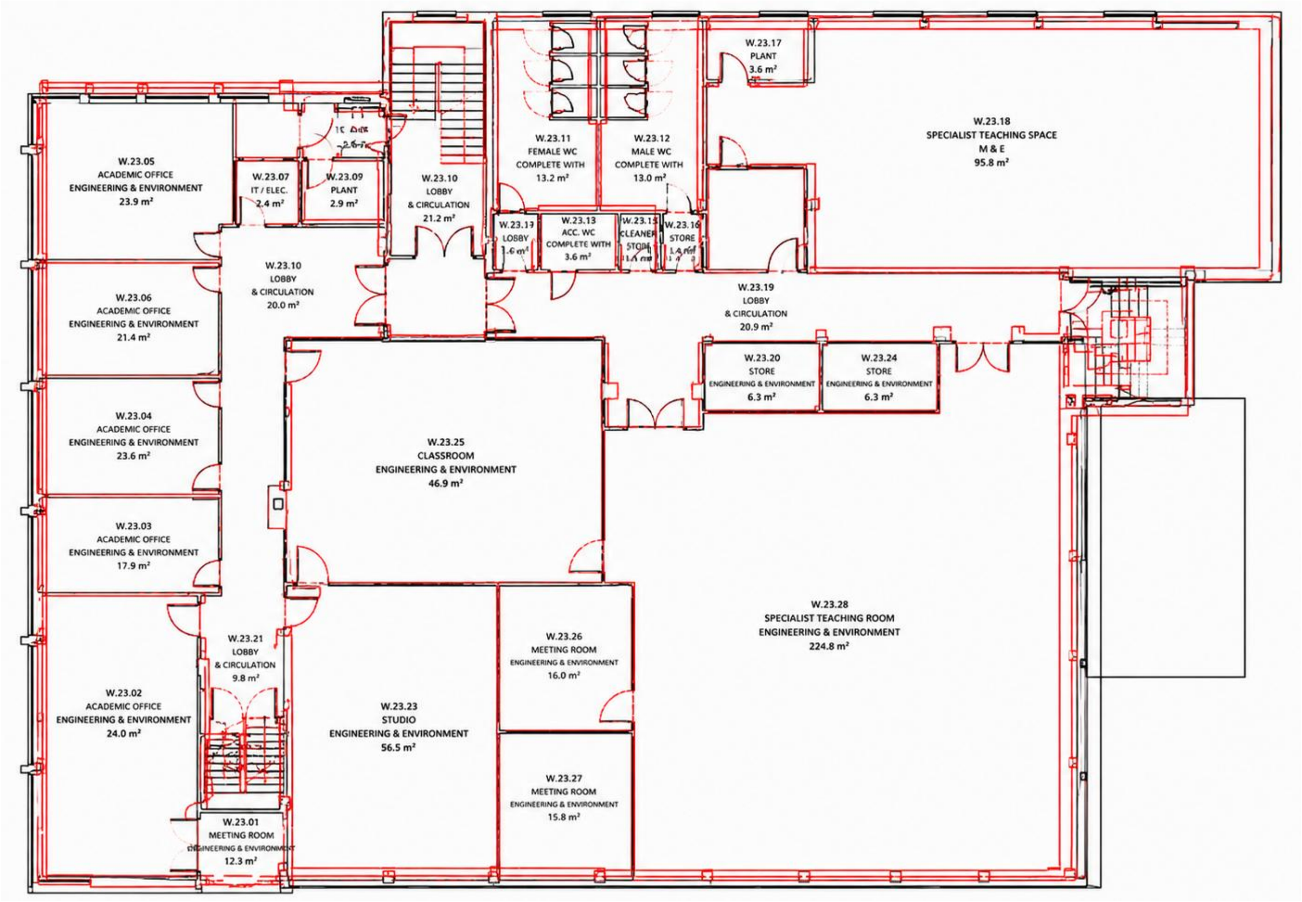


Fig. 2. Spatial Inconsistencies between As-planned (Red) and As-built (Black) Plan [9]

The BIM model lacked integrated finish schedules and material information, and it also presented spatial challenges. Crucial information on acoustic materials, surface textures, lighting hues, and paint colours was maintained in separate documents, which were sometimes difficult to retrieve. Discrepancies and incongruities in wall finish and lighting designs were evident throughout the later renovations due to this disparity. This signifies a significant ADI loss related to materials, affecting thermal parameters, acoustic performance, colour, texture, finish, and other factors. Inappropriate finish selections and insufficient lighting arrangements transformed lecture halls, intended for glare-free illumination and calming acoustic circumstances, into environments that were visually abrasive and musically resonant.

From a pragmatic perspective, these structural and architectural modifications adversely affected accessibility, sensory experience, and visual comfort. Students expressed dissatisfaction due to the inconsistent illumination, echoing sounds, and perplexing arrangement of the facilities, which failed to foster the intended relaxing or productive conditions. The initial design objective of facilitating learning, comfort, and cognition was considerably undermined.

These outcomes may have been averted with a more robust BIM procedure. Dimensional constraints, spatial zoning principles, and contextual information (such as "acoustic ceiling for noise mitigation" or "door strategically placed for direct visual access to natural light") could have been instrumental in maintaining design decisions from the inception of the process to its operational phase. Subsequent decisions in the project may be more informed if architectural elements in BIM workflows are assigned a priority level of low, medium, or high.

3.2.2 Case study two Alberta museum

A case study from the Alberta Museum renovation project, which included the transfer of a BIM model and over 11,000 pages of paper-based operations and maintenance documents [30], elucidates the subject matter. Nevertheless, the BIM environment was deficient in essential data about materials, including manufacturer specifications, completion timelines, and the rationale for material selection. This resulted in a significant reduction in ADI about materials, namely in cultural and symbolic meaning, colour, texture, finish, and considerations of lifespan and upkeep. Due to ambiguous requirements, FM teams encountered considerable inconsistencies in flooring materials and wall treatments throughout later refurbishment and maintenance phases [31]. Consequently, the museum's intended aesthetic and symbolic elements were undermined, resulting in insufficient substitutes that adversely impacted the tactile and visual experience of the interiors. A customised material palette that embodies Alberta's cultural and environmental essence was included in the museum's first ADI. Besides offering a tactile narrative for visitors, they were intended to serve symbolic and atmospheric functions. Replacement materials were chosen only based on availability or cost, without integrating such rationale into the BIM model, resulting in the obliteration of architectural significance. This impacted environmental responsiveness and sensory experience, since the new materials lacked the requisite thermal and acoustic qualities for sensitive gallery areas.

Finishes, fixtures, and selected materials exemplify several BIM components that might significantly benefit from the integration of structured information and design rationale. This may have been achieved by use tags such as “flooring selected for diminished reflectivity to safeguard artwork” or “paint finish chosen for low maintenance in high-traffic areas” to preserve the original design. Every model, regardless of its sophistication, forfeits its architectural significance without inherent meaning. Design integrity, as this example illustrates, encompasses more than just geometry; it also involves maintaining the narrative and contextual rationale behind material selections.

3.2.3 Case study three Royal Columbian hospital

Figure 3 from the research conducted by Tsay *et al.,* [32] illustrates the juxtaposition of the mechanical room's real on-site conditions with a federated BIM model generated in Navisworks. The identified discrepancies, such as misaligned expansion tanks, an unmodeled air separator, absent pipes and valves, and a thermostat panel excluded from the BIM model, reveal a substantial disconnect between design intent and construction regarding spatial, material, and functional attributes. The ADI loss for all three main components is shown in this singular location.

The entry area was much smaller, and the service clearance diminished since the expansion tanks were positioned nearer to the door than originally intended in the spatial configuration. This seemingly minor alteration compromised the intended symmetrical and legible layout designed for safe and efficient maintenance access, hence diminishing the circulation logic and clarity of navigation towards the fire safety door. The room's original proportional balance, designed to enable efficient technician movement, was disrupted. This resulted in visual clutter and artistic inconsistency, hence diminishing spatial clarity.

The coordination models were optimised for conflict detection at the expense of maintaining a clear and accessible architecture, resulting in concerns as technical needs overshadowed design considerations. The prioritisation of system compatibility above spatial usefulness led to the disregard of ergonomic and experiential factors. Serviceability, clearance, and operational issues might have been detected earlier in the design phase by FM teams, therefore maintaining ADI while meeting technology requirements. Incorporating constraints (e.g., "minimum service clearance to the fire exit: 1200 mm") and justification tags (e.g., "symmetrical layout for intuitive access and thermal control visibility") into BIM procedures may mitigate the probability of such dangers arising.

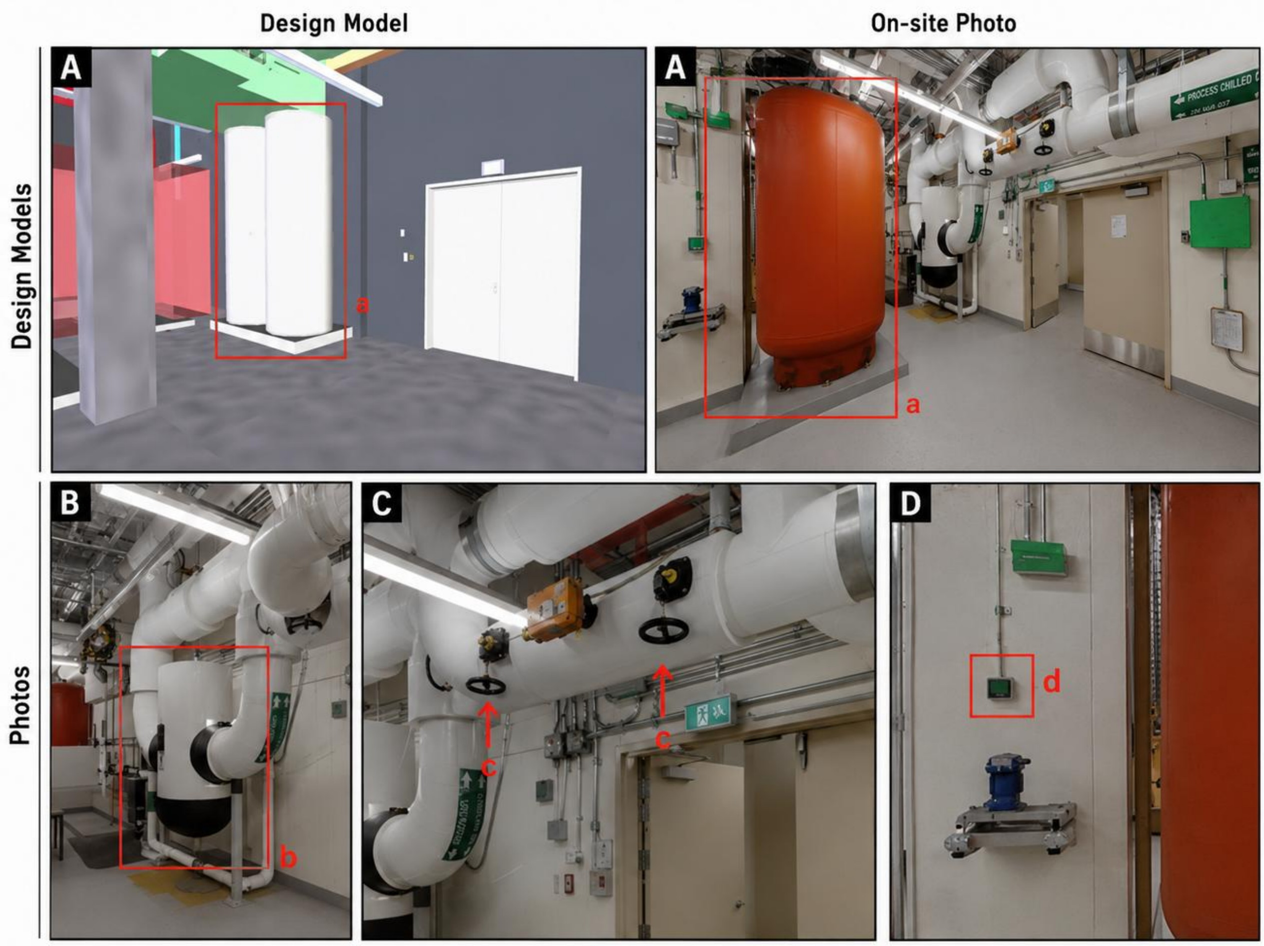


Fig. 3. Comparison between design model & on-site photos (A) Expansion tanks position inconsistent (B) Air separator not in the model (C) Pipes and valves not in the models (D) Thermostat not in the models [32]

3.2.4 Case study four Haeundae L High-Rise project

The Haeundae L Project, as detailed by Ham *et al.,* [33], exemplifies ADI loss in a BIM-enabled workflow. Despite the use of BIM, an astonishing 1,288 design deficiencies were identified during preconstruction. These validation concerns should have been resolved throughout the design phase but were neglected instead. Discrepancies across architectural, structural, and Mechanical, Electrical and Plumbing (MEP) designs, together with misaligned structural components and absent or conflicting measurements of columns and beams, constituted the spatial layout inconsistencies identified (Figure 4). The issues indicate that the spatial layout component of ADI, which addresses circulation logic, proportional consistency, and spatial zoning, is evidently flawed.

From a pragmatic standpoint, these errors impacted critical components of the structure, including the vertical cores and structural connections, disrupting the construction sequence and diminishing its functionality. Technical rework prevailed over functional intent and performance-oriented thinking, resulting in inefficiencies, spatial congestion, and operational delays. Despite reduced discourse on losses attributable to materiality, the selection and compatibility of finishing systems were compromised by the subsequent effects of unresolved functional and layout errors.

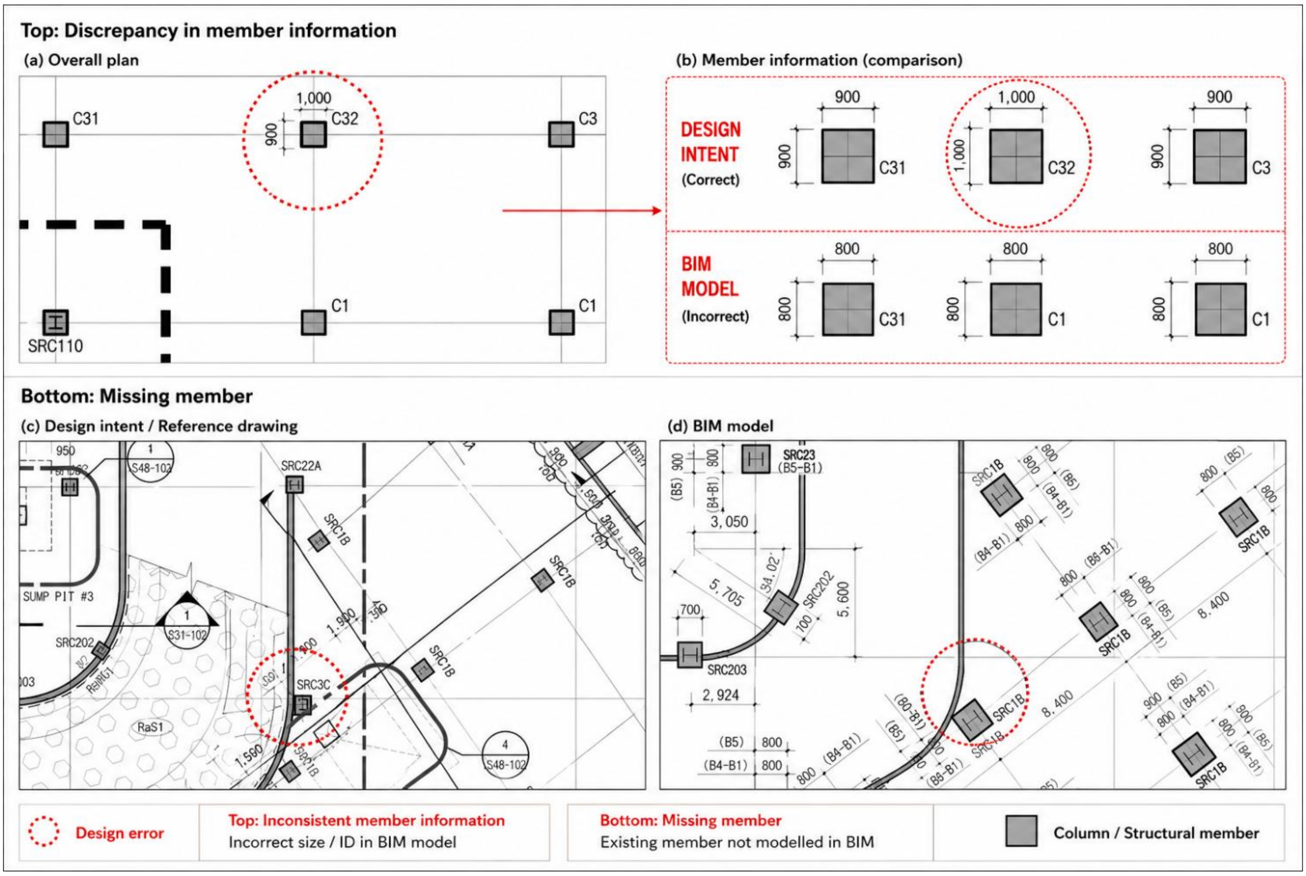
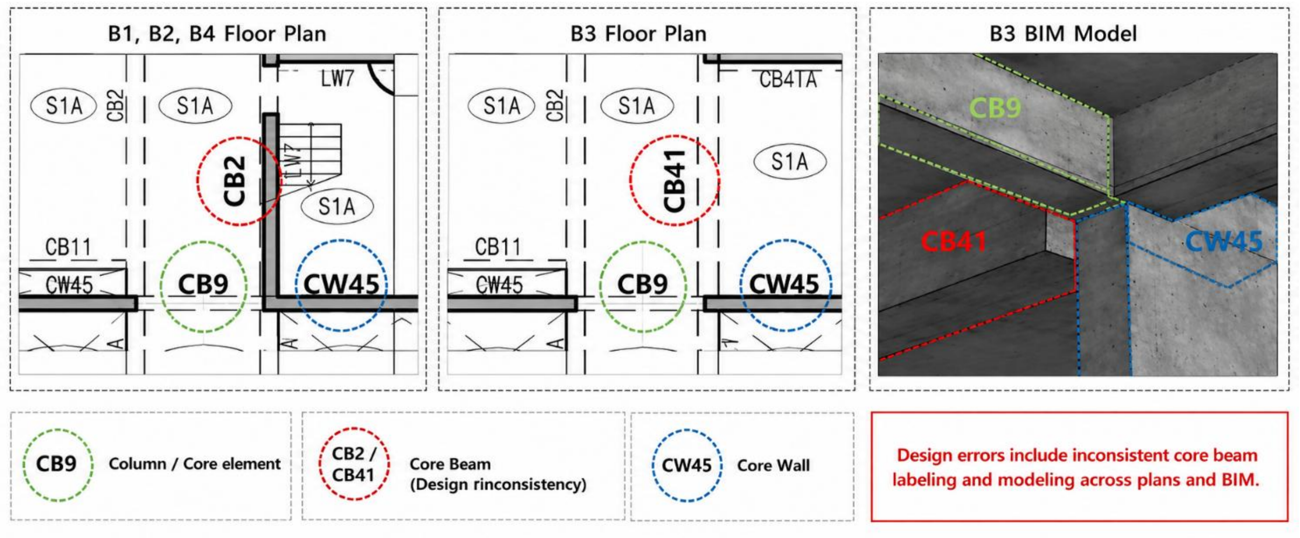


Fig. 4. Design errors while BIM Modelling (Top) Discrepancy in member information; (Bottom) Missing member [33]

Instead of functioning as a preventive strategy for ADI preservation, BIM was used at a later stage to detect and quantify these errors. Essential ADI elements were inadequately communicated across disciplines or lifecycle phases owing to the early BIM stages' deficiency in embedded information, reasoning tags, and constraints of spatial logic. The principal assertion of this study is substantiated by this case: ADI may be significantly undermined, even with advanced technologies, if BIM procedures do not effectively structure, annotate, and prioritise design decisions. This example illustrates that BIM alone is unable to safeguard architectural vision amid contextual changes without intentional strategies for gathering ADI. Preventing costly reworks and stakeholder confusion may be as simple as affixing a concise tag elucidating the importance of the wall next to the stairs or the function of square columns in Figure 5.



Design errors include inconsistent core beam labeling and modeling across plans and BIM.

Fig. 5. Design errors affecting core elements [33]

3.3 Comparative Study

The preceding case studies demonstrate that ADI loss may manifest in many forms across diverse initiatives, including those in the cultural, educational, healthcare, and high-rise domains. The claims by Luciani *et al.,* [6], regardless of variations in size, location, and project phase, a consistent theme persists: BIM workflows, despite their technical proficiency, frequently neglect the reasoning, logic, and experiential dimensions of ADI. This synthesis consolidates the findings from all four scenarios by comparing the affected ADI components, the times of erosion, and the deficiencies in BIM practices that facilitated this loss. Furthermore, it identifies particular process improvements necessary to address each failure scenario. Table 2 below presents the findings of these comparisons, illustrating trends in the sources and locations of ADI loss, as well as the necessary adaptations in BIM techniques to maintain intended sensitivity during a project’s duration.

Table 2
Cross-Case study of ADI Loss Across Projects

Project	ADI Factors Lost	Design Stage Gaps	Phase of ADI Loss	BIM Workflow Improvement
Northumbria University, UK	Spatial layout, Materiality, Functionality	Inconsistent reliance on BIM, missing finish schedules	Design →Construction→ FM	Embed dimensional constraints, zoning logic, and rationale metadata; assign priority tags to key elements
Alberta Museum, Canada	Materiality, Functionality	Lack of material specs and rationale in BIM	Design → FM	Tag finishes and materials with design reasoning (e.g., durability, symbolism); embed rationale-rich metadata
Royal Columbian Hospital, Canada	Spatial layout, Materiality, Functionality	Coordination model optimised only for clash detection, not usability or experience	Design → Construction	Maintain service clearances in BIM; embed experiential constraints and rationale tags in critical zones
Haeundae L High-Rise, South Korea	Spatial layout, Functionality (Materiality-implied)	Errors carried from poor early BIM modelling, undocumented rationale, and decisions	Design → Preconstruction	Structure early BIM models with spatial logic, metadata, and priority tagging; proactive validation needed

3.4 Analysis for Objective 3

This section analyses the issue via the lens of stakeholder experience, using on data from real-world situational situations that demonstrate how ADI is often diluted throughout project transitions. A systematic questionnaire survey was used to gather insights from 14 industry professionals about the management of ADI within BIM procedures. The group included 8 architects, 1 BIM manager, 3 facilities managers, and 2 contractors. The survey was structured into four main sections: background, practice observations, views toward intent preservation, and framework adoption. Their experience ranged from 3 to over 12 years, indicating diverse duties (Table 3). This study reinforced the need for a structured DIPF and identified the difficulties that such a framework should address, aiming to gather insights from various stakeholders' perspectives and experiences.

Table 3
Participant's Position and Experience

Participant's Number	Participant's Role	Years of Experience
1	Architect	5
2	Facility Manager	7
3	Architect	6
4	BIM Manager	8
5	Architect	3
6	Architect	10
7	Facility Manager	10
8	Contractor	12
9	Contractor	7
10	Facility Manager	4
11	Architect	3
12	Architect	9
13	Architect	9
14	Architect	5

Of the 14 individuals that participated in the study, 10 reported having experience with BIM projects, including FM handover or lifecycle planning. Nonetheless, just three individuals maintain that ADI is "frequently" preserved. The predominant response was a preservation rating of "rarely" or "sometimes," with just one individual indicating it is "never" preserved. A distinct discrepancy exists between the theoretical potential of BIM to provide lifetime continuity and the real challenges faced in sustaining ADI over a project's duration.

Significantly, facilities managers and contractors constituted the majority of respondents who selected "often," indicating a heightened awareness of ADI retention on their part. Architects were the most critical on the post-design management of their ADI, since none selected "always" or "often" (Figure 6). This mismatch underscores a perceptual divide between the two disciplines: architects prioritise the preservation of the design's intended function, while downstream experts focus on the seamless transmission of particular geometric or operational data. This aligns with the results of Coates et al. (2010), who emphasised that downstream actors often emphasise constructability and cost above design narrative. This supports the study's primary assertion that ADI may be diluted when not explicitly articulated in BIM models, owing to its intent-driven and qualitative characteristics.

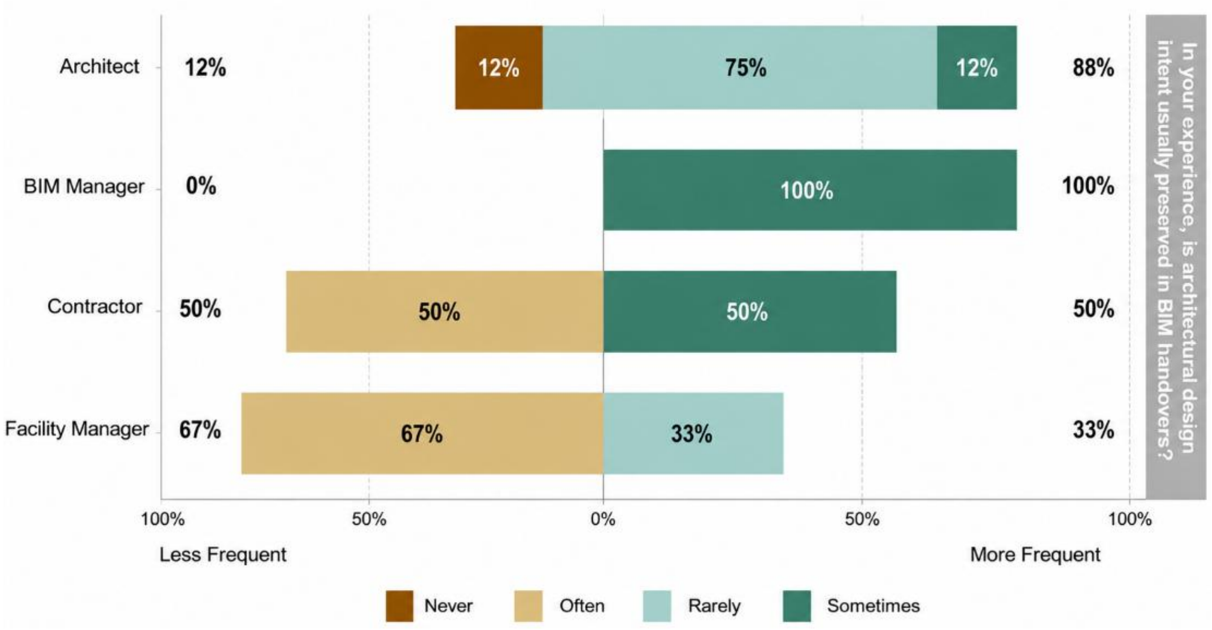
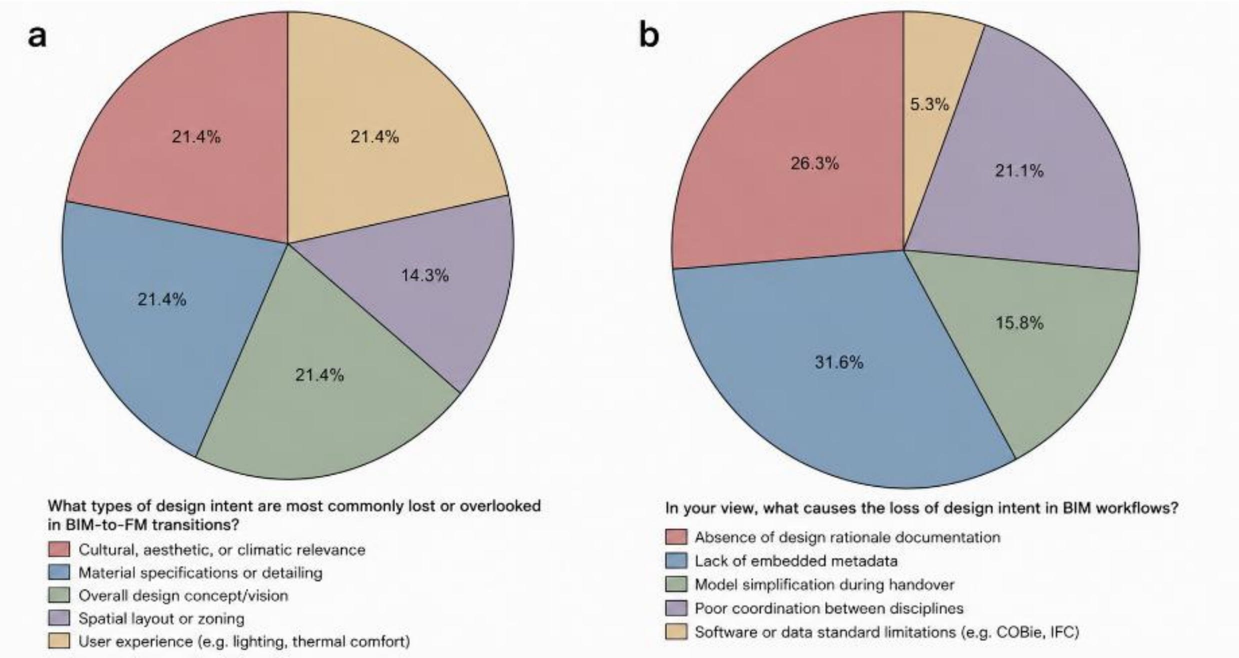


Fig. 6. Perceived Frequency of ADI Preservation During BIM Handovers by Profession

The persistence of ADI throughout project phases remains a significant obstacle, even for seasoned stakeholders. Despite BIM integration, projects continued to suffer from ADI erosion due to fragmented procedures, unclear documentation, or conflicting stakeholder goals, as shown in the preceding case studies in this chapter. In actual BIM projects, the loss of ADI is a prevalent and persistent issue that is inadequately addressed in current methodologies. The overarching tendency of the research corroborates that it is more than only a conceptual threat.



(a) Types of ADI loss

(b) Reasons for ADI loss

Fig. 7. ADI Loss in Practice (a) Types of ADI loss (b) Reasons for ADI loss

Figure 7 (a) illustrates the findings of the respondents' input, indicating that the perceived losses across many dimensions of ADI are uniformly distributed. 21.4% of the interviewees identified the following factors: material specifications, user experience, geographical layout or zoning, and cultural or artistic significance. This indicates that ADI degradation is influenced by a multitude of factors, rather than being dominated by a single source. The current limits of object-oriented BIM systems suggest that the relatively low proportion of 14.3% for overall design idea or vision likely reflects the challenges of recording complete, abstract architectural concepts.

The notion that the loss of ADI is conceptual rather than just technical is substantiated by this finding, which is the study's central argument. Directly articulating elements like as atmosphere, cultural resonance, and user comfort remains difficult without using intentional tagging strategies or supplementary information [34].

The Alberta Museum exemplifies how material replacements reduce symbolic relevance and sensory experience owing to imprecise completion timelines and insufficient cultural material references. Likewise, the lecture rooms at Northumbria University significantly diverged from their original use owing to the neglect of lighting and colour specifications throughout the FM transition. Consistent with the views of Zahedi *et al.,* [20], these occurrences validate the survey findings and indicate that the most often compromised ADI components are those reliant on narrative or sensory logic rather than only on geometric precision.

Figure 7 (b) contains further information about the variables said to have contributed to these losses. Thirty-one-point six percent of respondents identified the absence of documentation explaining the rationale behind the design as the main factor, underscoring a critical deficiency in the present application of BIM. Secondly, throughout the handover process, models were simplified 26.3% of the time, and information was not integrated 21.1% of the time. Conversely, just 5.3% indicated that data format constraints or applications such as COBie or IFC were contributing to the issue. This distribution indicates that procedural neglect, rather than technical incapacity, is the primary issue. It is customary to exclude non-essential qualitative data while optimising BIM models for handover; nonetheless, these factors fundamentally underpin the architect's rationale.

Figure 8 illustrates the results of a Likert-scale cross-analysis that identifies the affected design elements in connection to the origins of ADI loss. The absence of documentation on the architectural rationale was directly linked to the loss of zoning and spatial configuration. This underscores the need of having documented rationale for spatial design to prevent alterations or misinterpretations in subsequent phases. In a similar vein, the three most significant indications of diminished user experience are overall design aim (17%), cultural or aesthetic relevance (33%), and lack of integrated information (50%). This supports the assertions of Zahedi *et al.,* [20] on the need of tagging, since it suggests that qualitative significance may be easily diminished in later stages when metadata is neither gathered nor structured.

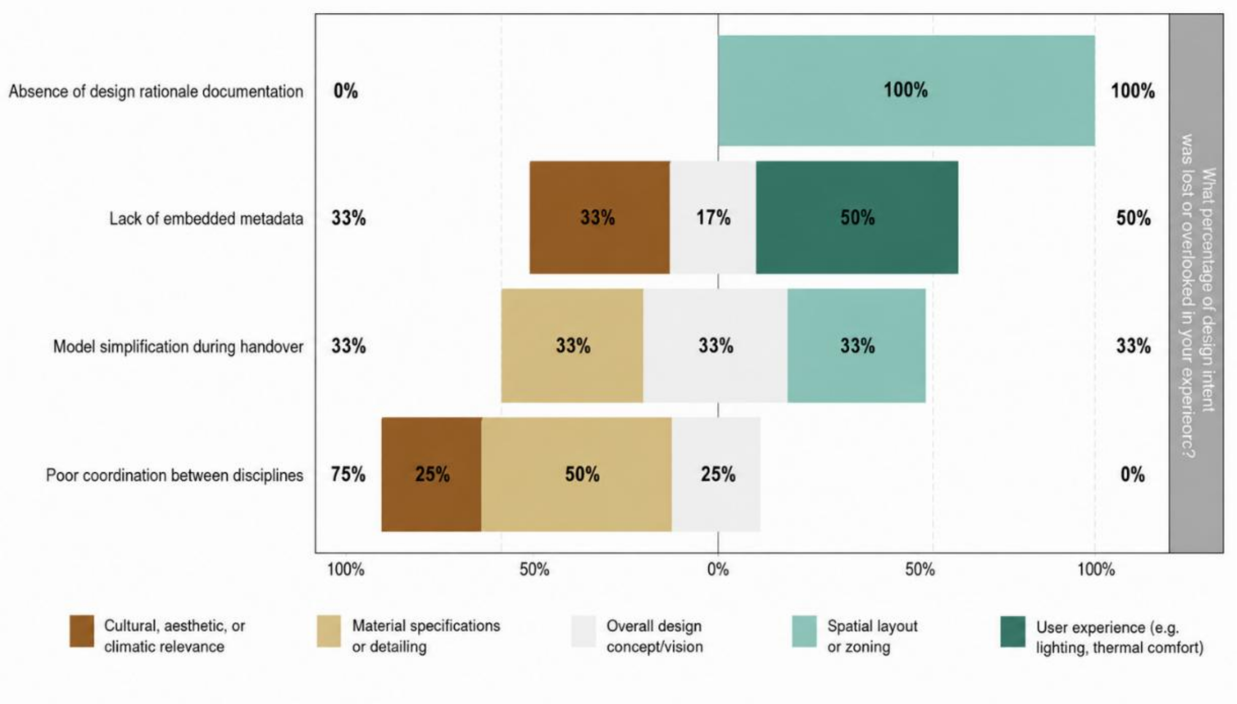


Fig. 8. Relationships Between ADI Loss Types and Contributing Factors

One-third of the survey respondents reported issues related to spatial configuration, overarching concepts, and material specifications due to model simplification during the handover process. This exacerbates concerns that BIM models often diminish their intrinsic design complexity at both physical and intangible levels when adapted for operational purposes. Ultimately, 50% of instances indicated that material specifications or specifics were associated with insufficient interdepartmental collaboration, while 25% of instances revealed that the overall design concept was linked to a diminished cultural, artistic, or climatic effect. The data illustrates the vulnerability of the experiential and symbolic aspects of design in the absence of robust interdisciplinary collaboration. Collectively, our findings substantiate that process gaps, as shown in the research of Martin *et al.,* [10], are the most likely source of significant ADI loss, rather than the technical limitations of BIM tools. Participants' qualitative descriptions of operational decisions that conflict with ADI support this interpretation. One participant noted the removal of "public gathering zones" to accommodate more bathrooms, while another noticed that "sun-shading fins were eliminated to mitigate structural challenges." Both options compromised ADI's core principles of thermal comfort, user experience, and architectural rhythm of the facade. These narratives are not isolated incidents; instead, they illustrate how professionals across several disciplines confront similar trade-offs often.

3.5 ADI Preservation and Strategies

A consensus was achieved among survey participants about the need of sustaining ADI throughout the BIM lifecycle. The respondents' uniform evaluations of the importance of its preservation as "extremely important" or "very important" underscore a prevalent professional concern over the transmission of intangible architectural knowledge. This perspective acknowledges the growing recognition that BIM has robust technical capabilities; yet it currently lacks mechanisms to articulate the rationale behind design decisions. Participants advocated for the inclusion of structured fields in BIM components to document the rationale behind the design. This would enable stakeholders to comprehend the rationale and grasp the project's objective in the future.

Figure 9 illustrates the correlation between the main sources of ADI element loss and the proposed solutions for its rectification. It is noteworthy that various forms of ADI loss were associated with the practice of annotating design rationale in BIM objects. Rationale tagging offers a multifaceted and comprehensive reaction mechanism, as 40% of participants linked it to the restoration of the solution's aesthetic or cultural relevance and overarching concept/design. Conversely, user experience was mentioned less often (20%), perhaps attributable to the challenges of categorising sensory perceptions or the lack of established metrics. Tsay et al. (2022) discovered a similar conclusion and said that reasoning tagging is essential for linking theoretical design logic with actual BIM data.

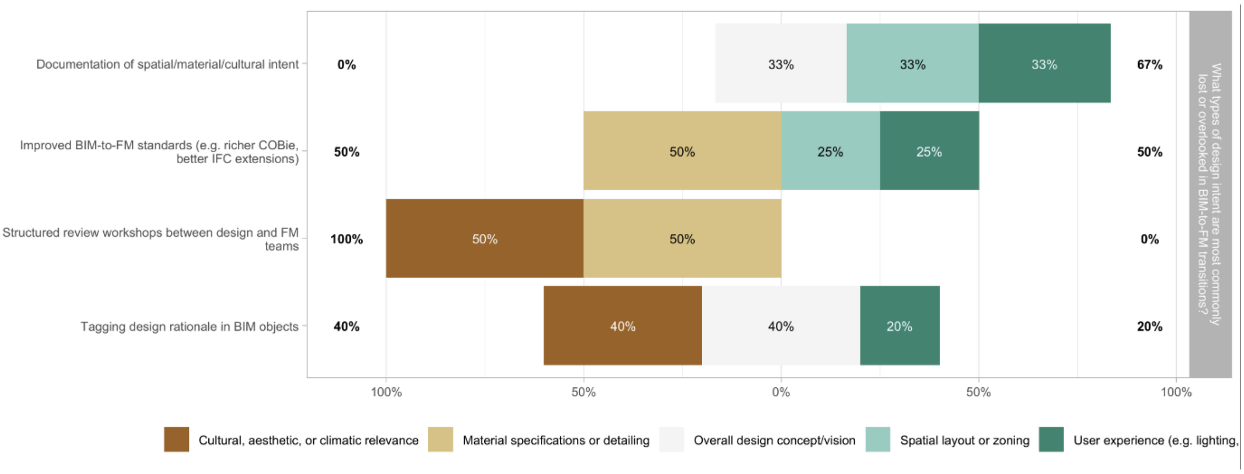


Fig. 9. Likert plot on ADI loss types and corresponding anticipated solutions

Restoring cultural or climatic importance (50%) and enhancing the consistency of material specifications were two domains where organised review workshops involving design and FM teams surfaced as a notable approach. This aligns with other findings from case studies indicating that meticulously crafted spatial or material narratives were ultimately lost owing to a breakdown in communication between the design and operational teams [35-37]. Additionally, when enquired about enhanced BIM-to-FM standards, 50% of participants said that they facilitated material knowledge retention, spatial zoning, and user experience. This implies that technological frameworks might be beneficial if designed with story capture methods considered.

Respondents recognised that recording spatial, material, and cultural purposes serves as an effective solution for many forms of ADI loss. One-third of the survey respondents associated this methodology with maintaining a holistic perspective throughout the design process, including spatial layout, zoning, and user experience considerations. This indicates that narrative recording is a crucial method for safeguarding intangible or experiential design reasoning, while being seen as resource-intensive in other survey areas. Table 4 presents a synthesis of significant perspectives from many stakeholders, highlighting their unique concerns and suggested remedies for the conservation of ADI.

Table 4
Stakeholder-Based Summary of Survey Findings

Stakeholder	View on ADI Loss	Main Issues	Preferred Strategies
Architects	Most critical; concerned with loss of spatial and narrative quality	Lack of rationale tagging; stripped metadata	Rationale tags, spatial logic constraints, DIPF adoption
Facility Managers	Mixed view; operational data retained, design intent diluted	No access to original design reasoning	BIM-FM standards, review workshops with designers
Contractors	Acknowledge compromises; focus on buildability	Substitutions, clash with structural needs	Priority tagging, coordination with design teams
BIM Managers	Less concern; trusts model completeness	Low focus on narrative or design logic	Limited suggestions; reflects technical perspective

A unified framework for recording and labelling various sorts of intent spatial, material, or user-centric during BIM was unanimously endorsed. Respondents indicated a willingness to adopt or seriously contemplate adoption, provided it was easily incorporated into existing procedures. A systematic ADI collecting system was essential, based on the reasons articulated in the Level of information need, notwithstanding varying perspectives [38]. However, we identified many tangible impediments to the implementation of DIPF. The expected challenges of this paradigm with current BIM writing tools, time constraints during project execution, and ambiguous responsibility for logic labelling among project stakeholders were significant concerns. Participants highlighted that a significant impediment was the absence of client-side requirements. Although aware of its long-term use, teams are unlikely to invest time in documenting design rationale without explicit expectations or contractual incentives. This supports the assertion made by Yalcinkaya [14] on the causes of implementation failure; although technology tools are available, there is a deficiency in practice-level incentives and clear job definitions.

These concerns are more pragmatic than ideological. The current project delivery criteria prioritise efficiency, cost-effectiveness, and compliance above story and experiential depth, so constraining stakeholders' capacity to maintain ADI, despite their collective recognition of its significance. Consequently, the survey's findings substantiate the theoretical foundations of the DIPF and provide practical recommendations for its implementation. Accordingly, the proposed DIPF is not an abstract concept but a response to a specific need in the business sector. In conclusion, the perspectives articulated by the stakeholders in this section provide compelling evidence supporting the study's principal assertion. Respondents often identified technical oversimplification, a lack of documentation explaining decision-making processes, and inadequate collaboration as prevalent breakdown patterns. However, they have also shown a desire for change by offering realistic, proven, and scalable solutions to improve the preservation of purpose across the design, construction, and FM stages. These responses notably enhance the broader academic discourse on BIM and design integrity by including the viewpoint of a practitioner. The DIPF to be examined in the subsequent chapter is grounded on actual demand, as well as scholarly literature and case studies, making it both pragmatic and contemporary.

3.6 Recommendations from Previous Studies

This section consolidates many contemporary technologies that may serve as fundamental components inside lifecycle-integrated BIM procedures to provide a comprehensive strategy for sustaining ADI. These recommendations inform the proposed DIPF and are indicative of concepts in the current literature.

The implementation of design rationale tagging systems is a well-supported method. Zahedi *et al.,* [20] assert that it is essential to include information in BIM objects that explicitly elucidates the rationale behind design decisions. Beyond a component's physical attributes, stakeholders may comprehend the aesthetic, intellectual, or experiential rationale behind its specification via these information fields, which may be depicted via structured annotations or visual iconography (Figure 14). Case studies and survey responses underscore the significance of this technique in addressing issues stemming from misalignments in spatial configuration, material substitutions, or inadvertent repurposing of designated areas due to insufficient rationale.

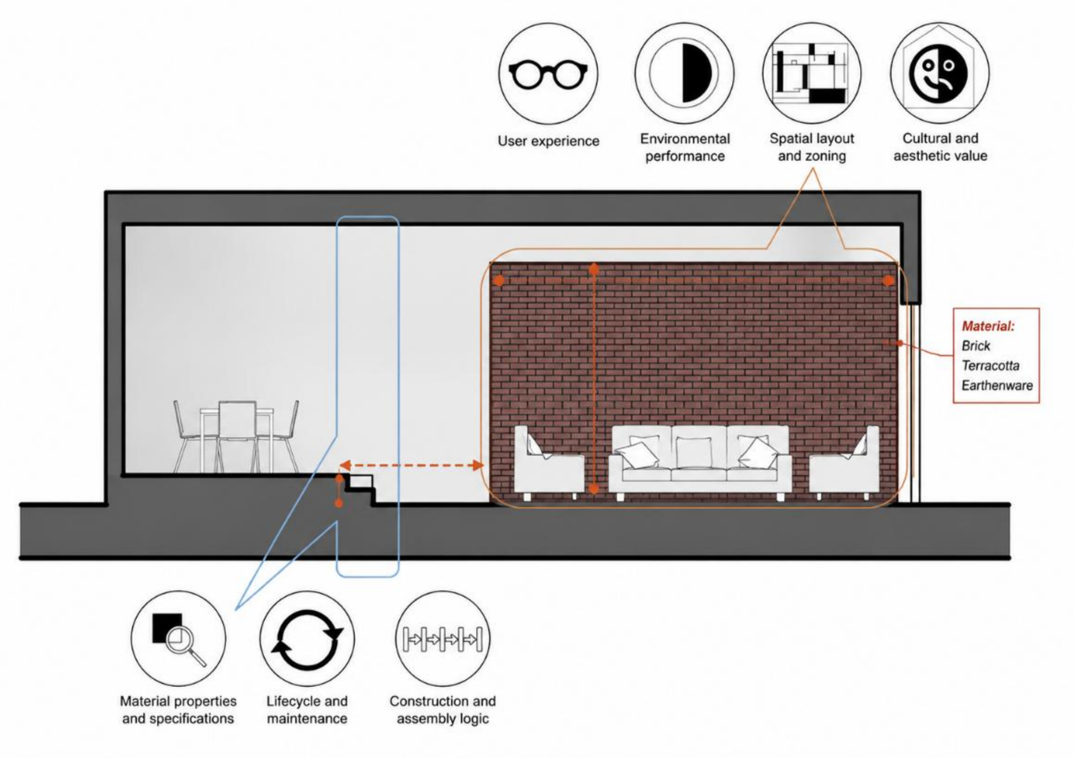


Fig. 10. Design Intent Annotation of Architectural Features and Associated Constraints [20]

A further protection against ADI deterioration is the use of design constraint tagging, which delineates spatial relationships (such as perpendicularity, parallelism, fixed lengths, or angles). To ensure the alignment of two staircase walls is maintained during successive design iterations or refurbishment phases, a "parallel" constraint may be applied to them (Figure 11). These inherent limits function as discreet but potent enforcers of spatial logic, guaranteeing the integrity of ADI despite modifications made by those not originally involved in the design process.

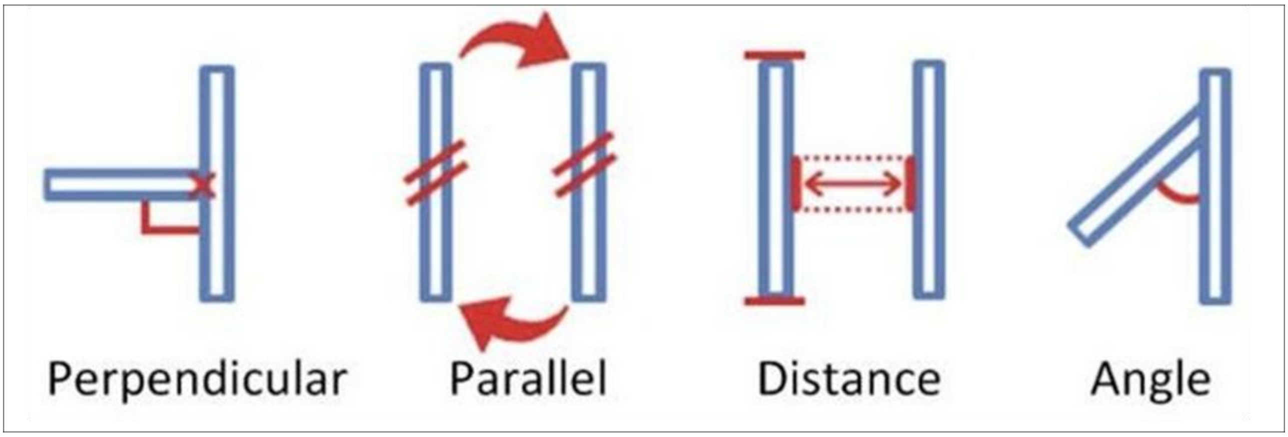


Fig. 11. Proposed Approach for capturing spatial constraints [20]

A novel method for ADI preservation that transcends conventional tagging is the use of DT technologies. Borrmann *et al.,* [39] assert that DT enable buildings to "retain" and modify their design logic over time by consistently transmitting performance data back into the model. This feedback loop allows intentional revisions aligned with original objectives, transforming ADI into a dynamic dataset and validating design assumptions post-occupancy. Furthermore, BEPs and AIMs, upon their first conception, may function as repositories for the collection and dissemination of design logic among various stakeholders. Contractual references that accurately consider spatial sequencing, material intent, and cultural objectives may facilitate the early alignment of expectations. Consequently, ADI is not only an implicit advantage but a tangible result.

It is important for professionals to have specialist training and education. The study often noted discrepancies between FM comprehension and design goals. Stevens and van Schaik [40] assert that just embedding information is insufficient unless the receiving team is instructed to understand it. Consequently, visual dashboards, summary guides, or interactive reviews between design and FM teams may elucidate complex information, enhance comprehension and reduce the likelihood of oversight.

Alongside validating patterns seen in the case studies and stakeholder surveys, these strategies demonstrate the existence of viable solutions; the only deficiency is in the implementation, not the capability to execute them. In addition to these principles, the DIPF establishes a comprehensive framework for integrating and monitoring design intent throughout a building's lifecycle, including clearly defined roles, schedules, and processes.

3.7 To Propose a DIPF for Objective 4

3.7.1 What to tag: categories of design intent

The architect's rationale is summarised by key sub-factors categorised into three overarching components: spatial arrangement, materiality, and utility. Key elements of spatial configuration that affect individuals' perception of space and the reasoning behind their motions are zoning and circulation, lighting and ventilation, wayfinding, framed views, privacy and visual control, and navigation. To maintain architectural consistency and relevance to its context, size and proportion are crucial, as are spatial patterns that reflect cultural sensitivity. The symbolic and performance-related dimensions of materiality include physical attributes, finish quality, acoustics, thermal properties, and the rationale for durability or maintenance choices in materials. The attributes influence aesthetics, comfort, and longevity. The last component, utility, encompasses elements of user-centred design such as thermal and visual comfort, accessibility, and environmental or sensory responsiveness, among others. Maintaining the integrity of qualitative design thinking throughout technological transitions is accomplished by identifying these elements.

The DIPF recommends categorising each design option with a priority level of low, medium, or high, and documenting the rationale for each selection. When subsequent teams face conflicting priorities during construction or post-occupancy modifications, this knowledge aids them in making informed judgements. A wall finish designated with a low priority tag may be subject to negotiation to save resources, but a cultural material palette or daylight corridor marked with a high priority tag signifies essential, non-negotiable elements of the design. This prioritising enables informed decision-making about the amount of potential impacts, facilitating a balanced negotiation between practical requirements and design integrity. The results of this study, which assert that uncoordinated assessments across phases stemmed from a deficiency in design thinking framework, are corroborated by this.

3.7.2 When to tag: integration with RIBA project stages

The timing of tagging is as crucial as the content of the labels for the effectiveness of the DIPF. The DIPF aligns the tagging process with the RIBA Plan of Work and integrates it into the natural progression of a project's lifecycle, ensuring that design rationale is documented consistently and meaningfully (Figure 12).

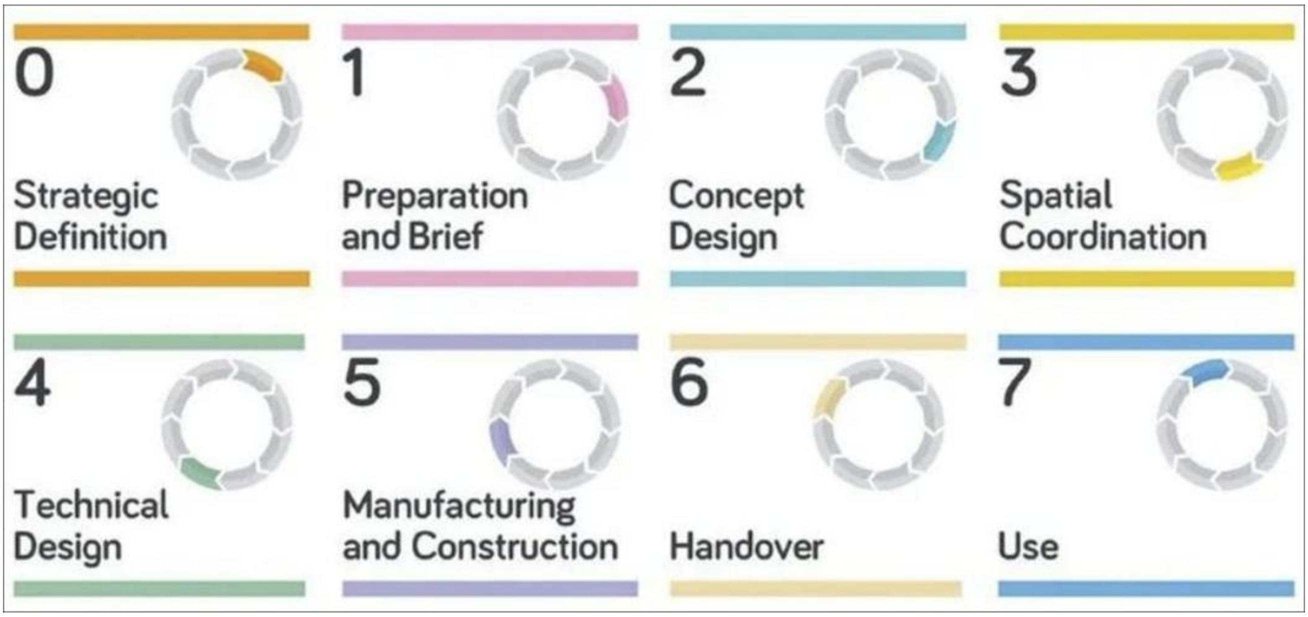


Fig. 12. RIBA Plan of Work [41]

Architects must include comprehensive categories for spatial arrangement, cultural significance, and initial experiential objectives at Stage 2 (Concept Design). Prior to exploring any technological specifics, these first tags serve as conceptual anchors to communicate the overarching narrative and symbolic intentions. In Stage 3 (Developed Design), designers can articulate the rationale for selecting specific materials, finishes, or spatial sequences, especially when these decisions influence sensory or climatic performance, by broadening the tagging criteria to encompass user experience elements and material justification. In Stage 4, Technical Design, BIM managers really excel. They are responsible for coordinating all activities, verifying the authenticity of tags, adhering to established standards, and accurately linking them to the appropriate objects within the model. This phase fosters design-sensitive solutions by incorporating tagging into processes for technical coordination or conflict identification. During Stage 5 (Construction), contractors use these tags for addressing on-site disputes, implementing modifications, or engaging in value engineering. To avert the unintentional dilution of design quality, the framework proposes that any deviation from tagged assessments be substantiated by the original rationale. During the last phase, “Handover and Close-Out,” FM teams evaluate the tags from an operational standpoint to ensure that FM systems can comprehend and execute intent-driven elements such as accessibility, serviceability, and maintenance logic. In accordance with the literature on ADI’s progressive layering [6], this incremental integration ensures that design logic is incorporated when it is conceptually sound, rather than as an afterthought, and that it occurs gradually and contextually throughout the project.

3.7.3 Who tags it: Role-Based responsibility matrix

The DIPF advocates for a distributed responsibility model in design intent documentation to ensure that tagging is included into standard professional practices and to avoid overwhelming any single stakeholder. Stages 2 and 3 are crucial as they need architects to elucidate the spatial rationale, the material justifications, and the objectives for the user experience. Architects are well positioned to integrate their concepts into BIM objects using structured reasoning tags, since they are the originators of design narratives and experiential objectives. In Stage 4 of a project, BIM managers often assume responsibility for consolidating inputs, standardising tag formats, verifying data integrity across platforms, and ensuring that model parts are correctly associated with the design rationale. The technical supervision guarantees the compatibility and usefulness of the integrated tags across diverse tools and project stakeholders. FM specialists, often engaged at a later stage, are urged to contribute earlier in the design process, ideally during Stages 3 or 4, via structured review workshops. Ensuring that design goal aligns with usability, their counsel may assist in identifying operational conflicts or serviceability constraints at an early stage. In Stage 6, FM teams ensure that the documented rationale is beneficial during post-occupancy phases by verifying and interpreting tags for integration into CAFM systems. By fostering a communal attitude of accountability in the preservation of ADI, this tripartite model of duty transforms tagging from a solitary task into a shared endeavour.

3.7.4 Where tags are stored: data carriers and platforms

The DIPF cannot effectively execute its responsibilities over the whole of a project unless the logic tags are preserved in universally comprehensible and usable formats. The most effective method to ensure that each element in a BIM has both geometric and narrative information is to include tags into its metadata, which may consist of Revit parameters or an IFC property set. Supplementary fields like ‘Attributes’ or ‘Description’ may be included into COBie deliverables to contain tags, hence enhancing the data’s use during transmission. Common Data Environments (CDEs) such as BIM 360 and Viewpoint facilitate the monitoring of reasoning by enabling users to annotate models with comments or markups. Project documentation, including BEPs and AIRs, must provide a specification of the tagging methodology from the outset to guarantee that all stakeholders share identical expectations. When engaging with emerging technologies such as DT or AI-driven platforms, it is essential to use established formats like XML or IFC extensions to ensure compatibility. By integrating design thinking into the digital project environment, the DIPF evolves into a robust protocol.

4. Conclusion

This study aimed to investigate the persistent challenges of sustaining ADI in BIM procedures over a building's lifecycle. The study included a literature review, empirical case studies, stakeholder surveys, and the design of a DIPF as components of its multifaceted methodology. It determined that ADI is not uniformly represented and often deteriorates when projects transition from design to construction to operation.

The current definition and incorporation of ADI within BIM were first established by the research. BIM excels at managing organised data and geometry; nevertheless, it significantly lacks in encapsulating the more abstract but equally vital elements that affect architectural choices, such as spatial logic, symbolic significance, and user experience. Current standards such as COBie and IFC do not provide alternatives for recording design thought; they just enable data interchange. As a result, essential information on the rationale behind a design is sometimes neglected, especially during the transition to construction or FM teams.

The loss is clearly tangible, as shown by the real-life situations in results. The interrupted circulation zones at Northumbria University and the material substitutions at the Alberta Museum illustrate that undocumented design decisions are often overridden, sometimes unwittingly. Such case examples demonstrate that ADI loss impacts several facets of a BIM it alters spatial configurations, replaces symbolic materials, and leads to the disregard of functional logics as a result. Decisions made without context by downstream teams dilute the desired user experience and architectural narrative.

A minority of experts, namely FM managers and contractors, in the stakeholder research had the opinion that ADI was "frequently" safeguarded. Architects were more severe, asserting that there was a consistent deviation from the design intent, particularly with cultural value, material specifics, and spatial zoning. The primary issues contributing to ADI deterioration, as shown by the survey results, include insufficient metadata integration, the simplifying of BIM models post-handover, and an absence of reasoning documentation. The bulk of respondents attributed the issues to workflow fragmentation and absent responsibilities, while a minimal minority cited technology limitations.

The research team responsible for the DIPF aimed to address this problem by developing a functional model for integrating and monitoring architectural reasoning into BIM workflows. The DIPF delineates the following: the timing of tagging (aligned with RIBA stages), the elements to be tagged (spatial, material, and functional considerations), the individuals responsible for tagging (architects or facility managers), and the appropriate locations for tags (e.g., BIM metadata or COBie fields). The intent documentation was once an unstructured, ad hoc process; DIPF formalises it for dissemination and organization. Design decisions may be classified as low, medium, or high relevance with the DIPF's novel prioritisation method. Consequently, participants may achieve a more effective equilibrium between practical requirements and essential design principles by informed compromises. This approach facilitates decision-making with a focus on longevity and promotes openness.

The framework is scalable and user-friendly, according to industry standards and compatible with current BIM procedures. This extends upon rationale tagging [20], DT [39], BIM Execution Plans (BEPs), Asset Information Models (AIMs), and structured review workshops with FM teams and designers. DIPF may address the practical challenges of project delivery by integrating existing tools into a cohesive and role-sensitive framework, without requiring a complete overhaul. All participants in the stakeholder responses indicated interest in either implementing or examining the framework in their processes, indicating substantial support for it. Challenges persist, including inadequate client-side specifications, unclear tagging roles, timing constraints, and incompatible software. These concerns are not theoretical but tangible, highlighting the need for client education and governmental measures to promote adoption.

The study's results indicate that ADI loss in BIM processes arises from structural challenges such as inadequate documentation, fragmented roles, and competing stakeholder objectives, rather than just a technology failure. Nonetheless, it also demonstrates a need for metamorphosis. The proposed DIPF offers a pragmatic, structured solution grounded in literature, bolstered by empirical experiences, and shaped by industry perspectives. This research posits that ADI and building performance are complementing objectives rather than conflicting ones. Preserving a building's coherence enhances its technical integrity, enriches the user experience, increases its contextual relevance, and simplifies its management throughout its lifespan. The DIPF is not only a conceptual instrument; it is a fervent appeal for BIM methodologies that are cognisant of narratives and attuned to intentions.

4.1 Future Recommendations

While the proposed DIPF offers a systematic resolution to the persistent problem of ADI loss in BIM processes, some elements need additional examination to enhance its efficacy and broaden its use. Initially, to ascertain the feasibility of logic tagging across various contract types, software platforms, and procurement procedures, experimental implementations in real-world projects are necessary. Concurrently, future research should investigate user behaviour and adoption trends, with particular emphasis on the operational issues identified by the survey. These considerations include ambiguous tagging obligations, time constraints for documenting rationale, and challenges related to interoperability. To alter the framework for broader industry acceptance, it is essential to understand the real-time involvement of project teams using ADI tags.

Standardisation is another significant avenue. As a definitive schema for encoding design logic has not been established, research must examine how DIPF might integrate with or enhance existing formats such as COBie, IFC 5.0, or ISO 19650. Designers, programmers, and cognitive scientists may collaborate to develop comprehensible techniques for describing ADI that minimise disturbance and benefit all stakeholders, including architects and facility managers. Generative techniques might use existing ADI knowledge to formulate contextually aware early-stage suggestions, provided that Artificial Intelligence (AI), Natural Language Processing (NLP), and DT systems facilitate the automated extraction, evolution, and verification of embedded design reasoning. And recent AI and decision-making tools can be adopted [42-46].

Simultaneously, intervention driven by policy is more essential. Legislators may endorse the preservation of ADIs by including reason tagging into digital delivery mandates such as the UK Construction Playbook that align with ISO standards. By requiring rationale-driven outputs in BEPs and AIMs, institutional clients may facilitate the integration of ADI processes. To evaluate these requirements, pilot trials, particularly within public-sector efforts, might be an appropriate starting point. Implementing these procedures would transform ADI preservation from an exception to a standard practice throughout the firm. In summary, while this study offers a robust framework, its practical use requires more research across several disciplines, coordinated governmental support, and continuous empirical validation to attain extensive lifecycle-driven design accuracy.

Author Contributions

Conceptualization, Yan Chen; methodology, Yan Chen; software, Junpeng Lyu; validation, Junpeng Lyu; formal analysis, Junpeng Lyu; investigation, Yan Chen; data curation, Yan Chen; writing original draft preparation, Yan Chen; writing review and editing, Yan Chen; visualization, Yan Chen; supervision, Junpeng Lyu; project administration, Michael Pitt. All authors have read and agreed to the published version of the manuscript. All authors have read and agreed to the published version of the manuscript.

Funding

This research received no external funding.

Data Availability Statement

The datasets generated and analysed during the current study are not publicly available due to privacy and ethical restrictions but are available from the corresponding author on reasonable request.

Conflicts of Interest

The authors declare no conflict of interest.

Acknowledgement

This research was not funded by any grant.

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