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Determining the Frequency of Component with Building Information Modelling-Level of Development in Facility Management: A Case Study in Vietnam

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Abstract: In the digital era, the application of new technologies, specifically information technology, has led to the development of building information modelling (BIM), a new technology that helps the construction management industries address current challenges. The level of development (LOD) and precision of BIM data throughout a project play a pivotal role in guaranteeing the triumph of building endeavours and asset management. The determination of the amount of depth and quality of BIM information plays a crucial role in influencing all aspects of a project and the lifespan of building assets. Therefore, this study aims to ascertain the frequency of components used for asset management drawing from a pilot project in Vietnam and to suggest the need for LOD components in facility management (FM). Expert polls, input from building operations managers and a literature review of LOD decision plans and BIM standards led to the conclusion that BIM was the most suitable approach for this objective. Two questionnaire surveys and an expert interview with key personnel from owners, contractors and consultants were conducted. The survey results table, which shows the substructure, superstructure and interior component categories, shows that the study results advise on how often to use different types of construction information. A framework is suggested that outlines the LOD and implementation model for the building of the database and the development of future studies. In the long term, the conceptual model promotes the transfer of knowledge from one project to another.

Keywords: Building information modelling, Level of development, Facility management, Operation management, Vietnam's construction industry

INTRODUCTION

Between 2020 and 2030, it is anticipated that global construction production will increase by 42%, or USD4.5 trillion, to reach USD152 trillion. The global construction sector is projected to be a worldwide driver of economic expansion and COVID-19 recovery (*Oxford Economics*, 2021). The construction industry is undergoing a digital transformation from project management and procurement to collaboration and communication (Papadonikolaki, Krystallis and Morgan, 2020). Digitisation

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must be used in technology tools, in which building information modelling (BIM) is a technology suitable for the digital transformation of the construction industry (Daniotti et al., 2022).

BIM may be used to determine the building or construction life cycle, encompassing the design, construction and operating phases. Especially, BIM is being increasingly embraced in a variety of building projects, allowing owners to employ BIM for facility management (FM) attempting with the design and construction phases (Lin, Hsu and Hu, 2022). Facilities management is the most receptive field to BIM adoption, although it is also the least established in terms of implementation, which is one of the fastest-growing real estate and construction industries, which makes BIM-FM even more significant. In addition, several governments have emphasised the need to transform the FM industry by promoting digital technology usage (Pinti, Codinhoto and Bonelli, 2022). Recently, the Vietnamese government issued Decision No. 258/QĐ-TTg on 17th March 2023 about approving the roadmap for the application of BIM in construction activities (Government of Vietnam, 2023) that plays an important role in strengthening the information exchange process between state management agencies in the process of acceptance.

The determination of the right level of development (LOD) is crucial in ensuring that the information supplied aligns with the requirements of the end user while minimising the inclusion of superfluous information. Comprehensive data from detailed LODs aids in evaluating the lifecycle costs of building systems. This helps facility managers make informed decisions on repairs, replacements and upgrades based on cost-benefit analyses (Nguyen et al., 2022). Higher LOD models provide detailed information about building components, allowing facility managers to access precise data, such as serial numbers, warranties and maintenance requirements (Daniotti et al., 2022). This practice not only optimises the time and resources allocated to project management and maintenance but also enhances overall efficiency (Dias and Ergan, 2016). Detailed models at a higher LOD include as-built conditions, which simplify planning and execution for retrofit projects. This reduces the need for site inspections and minimises errors due to discrepancies between existing conditions and plans (Alavi and Forcada, 2019). LOD only applies to individual objects, not to the entire project; it can be said that the LOD will be different at each project stage (Alavi and Forcada, 2019). Thus, choosing an appropriate LOD impacts FM by providing reliable and relevant information, improving planning and supporting efficient resource utilisation.

BIM uses LOD to define the extent and detail of a model at different stages of the project lifecycle. LOD specifies a model's exact requirements and expectations at any given stage (Carbonari, Stravoravdis and Gausden, 2018). The utilisation of BIM technology in project delivery and asset management holds significant potential in facilitating the transfer of information from the design and construction phases to the building operations phase. It enables design reviews to ensure compliance with owners' requirements, which assign LOD to FM jobs with too much information, but having too much unneeded information is difficult to manage (Cavka, Staub-French and Poirier, 2017; Bruno, De Fino and Fatiguso, 2018). Subsequent research endeavours may delve into a more comprehensive examination of BIM and the utilisation of model information for FM functions throughout the operational phase.

The structure of BIM data may vary among different software platforms, complicating data exchange and consistency. Existing FM systems often struggle to integrate fully with BIM models due to data format discrepancies, making it difficult to share information between design, construction and operations (Ignatova, Zotkin and Zotkina, 2018). Developing high LOD models can be resource-intensive, but FM models can contain too much information, making it difficult for facility managers to filter out the most relevant data for daily operations and strategic planning. Transitioning from construction to operational use often leads to data loss or inconsistency if not managed well, reducing the value of BIM-LOD for FM (Nguyen et al., 2023). Addressing these challenges requires coordinated efforts to define the needs of the BIM-FM model LOD and develop consistent standards. This research aims to assess the extent of progress in the BIM model by examining the LOD of component groups in a high-rise building in Vietnam. Post-construction, LOD determines the utility of the BIM model for FM and future renovations. A well-defined LOD can streamline maintenance, retrofitting and operational tasks. The research object is the database of BIM models in the operations management phase. The purpose is to optimise the use of BIM in operation management when choosing an appropriate LOD essential for successful collaboration, budget control and ensuring a smooth project workflow.

LITERATURE REVIEW

The Situations of Building Information Modelling-Based Application in Facility Management

BIM is increasingly valuable in FM due to its ability to create, maintain and use comprehensive digital models of buildings. The BIM with a model framework in FM provides actionable data that enhances maintenance planning, safety management, space utilisation and overall building efficiency (Matarneh et al., 2019). Fire safety systems, electrical panels and mechanical equipment are essential for safety and compliance (Chen, Lai and Lin, 2020). BIM models can include information on energy consumption patterns, allowing managers to identify areas of inefficiency that require measures and monitor their effectiveness (El Sayary and Omar, 2021). BIM is becoming a trend in the application of scientific and technological advances to serve the construction industry. BIM technology provides investors, building users and operators with a powerful tool to access and use all building information from a virtual building model (Altohami et al., 2021). BIM is not just a design tool but a system that supports management throughout the lifecycle of a project (Pinti, Codinhoto and Bonelli, 2022). Building information requirements for the full implementation of building operation management are the highest level of information required for BIM model information. According to the UK BIM Standard ISO19650 (Davidson et al., 2022), Level 3 achieves complete and comprehensive cooperation in the planning, construction and operational life cycle of a building.

The rapid urbanisation rate in large cities in Vietnam has created many high-rise buildings (Na and Hien, 2022). Decree 06/2021/ND-CP, which elaborates on the implementation of several regulations on quality management, construction and maintenance of construction works, states that the life cycle of high-rise buildings can span from 50 years to 100 years, with the construction investment phase accounting for only about 1/10 of this process; the operation phase accounts for the remainder (Government of Vietnam, 2021). The life cycle of an investment project in construction, operation and maintenance is a lengthy, complex and risky phase (Ministry of Construction, 2021). In Vietnam, high-rise buildings only appeared about 20 years ago and have not yet completed their first cycle. As a result, construction operation management is a new field in Vietnam (Hoang et al., 2020).

BIM is particularly useful in high-rise building management because of its complexity. BIM helps plan and monitor space utilisation, which is critical in high-rise buildings where efficient use of each floor impacts revenue. With BIM, managers can analyse the occupancy, adjust layouts and allocate resources effectively (Eastman, 2011). High-rise buildings involve multiple teams, with BIM centralising information and helping teams coordinate efficiently (Manzoor et al., 2021). Real-time updates ensure all stakeholders have access to the latest information. Many businesses implementing BIM in Vietnam are foreign-owned or privately owned (Mui and Giang, 2018). Design consultancy units are at the forefront of BIM applications, with a complete spectrum of design and application disciplines participating in numerous categories of construction works, including civil, industrial and road construction (Hoang et al., 2020). Construction has not implemented the BIM code of practice mandatorily to improve collaboration, ecological building criteria and material conservation (Quyet et al., 2018). As a result, the categories of data required to implement BIM-FM include management information, commercial information, technical information and all data about the entire life cycle (Kamaruzzaman, Suznan and Myeda, 2023). The implementation of BIM-FM is deemed advantageous because it increases the building's performance efficiency, closes the information gap, improves FM data administration, mitigates problems, identifies priority defects and improves FM processes. The BIM model fully integrates all building information, enabling faster and more accurate troubleshooting, cost savings and increased user satisfaction during building operations.

The Level of Development of Components in Building Information Modelling-Based Management Both Domestically and Internationally

BIM-LOD models contain detailed specifications about building components, such as location, size, manufacturer information and maintenance schedules. The BIM model is often generated using pre-existing library pieces. Library components often include comprehensive descriptive information, which becomes advantageous for later administrative tasks related to the facility. The American Institute of Architects (AIA) further modified the idea and dubbed it the LOD in 2008 (Dlesk et al., 2022). The working group of the BIM forum (BIMForum, 2021) created the LOD requirements from the AIA basics. It ensures that architects, engineers, and contractors agree on the reliability and details of the information. Different LODs require varying degrees of effort and time investment. By defining the required LOD, teams can budget accurately, allocate resources and avoid over-engineering or under-engineering the model. By accurately determining the LOD, stakeholders can minimise the risks of design errors, construction delays, or costly changes by identifying potential problems earlier. Based on the specs, it is evident that there are five distinct levels of LOD, namely 100, 200, 300, 350 and 400. The use of higher LOD components as a point of reference for operations and maintenance is a viable option for facility managers, given that these elements accurately depict the current state of installations.

LOD and BIM fields are currently making significant advancements. However, a notable challenge in their implementation is the lack of established standards or explicit recommendations. Previous studies may not have focused enough on developing standards and rules. For contracts that require specific LODs, having clear guidelines ensures legal compliance and that each party is meeting its obligations (Booty, 2006). Conventions expect the investor to predict the LOD400 when they specify the model categorisation and standardisation requirements for descriptive data in the contract (Dlesk et al., 2022). With accurate and comprehensive models, managers can better plan preventive maintenance. To achieve LOD500, it is required to accurately capture the geodetic state of the structure and then create a BIM model or make necessary modifications to the current model (Lin, Hsu and Hu, 2022). Limited resources or a lack of collaboration with stakeholders, such as construction companies or governments, can make it challenging to research the practical challenges and issues faced when implementing LOD and BIM in construction projects (Kamaruzzaman, Suznan and Myeda, 2023). The appropriate LOD level is determined using adequate documentation and expert opinion surveys. However, the service system serving the project, which includes mechanical, electrical, plumbing (MEP) and fire protection systems, presents more requirements and parameters than other systems. During operation and maintenance, the BIM model's settings must demonstrate the performance level (Alavi and Forcada, 2019).

Applying qualitative and quantitative analysis methods during the project's design stages allows for the transfer of information between BIM and FM systems, creating an information-gathering process for use in operational systems throughout the project lifecycle (Matarneh et al., 2020). A lack of standards or guidelines exists for applying LOD and BIM as they evolve. The study (Helander and Singh, 2016) affirmed the minimal information requirements of BIM in the renovation process using three typical renovation projects and 21 personnel and experts in this phase. Nevertheless, this study is limited in its breadth, as it only concentrates on a specific situation rather than providing general coverage. This is a challenge in terms of implementing these research findings into initiatives at different levels is a challenge.

For the questionnaire survey, there are several references to groups of components in the BIM model (as shown in Table 1). Although articles and studies have demonstrated the need for a set of information for the project's BIM-applied operational management phase, previous studies have not elucidated these requirements for the project's operational management units. Many previous studies have tended to focus on a narrow scope or particular case, resulting in a lack of thorough coverage. This presents challenges in applying these research findings to projects conducted at different levels. Additionally, many academic inquiries mainly focus on outlining and defining LOD and BIM without exploring the full range of benefits linked to their use in construction management and operations. These limitations offer opportunities for future research to explore and confirm the effectiveness of LOD and BIM implementation in the construction industry. The application of the population mean estimation method will offer a clearer understanding of the project management unit needs in the Ho Chi Minh City region. This study will not only determine the frequency of information utilisation for each project element in the operational management phase but also pinpoint the required level of detail. Detailing each project element is critical to meeting the minimal information requirements of the operational management phase.

Table 1. Summary table of groups of components in the BIM model

Category		Element	Group	Sources
A	Substructure	A10	Foundation	Alavi and Matheu (2019); Matarneh et al. (2020); GSA (General Services Administration, 2015); Applied Technology Council (2013)
		A20	Subgrade enclosures	Matarneh et al. (2020); GSA (2015); Applied Technology Council (2013)
		A40	Slab-on-grade	Alavi and Matheu (2019); GSA (2015); Applied Technology Council (2013)
B	Shell	B10	Superstructure	Alavi and Matheu (2019); Matarneh et al. (2020); GSA (2015); Applied Technology Council (2013)
		B20	Exterior enclosure	Alavi and Matheu (2019); Matarneh et al. (2020); GSA (2015); Applied Technology Council (2013)
		B30	Roofing	Helander and Singh (2016); Dias and Ergan (2016)
C	Interiors	C10	Interior construction	Alavi and Matheu (2019); GSA (2015); Teicholz (2013)
		C20	Staircases	Alavi and Matheu (2019); GSA (2015); Applied Technology Council (2013)
		C30	Interior finishes	Alavi and Matheu (2019); GSA (2015); Applied Technology Council (2013)

METHODOLOGY

Figure 1 outlines the three primary stages of the research process. The research team investigates the present state of BIM applications in the building operation management phase, which includes (1) pinpointing the essential research issues, objectives and scope, along with the duration of the research and (2) scrutinizing relevant documents such as studies on operation management and BIM applications in the operational management phase, along with the necessary information for this stage. Subsequently, the current research trajectory and pertinent concerns that require attention in this investigation are discerned. During Phase 2, the task at hand is to create datasets specifically designed for applicable BIM models within the operational management phase. After creating survey tables through an analysis of relevant papers and studies, the trainees surveyed to pinpoint the essential information needed for the efficient management and operation of high-rise buildings in Vietnam. The survey has two primary stages, with Phase 1 focusing on surveying to determine the frequency of information used about the various components inside the building. We conduct a thorough analysis and integration of data to collect relevant information for the creation of the Phase 2 survey. This Phase 2 survey includes a variety of question categories, including single-choice questions, multiple-choice questions and Likert scale questions (as shown in Table 2). In the subsequent section of the study, we collected and analysed the qualitative and quantitative queries gathered. Questions are posed to determine the LOD requirements for operational management components.

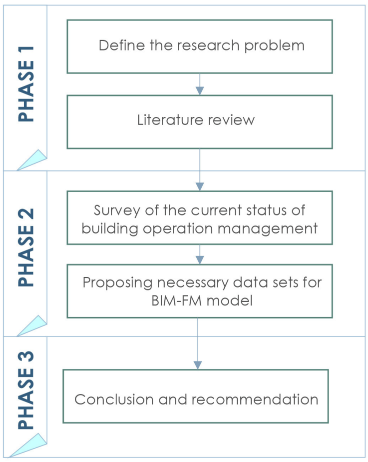


Figure 1. Research process

Table 2. Survey table format

No.	Content QA	Type of QA
I.A: Personal Information		
B1 and B2	Understanding of BIM and BIM models for FM work	Yes/No
B3	Information about documents collected during the handover of the building to the project operation management department	Multiple choices
B4	Information on collecting handover of FM stage	Yes/No
B5 and B6	Information about software or applications applied to the building management and operation stage	Multiple choices
B7	Collect data for software or computer applications during the FM phase	Single choice

(*Continued on next page*)

Table 2. *Continued*

No.	Content QA	Type of QA
B8	The barriers to BIM-FM adoptions	Multiple choices
II.A: Frequency of Using Component Information During Project Operation		
~	Frequency of using the information of each component during the operation phase	Likert scale
I.B: Personal Information		
II.B: Information Needs of Each Type of Component in the Operational Phase		
~	Information needs of each type of component in the operational phase	Likert scale

Interviews with individuals actively involved in BIM-FM integration initiatives were conducted using a qualitative research methodology for the current study. The second phase of the survey will conduct the primary survey, focusing on building management units and collecting information for each component within the building. The proposed database will include two essential elements: (1) a comprehensive list of components to be incorporated into the BIM-FM model and (2) the required development level for each component to meet project requirements and adequately address the operational management needs of the designated management delegate. Phase 3 represents the final phase of this investigation, presenting the findings and suggestions. Previous phases evaluated database appropriateness. Figure 2 represents the proportion of participants with three or more years of experience in the management position.

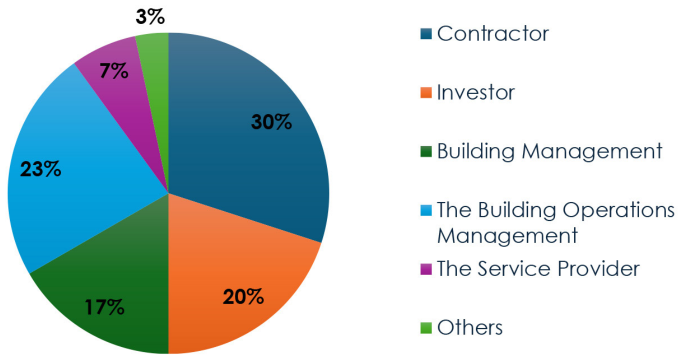


Figure 2. The field of surveyor information

The questionnaire's composition is divided into segments that inquire about the use of BIM-FM and software, as well as information technology applications relevant to building OM. These segments consist of information about the survey participants' expertise and details about the buildings where the participants have previously worked and are currently employed. The respondents targeted for this survey are individuals with at least three years of experience in building management roles in Ho Chi Minh City. Given Vietnam's developmental status and limited access to confidential information regarding the operation and management of high-rise buildings, these individuals frequently possess a higher level of information security.

To effectively gather data, a convenient sampling method was employed, where potential respondents were identified based on publicly available media information and direct engagements with building management departments. This approach facilitated the identification of approximately 60 individuals capable of providing comprehensive BIM data akin to that required in a BIM feasibility study aimed at small and medium-sized contractors and subcontractors. A targeted sampling yielded 70 responses (Sadeh et al., 2023). Notably, although the response rate was relatively low (30 out of 145), this was largely due to the composition of the focus group, which included a significant number of professionals based at airports. Given the stringent security measures typical of the aerospace sector, this demographic is highly relevant for acquiring insightful data (Keskin, Salman and Koseoglu, 2022). As a result, the chosen sample size reflects the pragmatic constraints associated with accessing the intended demographic and lacks external validity.

The Phase 1 survey, conducted from April to May 2022, targeted over 60 individuals with at least three years of experience in building management. The focus was on those involved in managing or researching high-rise building operations. The study's primary goal was to determine the informational requirements associated with the management and operation of high-rise buildings. The respondents typically included managers and researchers of high-rise facilities such as commercial centres, hotels, apartments and complex buildings, specifically from Ho Chi Minh City's building administration sector. The study collected contact information through online forms, personal referrals and direct outreach within the city, involving a total of 60 participants. Of these, 32 responded to the survey, yielding a response rate of 53.3%. Of the 32 survey questionnaires collected, two were deemed invalid, making up 3.33% of the total, while the remaining 30 were considered valid. These valid responses represented 96.67% of the returned surveys and 50% of the total number of participants.

A significant proportion of building data, namely 55.56%, does not possess a FM database. However, throughout the operations phase of the project life cycle, we transfer and continuously update information from all preceding stages. Several factors contribute to the challenges encountered throughout the survey process, resulting in a lower number of surveys acquired. One such factor is the survey's influence on the building's information security concerns. Additionally, the personnel questioned may not be affiliated with the technical management unit, further complicating the survey process. The subject matter of architecture is vast and multifaceted, making it impractical to include all aspects of building design and facility administration within a single discourse.

During Phase 2, the researchers reached out to over 36 participants, but only 18 of them agreed to participate in the survey. Several factors contributed to the survey procedure's difficulties, resulting in a low survey response rate. These factors include: The survey has an impact on the building's information security. However, those who are part of the administrative management unit rather than the technical management unit are unable to fully address all aspects of the building's information. The questions included in the Phase 2 survey were gathered in a qualitative format. The questioned participants were persons with expertise in building management and operation units chosen to enhance the precision of the survey findings. The demand for information development levels of components during the operation management process is assessed using a Likert scale. Questions are posed to ascertain the necessity for the growth of information levels in components of operational management. The survey findings provide information on the development levels of the BIM-FM model's components.

Previous studies (Ibrahim, Hashim and Jamal, 2019) employed quantitative methods to assess BIM deployment and perceived advantages. The Likert scale, with a score of 1 to 5 indicating "Strongly Disagree" to "Strongly Agree", employed a five-point scale, which is consistent with the methodology employed in other prior investigations (Lee et al., 2020). A Likert scale is a five-point scale that allows individuals to indicate their level of agreement or disagreement with a given statement (Haji et al., 2021; Hong et al., 2020). This study employed a descriptive statistical data analysis method. In Part 2 of both surveys, the questions were Likert scale questions. With this type of question, each type of choice will be calculated as a percentage of the total number of survey results obtained, then ranked in ascending order according to the sample average of the frequency of using the information of each component. The purpose of this step is to make choices about components that use the most common information. Each option will be averaged on a Likert scale, and the important information contained in the BIM-FM model and the LOD in the model will be determined. The construction of a database for actual works, based on proposals evaluated by personnel and professional building management units, is underway.

FINDINGS AND DISCUSSION

Images, as-built drawings, technical requirements, operating and maintenance instructions and device warranty information files are the primary sources of project management information, according to the survey results. The contractor transfers most of this information (44%) or from the project formation stage through the project development process (39%), while the project development process collects the remaining information.

In the field of project design and construction, BIM is rapidly advancing, much like the speedy progression of a wave. The proliferation of BIM expertise within the construction sector has seen a significant increase, reaching a rate of 72.22%. However, many of these approaches primarily focus on understanding and lack particular relevance to project OM. According to the results, a percentage of 61.11 indicates the immaturity of BIM-FM in OM. The key factor contributing to these challenges is the absence of dedicated management software for operational management. Instead, the organisation relies only on Microsoft Office and AutoCAD for administrative tasks and construction-related activities.

Frequency of Using Component Information During Project Operation

In Phase 2, a Likert scale questionnaire measures operation management component usage. The authors will proceed to create a simple Likert scale questionnaire to assess database viability. In OM, the survey evaluates database reliability and BIM utilisation. The Likert scale's average score for each choice will determine the relevance and component details of the BIM-FM model. The findings will be utilised to assess the database's appropriateness and provide plan suggestions. Figure 3 displays the format for the component LOD survey. The analysis utilised the Statistical Package for the Social Sciences (SPSS) average frequency method. Variance, which gauges each data point's deviation from the mean, generates the standard deviation (Field, 2013). The author uses SPSS and the Likert scale to process the data. Statistical hypothesis tests, like the one-sample t-test, detect if an unknown population varies from a given value. Sig. (2-tail) is less than 5%, leading to the rejection of the null hypothesis. If Sig. (2-tail) > 5%, the hypothesis is accepted. A five-point scale mean should be higher than 3.

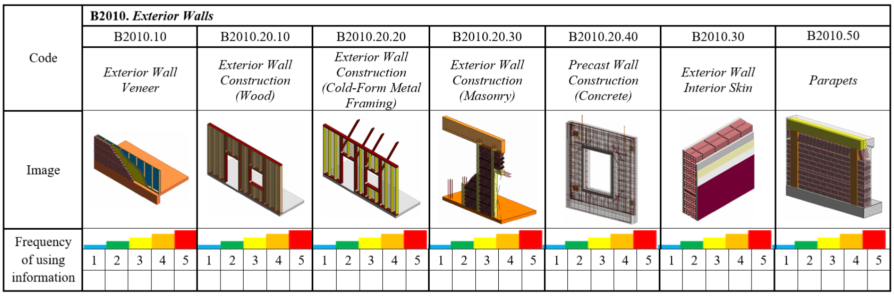


Figure 3. Survey sample of frequency of using information of each component during the operation phase

Table 3 frequently uses substructure information, particularly foundation information. Unless shifting or cracking occurs, most foundations require little upkeep. The foundation is evaluated and tested to verify the construction's structural integrity. Thus, most foundation elements (A1010) use information rarely during the project. The unique foundation, like the conventional footing (A1020), is rare. Only accidents, exceptional settling or cracking, or routine structural examinations use the A4010, A4020, foundation and floor structures for informative purposes.

Table 3. Frequency of using information on substructure

Code	Element	Mean	Standard Deviation
A1010	Standard foundation		
A1010.10	Wall foundations	1.22	–
A1010.30	Column foundations	1.28	–
A1020	Special foundation		
A1020.10	Driven piles	1.33	–
A1020.40	Foundation anchors	1.00	–
A1020.60	Raft foundation	1.22	–
A1020.70	Pile caps	1.56	–
A1020.80	Grade beams	1.44	–
A4010	Standard slab-on-grade	1.83	–
A4020	Structure slab-on-grade	1.89	–

The superstructure and substructure are critical components of building construction. The superstructure is the architectural part above ground level, seen without glasses. Initial layer to the topmost layer. In beam construction, Table 4 shows the B1010 steel composition. Vietnam uses many cast-in-place buildings, reducing the need for beams and columns. Roof structural beams (B1020) are as common as floor beams. We use roofing and light panels more because we replace and repair them more often. B1080 ladders, steps and railings provide a moderate amount of information. The average beam, column and bracing rod steel value surpasses 3. However, their *p*-values are above 0.05, indicating insufficient evidence to delete them. The author suggests including concrete and steel construction components in Phase 2 due to their complexity. Table 4 shows that the outside walls of high-rise buildings are largely brick and glass (B2010). The data analysis examines brick wall properties, including exterior paint. B2020 high-rise buildings with outside windows prioritise safety and wind mitigation. Many windows flap or slide. A few open windows reduce visibility. Users frequent the B2050 entrance. Most lobby and mesh doors have larger dimensions. Project activities do not include documentation of outdoor ventilation and louvres (B2070). The material focuses on outside walls, railings, wall accessories and outdoor décor (B2080). Beams, concrete columns, roof retaining wall components, sliding windows outside the home and decorative embellishments outside the house are inappropriate for selection despite having a mean value over 3.0 and a p-value over 0.05. Phase 2 of the review is necessary due to the increased utilisation of roof retaining walls and outer gate management service providers. Table 4 displays the continued use of superstructure information. The average usage frequency for B3010 roof finishes is 3.80. Permeation, roof leaks and roof tile replacement during the process may explain this periodicity. The rooftop accessories (B3020) rainwater drainage system plays a crucial role during heavy rains in Vietnam. Most Vietnamese B3060 and B3080 buildings lack distinctive characteristics, resulting in no roof openings. Vietnamese facades and outside architecture use glass, plastic, aluminium, or stone tiles. Thus, outdoor ceilings are often low-ownership projects.

Table 4. Frequency of using information on superstructure

Code	Elements	Mean	Standard Deviation
B1010	Floor construction		
B1010.10	Floor structure frame		
B1010.10.10	Floor structural frame (concrete)	3.17	0.407
B1010.10.11	Precast structural inverted T-beam	1.67	–
B1010.10.12	Precast structural column	1.70	–
B1010.10.20	Floor structural frame (masonry)	2.90	0.522
B1010.10.30	Steel framing columns	3.33	0.030
B1010.10.40	Steel framing beams	3.30	0.071
B1010.10.50	Steel framing bracing rods	3.10	0.573
B1010.10.60	Steel joists	2.83	0.420

(*Continued on next page*)

Table 4. *Continued*

Code	Elements	Mean	Standard Deviation
B1020	Roof constructions		
B1020.10	Roof structural frame	3.17	0.362
B1020.20	Roof decks, slabs, and sheathing	3.7	0.001
B1020.30	Canopy construction	3.56	–
B1080	Stair		
B1080.10	Stair construction	3.47	–
B1080.20	Precast structural stairs	2.03	–
B1080.50	Stair railings	3.40	0.008
B1080.70	Metal walkways	2.20	0.001
B1080.80	Ladders	3.57	0.002
B2010	Exterior walls		
B2010.10	Exterior wall veneer	1.33	0.008
B2010.20.10	Exterior wall construction (wood)	1.50	0.008
B2010.20.20	Exterior wall construction (cold-form framing)	2.85	0.588
B2010.20.30	Exterior wall construction (masonry)	3.63	0.001
B2010.20.40	Precast wall construction (concrete)	3.17	–
B2010.30	Exterior wall interior skin	3.77	–
B2010.50	Parapets	3.13	0.423
B2020	Exterior window		
B2020.10	Exterior operating windows	3.13	0.442
B2020.20	Exterior window wall	3.28	0.032
B2050	Exterior doors		
B2050.10	Exterior entrance doors	3.47	0.006
B2050.20	Exterior utility doors	2.60	0.008
B2050.30	Exterior oversize doors	3.37	0.039
B2050.40	Exterior special function doors	2.20	0.002
B2050.60	Exterior grilles	4.13	–
B2050.70	Exterior gates	3.03	0.879
B2070	Exterior louvres and vents		
B2070.10	Exterior louvres	2.61	0.712
B2070.60	Exterior vents	2.67	0.318

(*Continued on next page*)

Table 4. *Continued*

Code	Elements	Mean	Standard Deviation
B2080	Exterior wall appurtenances		
B2080.10	Exterior fixed grilles and screens	2.50	0.019
B2080.30	Exterior opening protection devices	2.47	0.024
B2080.50	Exterior fabrication	3.17	0.213
B2080.70	Exterior balcony walls and railings	3.37	0.025
B2080.80	Bird control devices	1.39	–
B3010	Roofing	3.80	–
B3020	Roof appurtenances		
B3020.10	Roof accessories	3.00	1.000
B3020.30	Roof specialties	2.67	0.086
B3020.70	Rainwater management	3.53	0.001
B3060	Horizontal openings	1.97	–
B3080	Overhead exterior enclosures		
B3080.10	Exterior ceilings	2.10	–

Many tenants, investors and owners utilise and modify interior finish information, according to Table 5. Due to architectural changes in residential and commercial buildings, ongoing renovations typically affect wall interiors. As a result, these projects use C1010 wall data. Restaurants, hotels and conference centres utilise adjustable partition walls, whereas residential structures use timber walls. However, projects seldom have both wall types. Apartment windows capture and harness natural light, creating a well-ventilated and open living atmosphere. The majority of residential C1020 windows are sliding and fixed. Swing, lobby sliding, folding and indoor rolling doors (C1030) have the highest door utilisation. Residential construction frequently has low rates of interior security control gates, particularly C1040 gates. Office buildings primarily use these gates to control entry and exit. However, the kiosks in these residential buildings have large vertical sliding doors. The majority of projects analysed use gypsum board, plastic sheets, or a C1070 ceiling. Usually designed for public use, special ceilings are scarce. People respect the industry for its specialised duties. Interior louvres (C1090), like outside louvres, use information sparingly. However, interior railing systems require periodic inspections and service.

Table 5. Frequency of using information on interiors

Code	Elements	Mean	Standard Deviation
C1010	Interior wall		
C1010.10	Interior fixed partitions		
C1010.10.10	Interior wall construction (masonry)	3.22	–
C1010.10.20	Interior wall construction (cold-form framing)	3.72	–
C1010.10.30	Interior wall construction (wood)	2.17	0.509
C1010.20	Interior glazed partitions	4.06	–
C1010.40	Interior demountable partitions	1.94	–
C1020	Interior windows		
C1020.10	Interior operating windows	3.17	0.001
C1020.20	Interior fixed windows	3.50	0.033
C1020.50	Interior special function windows	2.11	0.001
C1030	Interior door		
C1030.10	Interior swinging doors	3.33	–
C1030.20	Interior entrance doors	3.61	–
C1030.25	Interior sliding doors	3.44	0.778
C1030.30	Interior folding doors	3.61	–
C1030.40	Interior coiling doors	3.83	0.001
C1030.50	Interior special function doors	1.94	0.008
C1040	Interior grilles and gates		
C1040.10	Interior grilles	3.56	–
C1040.20	Interior gates	1.67	0.003
C1070	Suspended ceiling construction		
C1070.10	Acoustical suspended ceilings	3.89	–
C1070.20	Suspended plaster and gypsum board ceilings	3.72	–
C1070.50	Specialty suspended ceilings	1.83	–
C1090	Interior specialities		
C1090.10	Interior railings and handrails	3.22	0.048
C1090.15	Interior louvres	2.50	0.541
C2010	Wall finishing	3.56	–
C2030	Flooring		

(*Continued on next page*)

Table 5. *Continued*

Code	Elements	Mean	Standard Deviation
C2030.10	Tile flooring	4.28	–
C2030.20	Specialty flooring	4.00	–
C2030.30	Masonry flooring	1.56	–
C2030.45	Wood flooring	1.50	–
C2030.50	Resilient flooring	3.78	–
C2030.60	Terrazzo flooring	3.40	0.026
C2030.70	Fluid-applied flooring	2.23	0.003
C2030.75	Carpeting	3.50	–
C2030.85	Entrance flooring	3.27	0.326
C2040	Stair finishes		
C2040.20	Tile stair finish	3.78	–
C2040.40	Masonry stair finish	2.17	–
C2040.45	Wood stair finish	1.50	–
C2040.50	Resilient stair finish	1.47	–
C2040.60	Terrazzo stair finish	3.47	0.006
C2040.75	Carpeting stair finish	1.83	–

Table 5 shows that due to frequent changes, the flat design uses wall finishes (C2010). However, they typically constitute a substantial portion of the design. Tiled floors, stone tiles, terrazzo, laminate, vinyl and carpet are common floor finishing materials. The building should be altered to meet user demands and goals (C2020). Ladder finishing variants (C2040) exclusively apply to tile and stone cladding, unlike floor finishes. These buildings often employ stairs for fire escape; thus, tiling or stone cladding may save money while preserving safety. High-rise buildings with a multi-functional main hall usually have vinyl and aluminium alloy carpet on the entrance floor. The carpet material is typically damaged in this location due to excessive foot activity. This must be taken into account in step 2, even when the *p*-value exceeds 0.05 and the mean value exceeds 3.

The research identified specific architectural and structural components and underscored the importance of utilising component information. Future studies will encompass heating, ventilation and air conditioning, fire protection, MEP, discrete furnishings during the connection phase and the procurement of project equipment following facility construction and as-builts.

Information Needs of Each Type of Component in the Operational Phase

Figure 4 illustrates the components in the operating phase that require a questionnaire. The questions in Part 2 are similar to those in Part 1, which ask about the frequency of information used in OM. This includes reviewing components used frequently, assessing development for components used infrequently and advancing survey development for components with medium to high information use frequency. Because the foundation and floor elements in this structure are rarely used, they are only modelled at LOD200, but their shape, location and materials will be described.

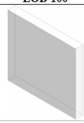
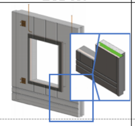
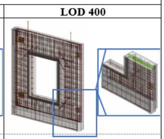
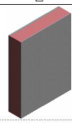
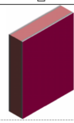
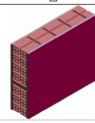
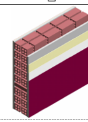
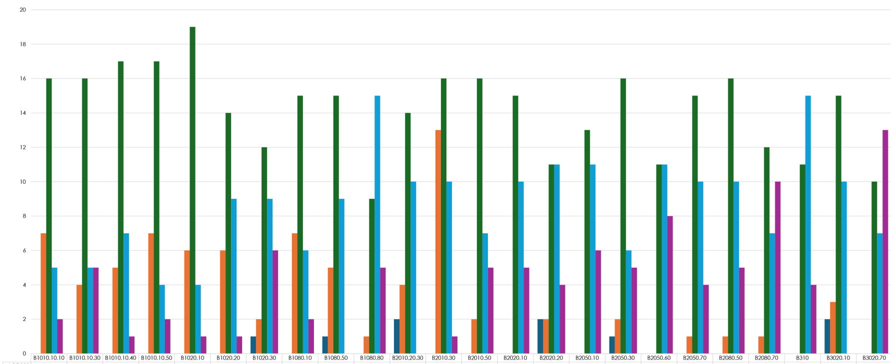
CODE	CONTENT	THE LEVEL OF COMPONENT DEVELOPMENT				
		LOD 100	LOD 200	LOD 300	LOD 350	LOD 400
B2010.20.40	Precast Wall Construction (Concrete)	 - General wall. - The size, shape and position shown are not accurate. □	 - Correctly represent wall materials for classification. - Thickness is shown approximately. - Location and wall height are shown accurately. □	 - Shape, size, thickness of wall finishes are accurately shown. - The shapes and sizes of openings on the wall are not shown accurately. □	 - The shapes and sizes of the openings on the wall are shown exactly. - Show an overview of accessories, structural layers in wall panels. □	 - Shows the exact location of pre-tensioned cables, reinforcement (anchor sections, connections), location of wall accessories for fabrication and installation. □
B2010.30	Exterior Wall Interior Skin	 - Generic finishing grade - The shape and size of the finish are shown in general. □	 - Main materials used to finish walls. - The overall thickness of the finished layer is shown approximately. □	 - The finished layer shows accurate structure and dimensions. □	 - On each wall surface, the finishing layers are modeled with exact dimensions to reality. □	 - The finishing layers are shown separately to clearly show the construction and finishing of the wall. □

Figure 4. Survey sample of information needs of each type of component in the operational phase

Figure 5 shows that the operating unit alone needs accurate dimensions and positioning of concrete beams, columns, wind-resistant steel columns, beams and braces (B1010). The amount of data matches LOD300 development. This is adequate for roof structures (B1020) to specify roof covering thickness, placement, elevation and slope, including roofing panels and roof decks. The study results emphasise the requirement for exact LOD300 staircase dimensions and form within the B1080 staircase setup. Additionally, both parties have similar stair railing component requirements. However, roof ladder connections and components need further detail. Thus, LOD350 must cover these features. For the outside wall (B2010), the element just needs the brick wall's size, position, material and opening shape. The door provides plenty of information for management. All they need to do is depict the wall finish in a uniform composition. For exterior sliding window components (B2020), people need accurate information about door components like glass panel sizes, door bars and accessories, but exterior windows need more details like frame system structure, structural layers and sealant. Similar to windows, external doors (B2050) require a medium LOD300, which includes precise dimension and shape information as well as near-perfect door components. Mesh and rolling doors take more work than LOD350. For outdoor railing components (B2080), exact details, sizes and placements are enough for operation. LOD350 data is needed to survey the roof finish layer (B3010), including measurements, roof inclination, accurate positioning and structural layer integration, including apertures. This growth stage shows the roof-wall connection. Construction projects commonly use gutters and rainwater pipes (B3020). Thus, LOD400 information must include precise materials, installation directions and slope parameters.

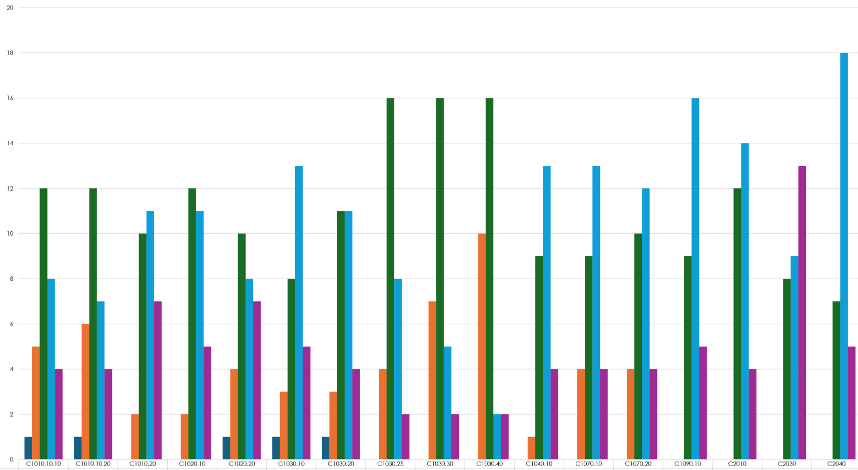


	B1010.10.10	B1010.10.30	B1010.10.40	B1010.10.50	B1020.10	B1020.20	B1020.30	B1080.10	B1080.50	B1080.80	B2010.20.30	B2010.30
LOD100	0	0	0	0	0	0	1	0	1	0	2	0
LOD200	7	4	5	7	6	6	2	7	5	1	4	13
LOD300	16	16	17	17	19	14	12	15	15	9	14	16
LOD350	5	5	7	4	4	9	9	6	9	15	10	10
LOD400	2	5	1	2	1	1	6	2	0	5	0	1

	B2010.50	B2020.10	B2020.20	B2050.10	B2050.30	B2050.60	B2050.70	B2080.50	B2080.70	B310	B3020.10	B3020.70
LOD100	0	0	2	0	1	0	0	0	0	0	2	0
LOD200	2	0	2	0	2	0	1	1	1	0	3	0
LOD300	16	15	11	13	16	11	15	16	12	11	15	10
LOD350	7	10	11	11	6	11	10	10	7	15	10	7
LOD400	5	5	4	6	5	8	4	5	10	4	0	13

Figure 5. Summary table of frequency of use of superstructure

Figure 6 shows interior partitions (C1010), which need accurate measurements, shapes and placements, such as outer walls. The element establishes structural classes through precise measurements that provide sufficient information for operation. Glass walls require additional information handling due to their complex structure. This increases demand for links and door accessories. Indoor windows, made of C1020 material, require the same average specifications as exterior windows, as well as shape information. Figure 6 illustrates the predominant use of indoor doors (C1030) in lobbies and rooms. Safety and security operations, along with other electronic software such as attendance and building security systems, depend on these components, necessitating frequent maintenance. Others, such as sliding and folding doors, divide residential areas, reducing informational requirements. The C1040 indoor screen doors are used to separate kiosks and specialised rooms. A plan is used to guide the door's maintenance. LOD350, which contains critical information, is displayed on the door. At this level, the information is complete enough for operational management. Maintenance and control of the MEP systems attached to the ceiling structure, C1070, is critical in LOD350 standards. Home railings (C1090) require cleaning, upkeep, repair and remodelling. Thus, this component requires average LOD300 information, with almost accurate geometric information in the model.



	C1010.10.10	C1010.10.20	C1010.20	C1020.10	C1020.20	C1030.10	C1030.20	C1030.25	C1030.30	C1030.40	C1040.10	C1070.10	C1070.20	C1090.10	C2010	C2030	C2040
LOD100	1	1	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0
LOD200	5	6	2	2	4	3	3	4	7	10	1	4	4	0	0	0	0
LOD300	12	12	10	12	10	8	11	16	16	16	9	9	10	9	12	8	7
LOD350	8	7	11	11	8	13	11	8	5	2	13	13	12	16	14	9	18
LOD400	4	4	7	5	7	5	4	2	2	2	4	4	4	5	4	13	5

Figure 6. Summary table of frequency of use of interiors

For survey purposes, the authors classified finishes with similar properties. Managers handling C20 finishing layers need precise measurements, composition, thicknesses, materials and colours. Their focus is on component specifics rather than individual layers or construction details. They publicly shared the results of the Phase 1 survey on structural information usage. This section covers architectural components requiring information from LOD300 to LOD350. Information usage decreases in some areas. A LOD200 model was released earlier. Most structural elements require moderately detailed information (LOD300), which informs development stages (as shown in Table 6). Rather than uniform LOD levels, this framework categorises components and LODs for efficiency. The next phase will evaluate component development to guide the pilot project model design.

Table 6. Proposing framework of LOD

Category		**Element**	**Group**	**LOD**
A	Substructure	A10	Foundation	200
		A20	Subgrade enclosures	200
		A40	Slab-on-grade	200
B	Shell	B10	Superstructure	300 to 350
		B20	Exterior enclosure	300 to 350
		B30	Roofing	350 to 400
C	Interiors	C10	Interior construction	300 to 350
		C20	Staircases	350 to 400
		C30	Interior finishes	350

CONCLUSIONS AND SUGGESTIONS

The input database will be used to develop BIM-FM models of Vietnamese building management units, focusing on high-rise units in Ho Chi Minh City. After examining operation management issues and requirements, the research study created input databases to improve the BIM model's FM capabilities. People involved in operation management research provided the survey results. The study deduced information collection, transfer, frequency and utilisation requirements for building components from the collected data. Project operations do not always use this type of information. The completion process and operation management both face numerous information transfer issues. These issues mainly come from a lack of clarity in selecting critical information for the operation process and identifying unnecessary drawing information.

This research has helped build and advance LOD and BIM standards in the construction industry. Assessing model and LOD information utilisation helps to create and improve industry standards and guidelines. This helps to establish a standard for their use. This study may provide ways to improve BIM efficacy during implementation. This study examines the benefits of LOD and BIM for building projects and construction OM. This includes time-saving analyses, asset optimisation and process improvements. Evaluate the impact of LOD and BIM in practical situations. Real-world scenarios may yield significant insights and skills. This research aims to disseminate information and share the study's findings to benefit the construction and project management communities throughout the digital transformation. This improves LOD and BIM awareness. This study does not offer guidelines or regulations to ensure the proper selection and sharing of critical information throughout construction. Implementing empirical pilot projects to test ideas in real-world situations can provide reliable evidence for plans.

Vietnam lacks BIM deployment in operational management, limiting understanding of BIM and its operational applications. BIM is still a new operational entity. Information utilisation by architectural structures and interior administrative bodies is unimportant. Based on the assessment of FM unit information management state and requirements, this research recommends a BIM-FM model database for information collection. Due to the necessity for detailed statistics on component information and operational management unit member usage, the database was created.

The extensive data in high BIM-LOD models helps facility managers plan preventive maintenance. By fixing problems early, you may reduce equipment downtime and extend the life of assets. The lack of empirical data on LOD and BIM in building projects is a major limitation. Simulated or predicted data in the study may not accurately represent BIM adoption. Many building project stakeholders must work together to get LOD and BIM data. This task may be difficult and delay information acquisition. This study focuses on LOD and BIM in OM, not on other phases. The goal is to create a comprehensive database to facilitate BIM-FM model development. The databases will focus on operational management. In further research, they will categorise component development for MEP and loose and fixed furniture. The database will prioritise target groups, creating BIM-FM models with improved application efficiency, usability and information management for future studies.

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