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HOLISTIC FRAMEWORK FOR SOFT COSTS IN BIM-BASED CONSTRUCTION PROJECTS

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Abdelrahman M. Farouk, Ph.D. Candidate
Faculty of Civil Engineering Technology, University Malaysia Pahang Al-Sultan Abdullah, Kuantan, Malaysia
abdelrahman.mfarouk@gmail.com

Ahmad Tarmizi Haron, Associate Professor
Faculty of Civil Engineering Technology, University Malaysia Pahang Al-Sultan Abdullah, Kuantan, Malaysia
ahmadtarmizi@umpsa.edu.my

Eleni Papadonikolaki, Associate Professor
Department of Materials, Mechanics, Management & Design, Delft University of Technology, Netherlands
e.papadonikolaki@tudelft.nl

Rahimi A. Rahman, Associate Professor, Visiting Professor* (corresponding author)
Faculty of Civil Engineering Technology, University Malaysia Pahang Al-Sultan Abdullah, Kuantan, Malaysia, *Faculty of Graduate Studies, Daffodil International University, Dhaka, Bangladesh
arahimirahman@umpsa.edu.my

SUMMARY: *Implementing Building Information Modeling (BIM) brings efficiencies to construction projects, yet evaluating the associated soft costs remains challenging. This study aims to develop and validate a framework for soft cost elements (SCEs) in BIM-based construction projects. A systematic literature review (SLR) and thematic analysis initially identified 31 SCEs, which were subsequently organized using framework analysis by project phase (planning, preconstruction, construction, and post-construction) and time category (discrete vs. continuous). Inter-rater reliability for the categorization reached 81.3%. Expert validation (n = 16) refined the framework and added seven BIM-specific SCEs, resulting in a total of 38. Theoretically, the framework extends soft-cost theory into the digital domain by modeling BIM-specific remuneration and overheads and by introducing a phase–time structure that explains when and how soft costs arise. Practically, it is operationalized as a decision tool: owners and quantity surveyors can use it as a checklist to create explicit budget lines, scope BIM roles, and update cadences in contracts, and monitor continuous costs monthly while tying discrete costs to milestones, thereby improving estimation accuracy, return-on-investment assessment, and risk control across the project lifecycle. To our knowledge, this is the first validated, phase–time SCE framework for BIM-based construction projects.*

KEYWORDS: *building information modeling (BIM), systematic review, soft cost, framework.*

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1. INTRODUCTION

Soft costs play a pivotal role in enhancing Building Information Modeling (BIM) implementation in construction projects (Saini *et al.*, 2021; Tah *et al.*, 1994). Soft costs encompass different aspects of construction projects, can impact decision-making processes among project owners (Zahirah *et al.*, 2013; Zahirah and Abidin, 2012). Without a clear understanding of what soft costs entail, owners often fear hidden or escalating expenses, face uncertainty in calculating their return on investment, and struggle to justify BIM adoption to internal or external stakeholders. This uncertainty increases perceived financial risk, which in turn discourages them from fully committing to BIM (Raouf and Al-Ghamdi, 2019). Additionally, underestimating soft costs can create unrealistic expectations and potential budget overruns (Azizi *et al.*, 2018; Jalaei and Jrade, 2015). Accurately estimating soft costs in BIM-based construction projects is essential for evaluating the return on investment (ROI), a key indicator of a project's overall financial performance. Without a clear understanding of these costs, projects risk inefficiencies that could compromise both financial control and stakeholder confidence.

Although existing research has investigated the hard costs associated with BIM implementation, discussions around the soft costs of BIM-based construction projects have been relatively limited (Criminale and Langar, 2017). This gap highlights an important opportunity for further exploration, especially as policymakers and researchers often underestimate the impact of ROI uncertainty in BIM implementation (Zheng *et al.*, 2017). For instance, reports from the UK government indicate that BIM implementation can reduce capital expenditure (CAPEX) from 30% to 20% (Lewis et al., 2017; Plan, 2015). These findings highlight the financial benefits of BIM, underscoring the importance of evaluating ROI from a business perspective rather than relying solely on financial incentives or regulatory requirements. By adopting this broader approach, project owners can gain a deeper appreciation of BIM, leading to more informed decision-making and sustained investment. Understanding soft cost elements (SCEs) is essential for making informed decisions and allocating resources efficiently, which can impact the financial viability of BIM-based construction projects (Jalaei and Jrade, 2015). Insights on SCEs enable project owners to fully grasp the potential benefits of BIM, thereby supporting its implementation. However, the continued absence of a systematic approach to identify and manage these costs has contributed to their persistent neglect in both research and practice. This underscores the necessity for a structured solution that can address this oversight and support more effective decision-making.

To address this gap, developing a structured understanding of SCEs becomes essential. By clarifying the types and categories of SCEs, a structured framework can guide more strategic resource allocation. This approach helps overcome challenges related to unknown or ambiguous costs, thereby improving financial planning. Additionally, insights gained from the framework can empower project owners to recognize the potential savings and added value that BIM can deliver. This, in turn, encourages broader implementation of BIM and contributes to optimizing project outcomes. To effectively demonstrate the high ROI of BIM to project owners, it is crucial to back soft cost estimations with concrete data. With insights into the costs associated with each SCE, project owners are better equipped to prioritize these elements and allocate resources more efficiently (Zahirah and Abidin, 2012). These insights not only help maximize the ROI of BIM-based construction projects but also ensure their financial viability. A thorough understanding of soft costs is crucial for overcoming the barriers to implementing BIM in construction projects.

In addressing the challenges of estimating soft costs in BIM-based construction projects, this study defines the problem as follows: while hard costs are widely researched and standardized, BIM-related soft costs remain fragmented, inconsistently categorized, and rarely validated through industry practice. This knowledge gap hampers accurate ROI calculations, weakens financial planning, and discourages confident adoption of BIM. Accordingly, this study hypothesizes that a structured framework can reduce ambiguity by explicitly identifying, classifying, and validating SCEs.

To test this hypothesis, the study addresses three research questions:

[1] What are the SCEs associated with BIM-based construction projects?
[2] How can these SCEs be structured into a framework organized by project phase and time category?
[3] How well does the validated framework align with current BIM-based practices and support improved estimation and decision-making?

To address these questions, the study has three objectives:

1) Identify the SCEs in BIM-based construction projects

2) Develop a framework of SCEs in BIM-based construction projects

3) Validate the framework of SCEs in BIM-based construction projects

To achieve these objectives, the study begins with a systematic literature review (SLR) to identify potential SCEs. The SCEs were then refined through expert interviews, which eliminated irrelevant items and incorporated new, pertinent ones. Finally, a framework was developed using the validated SCEs. The framework enhances decision-making in several ways. Firstly, by linking each SCE to both its project phase and its accrual pattern (discrete or continuous), the framework allows project owners to anticipate when costs will arise rather than encountering them unexpectedly. Secondly, this structuring supports the setting of realistic budgets and contingencies, reducing the risk of underestimation and late-stage financial shocks. Thirdly, the framework informs procurement and contracting by clarifying the scope of BIM roles and digital tools, which helps allocate responsibilities and costs more transparently. Ultimately, the framework empowers project teams to evaluate trade-offs more systematically and conduct more reliable ROI calculations.

2. RESEARCH BACKGROUND

This section explores key concepts and prior research related to soft costs in construction projects. It begins with an overview of BIM implementation costs, focusing on Total Cost of Ownership (TCO) and the role of soft costs as a critical yet often overlooked component. The discussion then examines advancements in BIM-based cost estimation, highlighting gaps in addressing soft costs. Finally, prior reviews are analyzed to position this study within the existing body of knowledge.

2.1 Costs of BIM implementation

In BIM-based construction, the costs of implementation comprise BIM-specific hard and soft components. Hard costs include software licensing for BIM authoring and coordination tools, as well as hardware and computing infrastructure, and training facilities, in addition to the standard expenses for labor, materials, and equipment. Soft costs include remuneration for BIM-specific roles, such as modelers, coordinators, consultants, and managers; recurring coordination activities and model update cycles; administration of the common data environment and data exchange; and simulation activities, including energy modeling. These items are closely tied to the operation of a BIM process; many of them recur across phases, and they can materially influence ROI.

Viewed through Total Cost of Ownership (TCO), BIM implementation costs sit alongside other lifecycle expenditures, helping stakeholders understand long-term financial impacts and supporting cost-effective resource allocation (Alhamouri et al., 2024). Prior research indicates that operational expenditures can account for up to 90% of a building's total lifetime costs (Effat, 2025; Pishdad and Onungwa, 2024). Although various SCEs have been discussed in the literature, there is still no universally accepted definition or standardized list (Zahirah *et al.*, 2013; Zahirah and Abidin, 2012; Zuhri *et al.*, 2024). This lack of clarity complicates estimation. Soft costs typically account for 20%–30% of construction budgets and can rise as high as 75% in complex projects. In BIM-based construction projects, failing to recognize digital soft costs can produce underestimation and late financial surprises. Explicitly identifying and categorizing these costs enables better resource allocation and more informed financial decisions (Kamar *et al.*, 2023).

2.2 Soft costs in construction projects

Soft costs often play a pivotal role in budget overruns, underscoring the importance of accurate estimation. El-Sawy et al. (2010) identified several factors contributing to increased soft costs in construction projects, noting the influence of specialized subcontractors, site preparation, organizational experience, and even the type of contract and client involved. These insights reinforce the importance of estimating soft costs, ensuring they are accounted for and controlled throughout the project lifecycle.

In the context of green building construction projects, Azizi and Abidin (2012) investigated the SCEs by deriving intangible and non-physical costs, identifying six critical SCEs: insurance, project owner experience, design costs, certification, commissioning, and energy modeling. The research also noted that design costs include architectural and engineering fees, eco-charettes, extended design time, and green consultant fees. Similarly, Zahirah et al. (2013) identified critical SCEs affecting project owner decisions on green building construction, including consultant fees, green building consultants, certification, commission, market conditions, and taxes. Accurately estimating these SCEs is vital, as neglecting them can impair decision-making and lead to cost overruns and compromised financial planning. Expanding on this, Azizi et al. (2018) identified eighteen SCEs and categorized them under three main categories: professionals, legal requirements, and procedures. The research highlights that most SCEs occur during project planning and can manifest as either continuous or discrete expenses (Kamar *et al.*, 2023).

Further emphasizing the importance of SCE estimation, Ade and Rehm (2020) reviewed the SCEs associated with acquiring necessary certifications for construction projects, finding that certification fees comprise a substantial portion of total soft costs. Furthermore, their research categorizes SCEs according to project lifecycle phases (i.e., planning, preconstruction, and construction), ensuring that costs are appropriately allocated and controlled at each phase. Moreover, Saini et al. (2021) broadened the understanding of SCEs by including project and organizational overhead expenses. Through case studies in India, the research estimated the soft costs for three construction projects, revealing that these costs were higher than those reported in the literature. Notably, the research also indicates a direct correlation between a contractor's operating revenue and total soft costs, offering valuable insights into the dynamics of soft costs in construction projects.

2.3 BIM and cost estimation

Cost estimation is central to construction project management because it shapes budgeting, financial planning, and resource allocation. Inaccurate estimates often lead to overruns, delays, and a loss of stakeholder confidence. In BIM-based construction projects, estimation gains added importance since BIM integrates design, scheduling, and cost data within a single digital model. This integration enables stakeholders to evaluate the financial implications of design choices early, compare alternatives, and make informed, evidence-based decisions that balance cost, quality, and time. Linking BIM with cost estimation, therefore, not only strengthens project control but also creates the foundation for incorporating soft costs into a holistic view of total project ownership (Farouk *et al.*, 2025).

Du (2021) explored using artificial intelligence and BIM to create a construction project cost simulation system. This system combined BIM with pricing data to simulate and analyze construction costs, helping project managers better understand and manage projects in the early stages. The research highlighted the importance of BIM in addressing information redundancy and improving information exchange among stakeholders by organizing and storing detailed project data in a digital model. The results demonstrated that the intelligent model effectively supported cost estimation and management in construction projects. Moreover, Thu et al. (2021) presented a BIM-database-integrated system for enhancing CCE by automating data extraction from BIM models, thereby reducing errors and improving efficiency through a 3D model interface. The system addressed the limitations of traditional methods and proposed further integration with decision support systems for optimized design and cost control. Similarly, Shehab and Abdelalim (2023) examined BIM's role in improving cost estimation and control by linking cost data directly to building models. The research discussed two methods: exporting data to software like Excel and directly connecting BIM components to estimating tools. A case study of a three-story facility demonstrated the effectiveness of BIM in reducing errors and increasing efficiency. They recommended integrating time and cost data into a unified platform to streamline processes, reduce learning curves, and promote broader implementation in the industry.

BIM enhances TCO optimization by improving cost estimation accuracy and supporting decision-making during the design and construction phases. A framework for calculating TCO using BIM has also been proposed, focusing on both hard and soft costs to help stakeholders understand the financial implications of their investments (Smith, 2016). Prior research has explored various aspects, such as integrating BIM with Life Cycle Cost Analysis to assess both initial and long-term costs, including operational and maintenance expenses (McNeil-Ayuk and Jrade, 2024). Additionally, Rashidi et al. (2024) research on pre-tender cost estimation demonstrates how BIM models incorporate time and cost dimensions to improve project budgeting. However, although significant progress has been made in applying BIM to cost estimation, most existing research primarily emphasizes hard costs and operational expenses. Discussions on soft costs remain fragmented and lack a comprehensive framework for integration within BIM. This underscores the need for further investigation into how BIM can be used to estimate better and manage soft costs, a critical yet often overlooked component of TCO in construction projects.

2.4 Prior review works on soft cost, construction projects, and BIM.

Tayefeh Hashemi et al. (2020) conducted a systematic review of cost estimation in construction projects from 1985 to 2020. It emphasized the importance of early estimation for project success. Various techniques were proposed, focusing on identifying critical SCEs and their impact on accuracy, with regional differences being crucial. Machine learning methods, such as Artificial Neural Networks (ANN) and Regression Analysis (RA), were popular. Hybrid models that combine ANN with other methods have shown promise. The research advised careful consideration of input data for ANN and highlighted the significance of expert knowledge. Building and highway projects received the most attention, with different approaches categorized. The research offered practical tips for using machine learning models in construction projects.

Ma et al. (2022) conducted a systematic review of factors influencing the pricing of recycled concrete, placing particular emphasis on SCEs. The research identified fifteen key factors influencing pricing, with a focus on how SCEs impact overall expenses. It highlights the substantial role of formwork activities in contributing to soft costs and introduces a framework for evaluating and selecting formwork systems to mitigate these costs. The research includes a case study validating the model's effectiveness in cost estimation, underscoring the need to consider SCEs, especially those related to potential failures in formwork systems. The research offers valuable insights into improving decision-making and budgeting by effectively estimating SCEs associated with construction projects. Abu Dabous et al. (2022) conducted a literature review on BIM implementation in construction projects. The research highlights that organizations hesitate to invest despite recognized benefits due to perceived high costs and a lack of empirical evidence. However, ROI was limited in capturing all costs and benefits. Cost-benefit analysis emerged as a solution for evaluating intangible benefits and soft costs. Challenges include confidentiality of cost data and project tracking (Farouk *et al.*, 2025).

2.5 Research gap and study positioning

This subsection synthesizes the existing literature to demonstrate the current state of knowledge and to position the need for this study. Previous research on BIM has noted the absence of standardized definitions for soft costs, which complicates accurate estimation and reduces comparability (Zahirah et al., 2013; Zahirah and Abidin, 2012). Other research on soft costs in construction projects, including case-based analyses, has shown that actual soft costs are often higher than reported in the literature, indicating persistent risks of underestimation (Saini et al., 2021). Research that links BIM with cost estimation has advanced the integration of design, scheduling, and cost data, yet discussions of soft costs remain fragmented and largely descriptive, with little effort to structure them within a consistent framework (Shehab and Abdelalim, 2023; Rashidi et al., 2024).

In summary, while prior research has examined aspects of soft costs in construction projects and the role of BIM in cost estimation, they have not produced a systematic and validated framework that explicitly categorizes SCEs in BIM-based construction projects. This missing framework constitutes the core research gap, as it limits cost predictability, ROI assessment, and informed decision-making in BIM implementation. Therefore, this study aims to address this gap by developing and validating a framework for SCEs in BIM-based construction projects.

3. METHODOLOGY

To achieve the study's aim and address its three research objectives, this study employed a structured three-phase methodology. The first phase, which corresponds to the first objective of identifying SCEs in BIM-based construction projects, involved conducting an SLR, followed by a thematic analysis to extract and categorize relevant SCEs. The second phase aligns with the second objective of developing a framework for SCEs, and was carried out using framework analysis to systematically organize the identified elements according to project phases and time categories. The third phase corresponds to the third objective, which aimed to validate the developed framework. This was achieved through expert validation, involving face-to-face interviews with BIM professionals to refine and confirm the framework. This structured methodological approach ensures alignment between the study's aim, objectives, and methods. As the data collection and expert validation were conducted at a single point in time, the study adopts a cross-sectional design, which provides a reliable snapshot of current practices but does not capture longitudinal changes in BIM implementation or soft cost structures. The overall methodology is illustrated in Figure 1.

3.1 Phase 1: Systematic Literature Review and Thematic Analysis

The first part of this phase involves an SLR consisting of four steps: (A) article identification, (B) screening process, (C) eligibility check, and (D) snowballing. This is followed by a thematic analysis to extract and organize the identified SCEs.

(A) Article identification

The search was conducted on July 22, 2024, in two major indexing databases, Scopus and Web of Science, using advanced search features to capture peer-reviewed articles related to SCEs in construction projects. Records retrieved from the two databases were merged, and duplicates were removed by matching title and DOI, yielding 149 unique articles that were carried forward to the screening stage.

To ensure consistency and replicability, explicit inclusion and exclusion criteria were applied. The inclusion criteria were: (i) articles published in peer-reviewed journals, (ii) written in English, (iii) focused on the architecture, engineering, and construction (AEC) industry, and (iv) explicitly mentioning "soft cost" or "indirect cost" in the title, abstract, or keywords. The exclusion criteria were: (i) conference proceedings, book chapters, and non-peer-reviewed sources; (ii) non-English publications; and (iii) articles outside the AEC industry or using broader financial terms (e.g., overheads) without specific relevance to soft costs.

These criteria were selected to maximize methodological rigor and comparability across articles while reducing the risk of misclassification. Peer-reviewed journals were prioritized because they undergo more stringent quality control than other sources. English-language restrictions ensured accuracy of interpretation and followed established practice in SLRs in construction project management, where English is the dominant academic language. Restricting the scope to the AEC industry avoided definitional inconsistencies common in finance or peripheral domains. Finally, narrowing the search terms to "soft cost" and "indirect cost" reduced false positives while ensuring alignment with widely recognized descriptors in the literature (Zahirah & Abidin, 2012; Abidin & Azizi, 2021). Together, these measures enhanced the reliability of the inclusion/exclusion process and provided a transparent and replicable foundation for subsequent screening.

(B) Screening process

In step two, a title and abstract screening was conducted to narrow down the 149 unique articles. Articles were excluded if they (i) did not explicitly address SCEs in construction projects, (ii) focused exclusively on hard costs, operational/maintenance costs, or unrelated financial topics. Only articles that directly examined or discussed SCEs in construction were retained. Applying these criteria reduced the pool from 149 to 28 articles, which were then carried forward to the full-text eligibility check.

(C) Eligibility check

In the third step, the same inclusion and exclusion criteria were applied, but at the full-text level rather than at the title and abstract screening stage. This distinction is important because some articles appeared relevant based on their abstracts but, upon closer examination, did not meet the eligibility standards. For example, several articles mentioned soft costs only in passing, without providing substantive analysis. Others lacked sufficient methodological detail to support systematic synthesis, and some focused on domains outside the AEC industry, despite using overlapping terminology. The full-text eligibility check therefore functioned as a quality and relevance filter, ensuring that only articles with rigorous methods and direct relevance to BIM-related SCEs in construction projects were retained. As recommended by PRISMA 2020 guidelines, each full-text article was independently reviewed against the criteria by two researchers to minimize bias. Discrepancies were resolved through discussion until consensus was reached. This process reduced the dataset from 28 articles to 8 eligible articles, which were then advanced to the synthesis stage.

(D) Snowballing

Due to the limited number of articles, the snowballing technique was conducted to find possible articles outside the search results (Moher *et al.*, 2015). In this step, both forward and backward snowballing techniques were employed. Snowballing is a frequently used method to find related articles on a topic beyond the original search results, particularly when a limited number of articles have been identified from the SLR. This technique helps to broaden the scope of the SLR and locate articles that may not have been discovered through the original search. Forward snowballing involves exploring the citations. In contrast, backward snowballing entails examining the references. The snowballing process consisted of four rounds until no additional articles were found, indicating that saturation had been achieved. This study involved four rounds of snowballing, during which six additional articles were identified, bringing the total number of identified articles to 14.

Thematic Analysis

After identifying relevant articles, thematic analysis was employed to discern patterns, themes, and subthemes within the data. Thematic analysis is a comprehensive qualitative method for data interpretation, and it can be used to analyze SLR data (Vaismoradi and Snelgrove, 2019). The thematic analysis involved six key steps:

- Familiarization with Data: The process began with a thorough review of the data from the selected articles. This step involved reading and re-reading the content to identify all potential SCEs mentioned in the literature.
- Generating Initial Codes: Next, the raw textual data from the included articles was systematically coded for further analysis
- Searching for Themes: Following the initial coding, the subthemes were grouped into broader themes. This step involved identifying patterns that captured the various dimensions of SCEs.
- Reviewing Themes: The identified themes were then reviewed to ensure they accurately reflected the data. This step involved refining and adjusting the themes for coherence and relevance. SCEs unrelated to BIM-based or conventional construction projects and those that could not be estimated were excluded. Repetitive or synonymous items were merged to streamline the analysis. This refinement ensured that the final themes provided a coherent and representative structure of the literature-derived SCEs.
- Defining and Naming Themes: Once reviewed, themes were clearly defined and named to capture their essence. This ensured that each theme was distinct and made a meaningful contribution to the analysis.
- Producing the Final Report: The final themes were synthesized to address the research questions. The thematic analysis resulted in the identification of 31 SCEs, which were grouped into four main themes: budget and design, subcontractors, permits and fees, and site work.

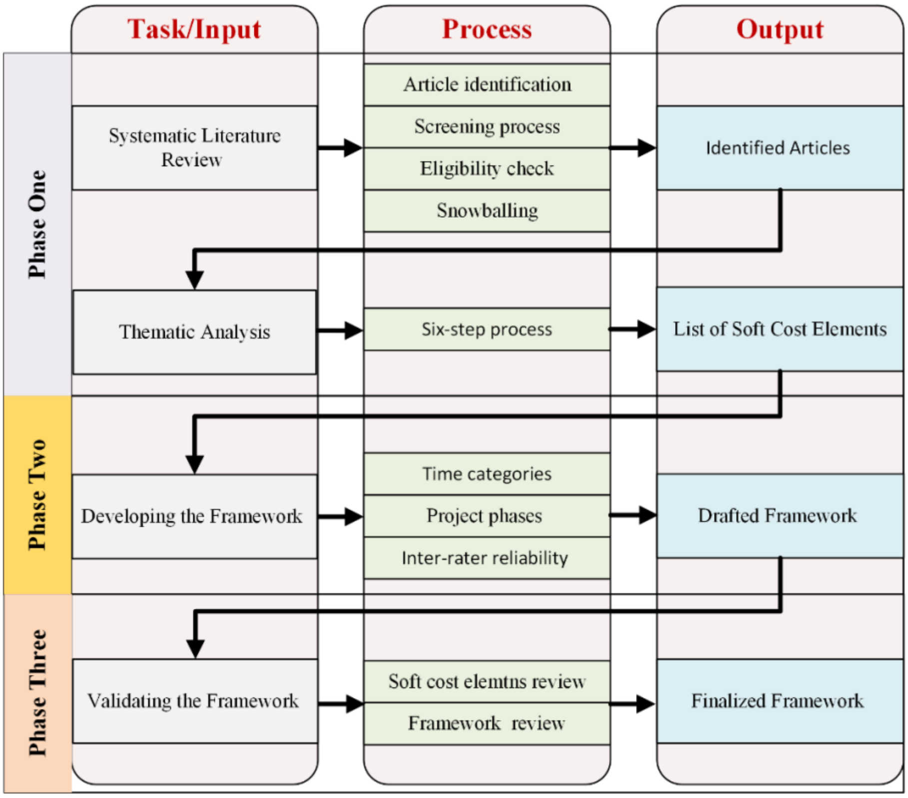


Figure 1: Research flowchart.

3.2 Phase 2: Developing the Framework

Next, framework analysis was used to develop the framework for SCEs in BIM-based construction projects. Framework analysis is a systematic approach to qualitative data analysis that is particularly well-suited to policy, management, and applied research, such as construction project management, as it enables structured categorization of complex qualitative data (Egwim et al., 2022). In this study, framework analysis allowed the categorization of SCEs through systematic comparison across project phases and time elements. The framework was drafted by combining the study objectives with the results of the thematic analysis. In this draft, relationships between SCEs, project phases, and time categories were explored to identify recurring patterns. The framework was organized into two main dimensions: (i) project phases (planning, preconstruction, and construction) and (ii) time categories (discrete versus continuous). Each SCE was allocated within this two-dimensional structure, which provides clarity on not only what costs occur, but also when and how they occur.

To illustrate, planning-phase SCEs, such as drawings and energy modeling, were categorized as discrete because they occur at specific milestones or only once. In contrast, BIM coordination was categorized as continuous, reflecting recurring costs throughout project development. Preconstruction-phase SCEs included items such as testing materials or development charges, which are discrete, whereas materials engineering support may be continuous across multiple project stages. Construction-phase SCEs, such as safety engineers, were also classified according to this logic. A small sample of the framework is presented in Table 1 to illustrate the organization and provide readers with a reference point for understanding how the SCEs are positioned. To ensure reliability, two researchers were independently assigned to categorize 15% of the SCEs within the framework. Their results were then compared, producing an inter-rater reliability score of 81.3%, which is considered acceptable for qualitative coding. This confirmed that the drafted framework was both robust and replicable, and it therefore served as the basis for the subsequent validation stage

Table 1: Sample organization of SCEs by project phase and time category.

Project Phase	Discrete SCEs (occur once)	Continuous SCEs (recur throughout project)
Planning	Drawings; Energy modeling; Landscape architecture	BIM coordination (design team meetings, updates)
Preconstruction	Development charges; Levy fees; Testing materials	Materials engineering support; BIM model updates
Construction	Certification costs; Commissioning	Safety engineer; Ongoing site coordination

3.3 Phase 3: Validating the Framework

The final stage involved validating the drafted framework. To ensure consistency and clarity, a validation package was prepared for the experts. This package included the draft framework of SCEs organized by project phase and time category, standardized definitions of each element, explanatory notes with examples, and a structured feedback form. Experts were asked to classify each SCE as "retain," "revise," or "remove," and to provide justifications for their choices. Open-ended questions allowed them to suggest additional SCEs not captured in the initial framework. This preparation ensured that all items were clearly defined and that the validation process was systematic and transparent.

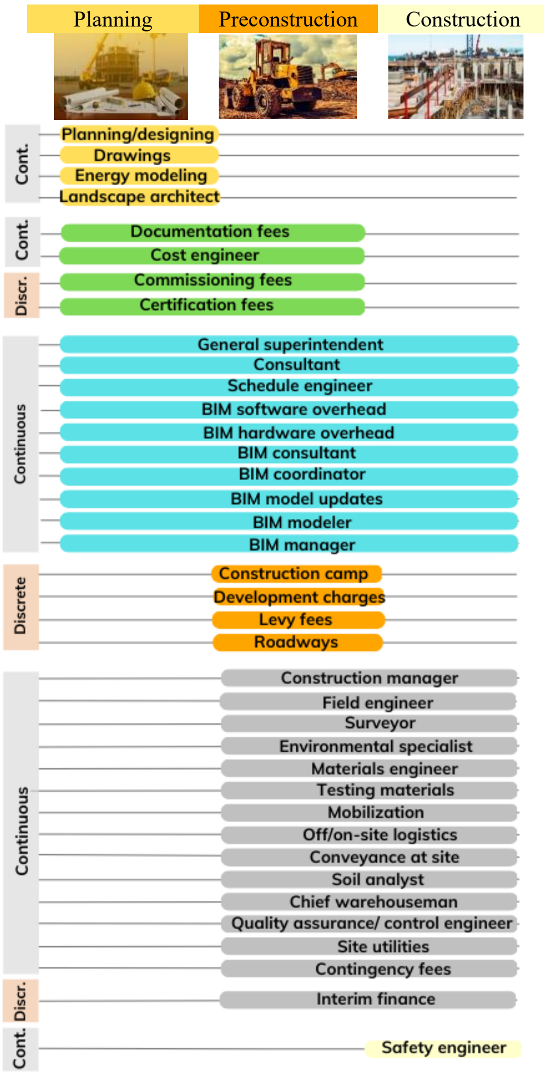
Experts were purposively selected based on three criteria: (i) at least five years of professional experience in the AEC industry, (ii) direct involvement with BIM processes or management, and (iii) representation across multiple sectors, including contractors, consultants, academia, and government. This approach ensured diversity of perspectives and practical expertise. In total, 20 experts were invited and 16 participated, which aligns with prior validation processes in construction project management research where 10–20 experts are considered sufficient to achieve meaningful consensus. Data were collected through face-to-face interviews, during which experts individually reviewed the validation package and recorded their responses.

Collected feedback was analyzed in three steps. First, responses were compiled to identify areas of agreement and disagreement. Consensus was defined as at least 75% of experts confirming or accepting a given SCE, a threshold consistent with prior expert-based research. In cases of disagreement, clarifications were discussed until consensus was reached. As a result, generic items deemed too broad (e.g., "general administration fees") were excluded. At the same time, new industry-specific elements, such as BIM coordinator costs, BIM model update costs, and energy-modelling costs, were added. Data saturation was achieved when no further new items were proposed. To further strengthen robustness, the consensus process was triangulated with the inter-rater reliability test from the framework analysis, which showed 81.3% agreement between two independent researchers. This combination of expert validation and reliability testing confirmed the comprehensiveness and robustness of the final framework, which consists of 38 SCEs.

Table 2 summarizes the profiles of the 16 experts, including their positions, educational background, fields of expertise, years of industry experience, and organizational backgrounds. Most had expertise in civil engineering, with others from project management, architecture, and construction technology. Over half possessed more than ten years of industry experience, and all had at least five years of experience with BIM. The sample included professionals from consultancy, contracting, academia, and government, ensuring diverse and representative perspectives for the validation process.

4. RESULTS

Table 3 displays the SCEs for BIM-based construction projects, their definitions, themes, related project phases, and time categories. Furthermore, Figure 2 presents the framework of the SCEs for BIM-based construction projects, organized by project phases and time categories. The following subsections present the results organized by theme, project phase, and time category.



Cont. Stand for continuous Discr. Stands for discrete

Figure 2: Soft-cost framework according to BIM construction phases.

Table 2: Profile of the BIM experts.

No	Designation and Position	Educational Background	Field of experience	Organization Background	Organization Location	Working experience	
						AEC industry	BIM
1	Construction Engineer	Master	Building and Construction	Contractor	Kuala Lumpur	1-5 years	1 > year
2	Head of BIM	Bachelor	Civil Engineering	Government	Kuala Lumpur	> 20 years	> 20 years
3	BIM Coordinator	Master	Interior Designer	Consultant	Pahang	6-10 years	6-10 years
4	CREAM SME	PhD	Civil Engineering	Contractor	Selangor	> 20 years	> 20 years
5	Senior Lecturer	Master	Civil Engineering	Academic	Johor	11-15 years	6-10 years
6	Senior Lecturer	Master	Civil Engineering	Consultant	Selangor	6-10 years	6-10 years
7	BIM Director	Master	Quantity Surveying	Consultant	Kuala Lumpur	> 20 years	> 20 years
8	BIM Engineer	Bachelor	Civil Engineering	Consultant	Kuala Lumpur	1-5 years	1-5 years
9	BIM Manager	Diploma	Architecture	Consultant	Selangor	> 20 years	> 20 years
10	Director	Master	Architecture	Consultant	Selangor	16-20 years	11-15 years
11	BIM Manager	Bachelor	Architecture	Developer	Kuala Lumpur	6-10 years	6-10 years
12	BIM Coordinator	Diploma	Building and Construction	Consultant	Putrajaya	11-15 years	11-15 years
13	Architect	Master	Architecture	Consultant	Putrajaya	1-5 years	1-5 years
14	Consultant	Bachelor	Civil Engineering	Consultant	Selangor	11-15 years	11-15 years
15	BIM Manager	Bachelor	Civil Engineering	Contractor	Selangor	6-10 years	6-10 years
16	General Manager	Bachelor	Land Surveying	Consultant	Kuala Lumpur	11-15 years	6-10 years

Table 3: The final soft cost elements in BIM-based construction projects.

No	Elements (subthemes)	Themes	ty / Item	Time	Phase/s			Source
					1	2	3	
1	Conveyance at site	Site Work	Moving objects from one location to another using mechanical or physical means	Continuous		✓	✓	SLR
2	Mobilization	Site Work	Carry out specific preliminary tasks required before starting construction	Continuous		✓	✓	SLR
3	Off/on-site logistics	Site Work	Plan the movement of people off and on construction sites	Continuous		✓	✓	SLR
4	Testing materials	Site Work	Inspect each structural material that will be used in the construction project.	Continuous		✓	✓	SLR
5	Construction camp	Site Work	A building or group of buildings for residential use while the project is carried out	Discrete		✓		SLR

No	Elements (subthemes)	Themes	ty / Item	Time	Phase/s			Source
					1	2	3	
6	Roadways at the construction site	Site Work	Construct roads on the construction site	Discrete		✓		SLR
7	Site utilities	Site Work	Electricity, gas, water and sewage, and communications services	Continuous		✓	✓	SLR
8	Drawings costs	Site Work	Cost of Design drawings in the construction project	Continuous	✓			SLR
9	Energy modeling	Site Work	Costs for the simulation of project designs	Continuous	✓			SLR
10	Planning/designing	Site Work	A process a construction manager uses to lay out how they will manage and execute a construction project, from building design to completion.	Continuous	✓			SLR
11	Interim finance	Permits & Fees	Funding for a project on a short-term basis	Discrete		✓	✓	SLR
12	Development charges	Permits & Fees	Fees collected from local authorities at the time of a building permit to help pay for infrastructure costs	Discrete		✓		SLR
13	Certification fees	Permits & Fees	Certification of confirmation that the construction plans and development specifications are consistent with the development consent and comply with the local building code and other requirements	Discrete	✓	✓		SLR
14	Commissioning fees	Permits & Fees	Commissioning fees amount to approximately 0.6 to 1.8% of the overall construction cost for the project	Discrete	✓	✓		SLR
15	Contingency fees	Permits & Fees	A certain amount of money is set aside to cover any unexpected costs that may arise during a construction project.	Continuous		✓	✓	SLR
16	Levy fees	Permits & Fees	Calculated % of the contract sum	Discrete		✓		SLR
17	Documentation fees	Permits & Fees	Fees, costs, and expenses incurred by the developer in connection with drafting and negotiating	Continuous	✓	✓		SLR
18	Environmental specialist remuneration	Subcontractors	Ensure that construction projects comply with relevant environmental regulations and meet established targets.	Continuous		✓	✓	SLR
19	Chief warehouseman remuneration	Subcontractors	Expedite the receipt and shipping of goods, and ensure efficient and organized storage.	Continuous		✓	✓	SLR
20	Field engineer remuneration	Subcontractors	Inspect and install equipment, direct on-site crews or workers, conduct research, and report on project status.	Continuous		✓	✓	SLR
21	General superintendent remuneration	Subcontractors	Oversee virtually every aspect of a given project, including safety, scheduling, and financials.	Continuous	✓	✓	✓	SLR
22	Landscape architect remuneration	Subcontractors	Advise on, plan, design, and oversee the creation, regeneration, and development of the construction project.	Continuous	✓			SLR
23	Materials engineer remuneration	Subcontractors	Source, test, and assess the materials used in construction.	Continuous		✓	✓	SLR
24	Safety engineer remuneration	Subcontractors	Ensures all workers at a job site are safe	Continuous			✓	SLR

No	Elements (subthemes)	Themes	ty / Item	Time	Phase/s			Source
					1	2	3	
25	Soil analyst remuneration	Subcontractors	Provide information about its quality and structure for construction, agricultural, government, industrial, and scientific staff.	Continuous		✓	✓	SLR
26	Surveyor remuneration	Subcontractors	Create land surveying reports and calculate measurements and evaluations.	Continuous		✓	✓	SLR
27	Construction manager remuneration	Subcontractors	Collaborate with engineers to determine project specifications. Negotiating contracts with external vendors to reach profitable agreements. Obtain permits and licenses from authorities.	Continuous		✓	✓	SLR
28	Consultant remuneration	Subcontractors	Contribute their operational, strategic, or technical expertise to projects. They collaborate with clients to determine project parameters, develop project plans in line with business objectives, and assign project tasks and resources.	Continuous	✓	✓	✓	SLR
29	Cost engineer remuneration	Subcontractors	Provides estimates, cost control strategies, cost forecasting, investment appraisals, and risk analysis for construction projects.	Continuous	✓	✓		SLR
30	Quality assurance/control engineer remuneration	Subcontractors	Responsible for ensuring the quality of products and services produced on the construction site	Continuous		✓	✓	SLR
31	Schedule engineer remuneration	Subcontractors	Carry out planning and scheduling functions during all stages of the project.	Continuous	✓	✓	✓	SLR
32	BIM modeler remuneration	Subcontractors	Creates a three-dimensional visual plan for a project using BIM software.	Continuous	✓	✓	✓	Respondents (4,15,16)
33	BIM coordinator remuneration	Subcontractors	Manage and organize multi-disciplinary teams in BIM-based construction projects according to the resources, the standards, and the company's procedures.	Continuous	✓	✓	✓	Respondents (2,4,8)
34	BIM consultant remuneration	Subcontractors	Accountable for the planning, construction, and management of the BIM-based construction project	Continuous	✓	✓	✓	Respondents (3,4,8,15,16)
35	BIM manager remuneration	Subcontractors	Overseeing and managing all BIM-related issues and ensuring their contribution to the project is maximized.	Continuous	✓	✓	✓	Respondents (2,4,8,15,16)
36	BIM software overhead	Budget and Design	Costs required to obtain the licenses and permissions for using BIM software	Continuous	✓	✓	✓	Respondents (2,3,4,8,15,16)
37	BIM model updates cost	Budget and Design	Costs due to the changes in the BIM models during the design phase	Continuous	✓	✓	✓	Respondents (3,8,16)
38	BIM hardware overhead	Budget and Design	Costs of hardware that is used during the designing phase	Continuous	✓	✓	✓	Respondents (2,16)

1=Planning, 2= Preconstruction, and 3= construction

4.1 Results according to themes

The final SCEs included 38 elements and were categorized into four themes: budget and design, subcontractors, permits and fees, and site work. The first theme is Budget and Design, which includes expenses related to planning/designing, updating BIM models, energy modeling, and drawings. Overhead costs for BIM software and hardware were also included in this theme. The second theme is Subcontractors, covering the remuneration for various specialists and engineers. This includes environmental specialists, chief warehousemen, field engineers, general superintendents, landscape architects, materials engineers, safety engineers, soil analysts, surveyors, construction managers, consultants, cost engineers, quality assurance/control engineers, and schedule engineers. Additionally, it encompasses the remuneration for BIM professionals, including BIM modelers, BIM coordinators, BIM consultants, and BIM managers. The third theme is Permits and Fees, which encompasses costs associated with permits and certifications, such as development charges, levy fees, documentation fees, certification fees, commissioning fees, Interim finance, and contingency fees. Finally, the fourth theme is Site Work, which encompasses site utilities, testing materials, construction camps, roadways at construction sites, site conveyance, mobilization, and on/off-site logistics.

4.2 Results according to project phases

Construction projects are often divided into four phases: planning, preconstruction, construction, and closeout. The planning phase involves defining the project's goals, outlines, and plans, typically through discussions among the owner, architect, and construction manager. The second phase, preconstruction, involves the architect preparing construction documents by translating the initial planning exercise into contract documents. These documents are then submitted for building permits and communicated to contractors to clarify the scope of the project. During the construction phase, the construction manager and contractor transition the project into actual construction. Finally, the closeout phase is crucial, as neglecting it can turn a successful project into a problem for the owner. Figure 2 represents the framework according to the construction phases. Some SCEs occur in a single phase, while others occur in two or three phases. The SCEs are arranged according to the project phases, starting with planning and ending with preconstruction and construction.

4.3 Results according to time categories

The framework also classifies SCEs according to time categories, distinguishing between discrete and continuous costs. In this context, discrete refers to SCEs that occur once or at specific milestones (e.g., certification fees, commissioning fees, levy fees). In contrast, continuous refers to SCEs that recur or accrue over an extended period (e.g., BIM coordination, software licensing, safety engineers). Although the term "duration" could be used, time categories are retained here because it is more consistent with established classifications in cost management and project control literature, which emphasize the recurrence pattern of costs rather than their absolute length (Egwim et al., 2022; Lu et al., 2021). Among the 38 validated SCEs, 31 were classified as continuous and 7 as discrete. These are distributed across different themes: in the Site Work theme, there are five continuous SCEs and two discrete SCEs (construction camps and roadways at the construction site). The Budget and Design theme comprises six continuous SCEs with no discrete items. Within the Permits and Fees theme, two continuous SCEs were identified alongside five discrete ones (interim finance, development charges, certification fees, commissioning fees, and levy fees). Finally, the Subcontractors theme includes 18 continuous SCEs and no discrete ones. This distribution indicates that discrete SCEs are primarily concentrated in the Permits and Fees and Site Work themes, whereas continuous SCEs are prevalent across all themes. It is worth noting that the final numbers (31 continuous, 7 discrete) happen to mirror the split between the SCEs identified initially from the SLR (31) and those added through expert validation (7). This is a coincidence, as the time categorization was conducted independently of the source of each SCE. Both literature-derived and expert-added SCEs are present across the discrete and continuous categories.

5. DISCUSSION

The discussion is structured according to how SCEs manifest across the project lifecycle. To provide clarity, the analysis begins with SCEs that occur in only one phase, followed by those that span two phases, and concludes with SCEs that recur across all phases. This sequence highlights the increasing continuity and persistence of costs as projects progress, allowing for a systematic comparison of how discrete and continuous costs emerge and accumulate over time. By presenting the findings in this order, the discussion mirrors the logic of the framework and guides the reader from isolated, phase-specific costs to those that cut across the entire BIM process.

5.1 One phase

These upcoming subsections discuss the SCEs that occur in only one phase.

5.1.1 Planning

During the planning phase of BIM-based construction projects, several SCEs are commonly encountered, including "planning/designing," "drawings," "energy modeling," and "landscape architecture." In a BIM context, planning and design costs typically cover fees for architects, engineers, and other professionals involved in producing and coordinating digital models and documentation. BIM enhances the design process by enabling better collaboration, clash detection, and visualization, which can influence both cost and efficiency. The preparation of digital drawings within a BIM environment also incurs costs associated with software tools and coordination efforts. Additionally, energy modeling—often integrated within BIM platforms—depends on project complexity, building type, required simulation detail, and the location of the modeling team (Construction Industry Development Board, 2019). Finally, landscape architecture costs include not only traditional design and planning fees, but also potential BIM-related coordination if the landscaping components are integrated into the overall model for visualization or simulation purposes.

5.1.2 Preconstruction

In BIM-based construction projects, the SCEs that occur during preconstruction include "construction camp," "materials engineer," "testing materials," "roadways at site construction," "levy fees," and "development charges." The cost of a construction camp depends on the project's size, duration, location, and the amenities included. The cost of materials engineering depends on the project's complexity and the extent of materials testing required. Roadway construction costs encompass the expenses for materials, equipment, and labor required to construct roadways at construction sites. Levy fees are charges that government agencies or other organizations impose on construction projects, typically paid during the preconstruction phase. Development charges are fees that local governments assess to fund the infrastructure needed to support new development, collected at the beginning of preconstruction (Zahirah and Abidin, 2012).

5.1.3 Construction

Moving to the final category, the construction phase is typically referred to as the execution phase, where all the planning and design efforts come to fruition, and the blueprints are transformed into reality. The only SCE associated with this phase is the "safety engineer." Safety engineers are professionals responsible for ensuring that construction projects are completed safely and in compliance with applicable regulations and standards (Lu *et al.*, 2021). They may be involved in conducting risk assessments, developing and implementing safety plans, providing safety training to workers, and monitoring and inspecting construction activities to ensure they are carried out safely. The cost of hiring safety engineers for construction projects is determined based on the engineer's experience, qualifications, and level of responsibility.

5.2 Two phases

In the following subsections, SCEs that occur in two phases are discussed. As in Figure 2, several SCEs occur during planning and preconstruction, as well as during preconstruction and construction.

5.2.1 Planning and preconstruction

SCEs that occur during planning and preconstruction include "documentation fees," "commissioning fees," "certification fees," and "cost engineer." These phases involve developing a strategic plan, finalizing the design, obtaining necessary permissions and entitlements, and assembling the required labor and resources. The primary expenses in these phases include documentation, commissioning, and certification fees, which are typically paid before construction commencement. Delays in this phase can cause disruptions in subsequent phases, as seen during the COVID-19 pandemic when documentation approval processes were delayed, leading to construction project shutdowns. However, the uncertainties associated with the pandemic were incorporated into project scheduling and cost estimation (Rani *et al.*, 2022). Cost engineering is the process of estimating and managing the costs of construction projects, and cost engineers are responsible for this process.

5.2.2 Preconstruction and construction

The SCEs that occur during the preconstruction and construction phases include “field engineer,” “environmental specialist,” “surveyor,” “materials engineer,” “material testing,” “mobilization,” “off/on-site logistics,” “soil analyst,” “chief warehouseman,” “quality assurance/control engineer,” “conveyance at site,” “site utilities,” “interim finance,” “construction manager,” and “contingency fees.” Most SCEs are closely associated with construction sites. Environmental specialists are responsible for ensuring that construction activities comply with relevant environmental regulations and standards. Surveyors, on the other hand, are responsible for surveying and mapping land. The costs of materials engineers and material testing depend on the test types, sample complexity, sample quantity, and location. Materials engineers are responsible for testing materials and goods on-site during both pre-construction and construction phases. Soil analysts conduct the primary soil analysis at construction sites. The cost of soil analysts depends on type of analyses, location, and number of samples. Quality assurance/control engineers ensure that materials meet suitability and quality standards before use or transfer to chief warehousemen and material engineers, and also verify that the BIM-based construction project meets project owner requirements throughout the project lifecycle. Construction managers' primary tasks include developing a schedule and budget, coordinating the procurement of materials and equipment, supervising and directing the work of other construction professionals, monitoring project progress, and identifying and mitigating potential risks. Several additional costs are associated with these two phases, including conveyance costs for transporting materials and equipment to and from construction sites, site utility costs for installing and maintaining services like electricity, water, and sewerage, interim financing costs for funding the project during construction, and contingency fees reserved to cover unexpected expenses, such as cost overruns or delays (Abu Dabous *et al.*, 2022).

5.3 Three phases (All)

The SCEs that occur in all three phases include "General superintendent," "Consultant," "Schedule engineer," "BIM Software overhead," "BIM hardware overhead," "BIM consultant," "BIM coordinator," "BIM modeler," "BIM model updates," and "BIM manager." The consultants and BIM consultants are responsible for facilitating the processes in construction projects. Therefore, project owners must select consultants with appropriate organizational BIM capabilities. Consultants impact project quality, cost, duration, and value. On the contrary, schedule engineers are responsible for developing project schedules. Ineffective planning and scheduling are the main reasons for project delays. BIM hardware, software, and managers are continuous SCEs within and across all BIM-based construction projects. These costs are ongoing because they are essential for maintaining and operating the BIM environment, ensuring continuous access to up-to-date tools and systems. Additionally, BIM modelers and BIM model updates are continuous SCEs, as the information models are updated periodically throughout all project phases. BIM coordinators are responsible for coordinating BIM processes, solving soft and hard clashes, and ensuring that information models, drawings, and data are well-organized (Tayefeh Hashemi *et al.*, 2020).

5.4 Comparison with construction projects without BIM

Table 4 presents a comparison between the identified SCEs in this study and those reported in prior research on construction projects without BIM. The study findings demonstrate symmetries of the identified SCEs between construction projects with and without BIM. Specifically, of the 38 SCEs identified, 31 are also found in construction projects without BIM, highlighting their relevance across different project types. For instance, SCEs such as “conveyance at the site,” “off/on-site logistics,” and “mobilization” have been acknowledged as SCEs in both general construction projects and specialized projects like bridge deck construction (Said *et al.*, 2009). Similarly, “documentation fees,” “certification fees,” and “contingency fees” are consistently identified across multiple research as SCEs, underscoring their importance in ensuring smooth project execution (Zahirah *et al.*, 2013). The inclusion of SCEs, such as “environmental specialist remuneration” and “landscape architect remuneration,” further illustrates the alignment of these findings with green projects, where environmental and design considerations are paramount. Notably, seven SCEs were derived explicitly from interviews with BIM experts.

Table 4: Soft cost elements alignment with construction projects.

Soft cost elements	This study	[1]	[2]	[3]	[4]	[5]	[6]
Conveyance at site	√	√	-	-	√	-	-
Mobilization	√	-	√	-	√	-	-
Off/on-site logistics	√	√	-	-	√	-	-
Testing materials	√	√	√	-	-	-	-
Construction camp	√	√	√	√	√	-	-
Roadways at construction site	√	√	√	-	√	-	-
Site utilities	√	√	√	√	-	-	-
Drawings costs	√	-	-	-	√	√	-
Planning/designing cost	√	-	-	√	√	√	-
Interim finance	√	√	-	√	√	√	√
Development charges	√	-	-	√	√	√	√
Certification fees	√	√	-	√	√	√	√
Commissioning fees	√	√	√	-	√	√	√
Contingency fees	√	√	√	√	√	√	√
Levy fees	√	√	√	√	√	√	√
Documentation fees	√	√	√	√	√	√	√
Environmental specialist remuneration	√	√	√	√	-	√	√
Chief warehouseman remuneration	√	√	√	-	-	-	√
Field engineer remuneration	√	√	√	-	-	-	√
General superintendent remuneration	√	√	√	-	-	-	√
Landscape architect remuneration	√	√	√	√	-	√	√
Materials engineer remuneration	√	√	√	-	-	-	√
Safety engineer remuneration	√	√	√	-	-	-	√
Soil analyst remuneration	√	√	√	√	-	√	√
Surveyor remuneration	√	√	√	√	-	-	√
Construction manager remuneration	√	√	√	-	-	√	√
Consultant remuneration	√	√	√	√	√	√	√
Quality assurance/control engineer remuneration	√	√	√	-	√	√	√
Schedule engineer remuneration	√	√	√	-	-	-	-
BIM modeler remuneration	√	-	-	-	-	-	-
BIM coordinator remuneration	√	-	-	-	-	-	-
BIM consultant remuneration	√	-	-	-	-	-	-
BIM manager remuneration	√	-	-	-	-	-	-
BIM software overhead	√	-	-	-	-	-	-
BIM model updates costs	√	-	-	-	-	-	-
BIM hardware overhead	√	-	-	-	-	-	-
Energy modeling costs	√	-	-	-	-	-	-
Cost engineer remuneration	√	-	-	-	-	-	-

√ = Content related to cost, - = Content unavailable

[1]: (Saini *et al.*, 2021), [2]: (Said *et al.*, 2009), [3]: (Azizi *et al.*, 2015), [4]: (Abidin and Azizi, 2021), [5]: (Azizi *et al.*, 2018), [6]: (Hu and Skibniewski, 2021)

5.5 Comparison with existing standards and guidelines on BIM

Table 5 presents a comparison between the newly identified SCEs and existing standards and guidelines on BIM. The comparison shows both symmetries and asymmetries in how the SCEs are classified. According to the British Standards Institution (BSI), RICS New Rules of Measurement (NRM), and the International Cost Management Standard (ICMS), certain SCEs are directly related to costs, and others are recognized as soft costs or tied to broader BIM standards (British Standards Institution (BSI), 2015; Williams, 2015; ICMS Coalition, 2021). For instance, BIM modeler remuneration is directly considered as a cost element across all three standards. However, the remuneration of BIM coordinators and consultants is recognized as a hard cost element in BSI and an SCE in

NRM and ICMS. BIM manager remuneration follows a similar pattern. Additionally, SCEs such as BIM software and hardware overhead are considered cost elements in ICMS but not in BSI or NRM. At the same time, BIM model update and energy modeling costs are indirectly associated with costs in all three standards, although they are directly related to BIM processes. This study emphasizes the need to reconsider how these SCEs are categorized within construction and BIM standards by identifying and classifying these SCEs as contributors to the soft costs in BIM-based construction projects.

Table 5: BIM soft cost elements alignment with Construction and BIM standards & guidelines.

Element	This study	BSI	RICS NRM	ICMS
BIM modeler remuneration	√	√	√	√
BIM coordinator remuneration	√	√	x	-
BIM consultant remuneration	√	√	x	x
BIM manager remuneration	√	√	x	x
BIM software overhead	√	x	x	√
BIM model updates costs	√	x	x	x
BIM hardware overhead	√	x	x	√
Energy modeling costs	√	-	x	x
Cost engineer remuneration	√	-	√	-

√ = Content related to cost, x = Content related to other elements besides cost, - = Content unavailable

5.6 Theoretical Implications

By validating 38 SCEs and structuring them by both project phase and recurrence pattern (31 continuous, 7 discrete), this study provides researchers with a theory-ready taxonomy of BIM-related soft costs. This enables empirical models to move beyond generic overhead categories and examine BIM-specific remunerations (e.g., coordinators, consultants, modelers), digital overheads (e.g., software, hardware, model updates), and phase-bound items (e.g., design drawings, permits, commissioning fees) as distinct constructs. Future research can operationalize these SCEs into measurable variables, such as continuous coordination hours per month or discrete certification charges at milestones, and test their influence on budget variance, schedule risk, or ROI. The framework also allows comparative research across project phases, delivery methods, and scales by providing a consistent cost structure that is transferable to different datasets. Moreover, the phase–time distinction supports new theoretical exploration of learning curves and maturity effects in BIM, where recurring costs, such as model updates, may diminish with experience, while discrete costs remain fixed. Researchers can also use the taxonomy to design validated survey instruments, construct panel datasets, and run simulation models that distinguish between one-time and recurring digital coordination costs. In short, the framework transforms diffuse "soft costs" into structured, testable constructs, enabling hypothesis-driven research and cumulative theory building on the financial dynamics of BIM-based construction.

5.7 Practical Implications

The validated framework provides industry professionals with a structured tool that can be applied to project planning, budgeting, and cost control across all phases of a project. By distinguishing between continuous SCEs, such as BIM coordination, software licensing, and model updates, and discrete SCEs, such as certification or commissioning fees, project owners and quantity surveyors can develop more transparent and phase-specific cost plans. For example, in the planning phase, discrete items such as design drawings or energy modeling can be budgeted as one-off costs. In contrast, continuous items such as coordination meetings or consultant inputs can be monitored throughout multiple phases. During the preconstruction and construction phases, the framework helps allocate recurring expenses, such as BIM model updates or safety engineer costs, as continuous commitments. It also ties permit fees, levy fees, and commissioning charges to clear milestones. This phase–time integration allows procurement teams to prepare clearer contracts by identifying BIM-related roles, specifying expected update frequencies, and allocating digital overheads transparently. During delivery, project managers can track continuous costs on a monthly or quarterly basis and confirm discrete costs after specific stages, which improves variance analysis, strengthens forecasting, and makes ROI assessments more reliable. By linking SCEs to both recurrence patterns and project phases, the framework enables organizations to anticipate exactly when costs will arise, manage risks proactively, and ensure that BIM-related expenditures are recognized and controlled throughout the entire project lifecycle.

5.8 Managerial Implications

Project managers can use the framework to enhance the planning and control of BIM-based construction projects by linking SCEs to specific project phases and recurring patterns. For example, discrete costs such as development charges, certification fees, or commissioning can be allocated directly to the planning or closeout phases, ensuring these one-off items are budgeted against clear milestones. Continuous costs, such as BIM coordination, safety engineers, or recurring model updates, can be integrated into monthly monitoring systems during the design and construction phases, enabling managers to track resource use in real-time. The framework also highlights SCEs that extend across two or more phases, such as BIM manager remuneration or ongoing software licensing, which managers can now treat as recurring commitments throughout the project lifecycle rather than isolated line items. By adopting this phase- and time-based classification, project managers can establish realistic staffing curves for BIM roles, allocate contingency funds more precisely, and enhance reporting by distinguishing between milestone-based expenditures and ongoing commitments. This enables more accurate variance analysis, tighter budget discipline, and better alignment of contracts with actual project needs.

5.9 Societal Implications

At the societal level, the framework enhances transparency and accountability in the costing and delivery of BIM-based construction projects. By explicitly distinguishing between continuous soft costs, such as BIM coordination, model updates, and software licensing, and discrete costs, such as levy fees, commissioning, and certification, public agencies and regulators can require project reports that reflect both capital expenditure and recurring digital commitments across phases. This reduces the likelihood of hidden or underestimated costs being transferred to taxpayers and enhances the credibility of public investment. The recognition of BIM-specific remuneration categories, including BIM coordinators, modelers, and consultants, also provides a foundation for professional certification and targeted workforce training programs that strengthen employability and raise industry productivity. By linking soft costs to project phases, policymakers and funding agencies can benchmark national projects more consistently, comparing not only overall budgets but also the timing and recurrence of digital overheads. This contributes to the better governance of infrastructure investments and supports Sustainable Development Goals 9 on Industry, Innovation, and Infrastructure and 12 on Responsible Consumption and Production by reducing late design changes and material waste. Embedding these findings into procurement standards creates more consistent benchmarking across projects, strengthening trust between owners, regulators, and society while contributing to the resilience and sustainability of the built environment.

5.10 Limitations and Future Directions

This study has several limitations that need to be acknowledged. Firstly, the SLR identified a relatively small sample size of 13 articles, which may constrain the breadth of findings, since much of the existing research focuses on broader construction trends, such as green buildings, rather than BIM-related soft costs. To address the limited pool of literature, both forward and backward snowballing techniques were applied, and expert consultations were used to validate and enrich the dataset.

Secondly, the framework has not yet been applied to real-world BIM-based construction projects. Implementing it in real-world projects will provide key findings and insights into its effectiveness and implications, and help identify the challenges or barriers that industry practitioners may face in implementing and adopting the framework. Although the framework was not applied in real-world projects, it was validated by experts, which ensures its validity.

Thirdly, the cross-sectional research design means that the framework does not yet incorporate formal mechanisms for continuous improvement based on ongoing feedback and evolving industry practices. This is a limitation given the rapid pace of change in both BIM processes and construction technologies. Nonetheless, the framework is designed for extended use because its structure, which classifies soft costs by project phase and by recurrence pattern (continuous versus discrete), is not tied to a single project type, software version, or regulatory environment. These two organizing dimensions are stable features of construction projects, ensuring that the framework remains relevant even as new BIM tools, roles, or cost categories emerge. In practice, practitioners can extend the framework over time by adding new BIM-related soft costs within the same classification logic, making it a flexible tool that can evolve as the industry matures. Future research should therefore focus on establishing feedback loops, such as longitudinal case studies or industry benchmarking, to refine and continually update the framework.

Lastly, this study concentrated exclusively on developing a framework for SCEs associated with BIM-based construction projects and did not explore key SCEs or other related aspects. Future research should focus on expanding the understanding of soft costs, particularly in estimating these costs and determining their duration. It is important to investigate the key SCEs in the framework to enhance the development process further. The improvement of the framework includes applying methodologies to help estimate soft costs, including diverse stakeholder perspectives, to ensure its comprehensiveness and relevance. This exploration can help refine the framework and improve its applicability across various project scenarios. The framework can be utilized to understand and manage the soft costs in BIM-based construction projects.

6. CONCLUSION

This study aimed to develop a framework for SCEs in BIM-based construction projects. To achieve this, the study pursued three objectives: identifying SCEs in BIM-based construction projects through an SLR and thematic analysis; developing a framework for these SCEs using framework analysis; and validating the framework with BIM experts. The SLR and thematic analysis identified a total of 31 SCEs in BIM-based construction projects. These elements were grouped into four main themes: budget and design, subcontractors, permits and fees, and site work. Framework analysis was then employed to structure these SCEs by project phases (planning, design, construction, post-construction) and time categories (discrete and continuous). The framework's reliability was confirmed with an 81.3% agreement between the two researchers. In the final stage, 16 BIM experts reviewed and refined the framework to ensure its relevance and comprehensiveness. The final framework was validated and adjusted based on expert insights.

This study delivers the first validated framework that explicitly incorporates BIM-specific SCEs and organizes them by project phase and time category. This originality advances the theoretical understanding of soft costs by extending them into the digital domain, while providing a practical tool that enables project owners and managers to budget more accurately, improve ROI assessments, and strengthen decision-making. Beyond its immediate application, the framework provides a foundation for further research, inviting empirical testing in real-world projects and exploring how soft costs evolve with the advancement of BIM practices and emerging digital tools.

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