BIM-Enabled Claims Management Concept: Implications for Dispute Avoidance and Management

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Abstract: Investigating the implications of integrating building information modeling (BIM) with claims management and the consequent effect on quantity surveying practices is essential for advancing digitalization and for avoidance of disputes in construction. Based on primary semistructured interviews with eight construction professionals in the UK and 48 peer-reviewed articles (secondary data), BIM's potential to enhance collaboration, improve cost estimation, and streamline claims management processes using text mining was studied. Text mining collocation analysis was applied using RStudio to elicit BIM and claims management concepts. The findings suggested that although BIM integration offers considerable benefits, challenges—such as resistance to change, lack of standardization, and the need for continuous upskilling—may hinder its full implementation. These findings contribute to the emerging need for as-built intelligent BIM with claims management operations in the construction industry from a theoretical perspective. BIM's potential to redefine the role of construction professionals such as quantity surveyors may engender a collaborative construction sector because of the efficiency it brings to the construction industry.

Author keywords: Building information modeling (BIM); Claims; Claims management; Construction industry; Dispute; Text mining; Quantity surveying.

Introduction

Persistent challenges in the construction industry have stemmed from the substantial impact of claims on project timelines, costs, and business relations (Shaikh et al. 2020; Bhatt and Bhavsar 2014). Resolving such claims is daunting due to complications arising from their presentation, assessment, and settlement (Khawaja and Mustapha 2021). Regrettably, existing contractual provisions often lack clear guidance for navigating these steps, and contracting parties' lack of awareness regarding these lacunae during the con- tract phase precipitates difficulties during construction. In addition, the adoption of technology in claims management has been quite slow-paced. Obsolete manual recordkeeping systems remain entrenched among most contracting parties, inevitably leading to the loss of records, which escalates the complexities of claims resolution (Carmichael and Murray 2006; Braimah 2013; Gangane et al. 2017). Preserving contemporaneous documents is frequently problematic, making data retrieval challenging and potentially jeopardizing the entire claims process due to missing vital evidence. Given these challenges, adopting building information modeling (BIM) with a common data environment surfaces as an imperative. Such a measure will result in the intricate details of the building facility being securely archived, ensuring swift retrieval of information and ensuring data quality and procedure through version and documentation management (Preidel et al. 2018; McNamara and Sepasgozar 2018). Furthermore, BIM allows for the automation of contract administration by establishing intelli- gent contracts that are intrinsically linked to the system (McNamara and Sepasgozar 2018). Moreover, the application of BIM has demonstrated a remarkable capability to identify potential claim causes at the project's commencement through BIM model run-throughs, identification of design conflicts, schedule perception that show ac- tivity paths/dependencies, numeric assent, and expense estimates (Al Shami 2018; Alghazali 2018).

Although research has been conducted to emphasize the impact of BIM in claims management, a knowledge gap still exists in the attribution of BIM-based claims management to quantity surveying practice. In this study, themes for merging BIM with claims management based on quantity surveyors' lived experiences, research perspectives, and the peculiarity of claims management to quantity surveying (QS) practice.

Literature Review

BIM adoption has been much slower than anticipated in construc- tion companies globally. Technical and managerial factors are two main reasons for the limited uptake (Azhar 2011). Giel and Issa (2013) and Obi et al. (2021) categorized factors affecting BIM adoption into technical and nontechnical strategic issues. The tech- nical reasons can be broadly classified into transactional business process evolution, computability of digital design information, and meaningful data interoperability (Azhar 2011). Challenges to BIM adoption further include lack of senior management support, cost of software and training, the scale of culture change required, other competing initiatives, lack of supply chain buy-in, staff resistance and information technology (IT) literacy, legal uncertainties, ownership and intellectual property, contractual arrangements, product liability risks, professional indemnity insurance, and authenticity (Eadie et al. 2014). Further barriers include nonexistent client demand, application interfaces, and standards. There are various challenges in adopting BIM, such as adapting existing workflows to lean-oriented programs, a clear understanding of responsibilities among teams, and a lack of understanding of the required high-end hardware resources (Arayici et al. 2012).

The multidimensional capacity of BIM (nD modeling) allows information to be added to a model, thereby enriching it (RICS 2015). This information can be scheduling (4D modeling), costing (5D modeling), sustainability (6D modeling), and growing (the terminology differs around the world) (RICS 2015). The multidimensional nature of BIM enables project parties to retrieve data from a single model, enabling collaborative working during a project (Ding et al. 2014). Traditionally, the fifth dimension (5D) is the dimension that stores data for estimating, and the fourth dimension (4D) stores scheduling data. This has triggered a new organizational practice in QS firms, altering traditional QS functions, which are error-prone, time-consuming, and tedious (Kehily and Underwood 2017). With 5D BIM application, a virtual meeting can be held to discuss changes and cost alterations between contracting parties immediately (Eadie et al. 2013). To explore the benefits of 5D BIM, a three-dimensional (3D) model must be prepared in conformance with a level of detail (LOD) of 300 and above (Mitchell 2012). The higher the LOD, the better the model's suit- ability to value variation, change orders, and progress payments (Smith 2017). This would reduce the possibility of errors, reduce project costs, and result in fewer claims.

The QS firm can decide to implement BIM as an innovative tool for working collaboratively, reducing the time spent on data analysis, improving services rendered, and removing the mundane elements of traditional practice (Zainon et al. 2016). However, practically, these decisions are crippled by several challenges, including the cost of BIM implementation, lack of client demand, a dearth of awareness of the benefits, skill shortages, contractual/ legal issues, and transformation and adaptation issues (Ahmed et al. 2018). The quantity surveying practitioners mostly use BIM for quantity takeoff and cost estimation (Mohammad et al. 2019; Soon et al. 2019; Babatunde et al. 2020). Despite the widespread use of BIM in the architectural engineering and construction (AEC) sector throughout the project span, especially in design and construction, BIM still needs to be utilized for claims management and dispute resolution. Experts in claims and forensic engineering investigations still hesitate to adopt BIM (Hammam and El-Said 2018). Therefore, a deficit in claims management function can negatively affect value creation for the client.

Moreover, the use of BIM in the early design and construction stages can incorporate contract conditions and cost data and extend to accommodate the claim dimension and produce as-planned and as-built designs through the update (Khawaja and Mustapha 2021). It is a powerful tool for overcoming various barriers in construction claims through 3D visualization, quantity takeoff (QTO), and effortless and accurate estimation of building quantities (Khawaja and Mustapha 2021). Practically, these functions can be optimized by quantity surveyors to manage claims provided there is adequate access to an up-to-date data repository.

The challenge is that the transition to BIM compliance is not easy to implement due to a lack of skills and a willingness to change from conventional practices. Therefore, a paradigm shift

in claims management services is far from becoming a reality. The takeaway from the foregoing is that it is important to be aware of the role of QS in construction cost management and that it seems to have evolved in rendering cost management services. According to Zainon et al. (2016), there is resistance among QS practitioners to the changes BIM brings. QS practitioners have a presumption of performance through the traditional job scope, which would eventually replace the profession in the construction market. This perception is only problematic when the effect is meted on unsuspecting clients who expect value for their money. Mundane practices emerge as a common barrier and become problematic when QS practitioners do not upskill to provide value-added service and become a burden formulated outside the core project production team.

Claims Management in the Construction Industry

Construction claims are considered inevitable due to the risks and complexities of projects and the divergent interests of contracting parties (Lu et al. 2015). Therefore, it is not a question of whether there will be claims but a question of how serious the claims will be, because 90% of project problems are linked to claims (Ekung et al. 2021). Construction disputes may arise from unresolved claims. Construction claims can be defined as a means by which a contractor or owner can recover unlawful extra costs incurred during a project or for poor execution by the contractor. A claim is a legal action against another party to obtain money or property or enforce a right protected by law. Claims management is, therefore, the pro- cess of employing and coordinating resources to move a claim from identification and analysis through to preparation and presentation and then to negotiation and settlement (Ren et al. 2001).

The concept of a construction claim is not new, but what has been lacking is a methodology that can help construction managers assess how effective their claim management process is (Bakhary et al. 2013). Some challenges in claims management are due to a deficit in automated systems such as BIM for managing the pro- cess. There have been few efforts toward developing effective tools to support claims management activities (Ren et al. 2001). It is, therefore, important to have an automated system such as BIM for auditing the claims process that enables collaboration and transparency between the contracting parties and supports legal arguments that will benefit the industry through amicable settlements (Dougherty 2015).

Contractors often act opportunistically through claims post- contract to recoup unrealistic bids made during the tendering stage, as shown in Fig. 1. Clients may refuse to give fair compensation even if a claim legitimate; this causes disputes that affect the relationships between parties. Organizations should, therefore, handle claims management as a management function like estimating, cost control, scheduling, and planning, because the profitability of a project depends largely on the ability of a contractor to use claims clauses easily.

Claims Identification and Evidence in the BIM Environment

Narrating evidence of a claim may fail to provide clarity and may confuse the liable party during negotiations. Therefore, claimants must present their evidence more convincingly (Likhitruangsilp et al. 2018). Using software-readable project data and computerized tools that present graphical illustrations of the construction process may positively impact claims resolution. Claims are mostly caused by uncertainties in design and construction; consequently, claims

can be reduced through the authenticity and verification provided by BIM recordkeeping and contract administration. BIM is a powerful tool for overcoming various barriers in construction claims through 3D visualization, QTO, and effortless and accurate estimation of building quantities (Khawaja and Mustapha 2021). Forensic information modeling (FIM), when applied to claims, uses BIM strategies to conduct forensic investigations of projects. FIM incorporates documents such as photos, project reports, and field notes, and thereby links structural geometry with project-related data (Guévremont and Hammad 2020; Khawaja and Mustapha 2021).

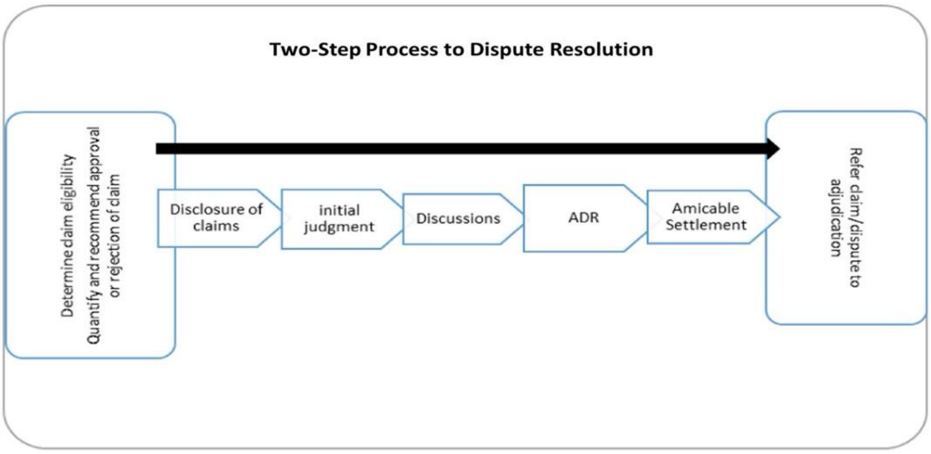


Fig. 1. Two-step process for dispute resolution (DR). (Adapted from Barakat et al. 2019.)

The BIM common data environment (CDE) and visualized environment can enable the storage and sharing of project documents and information and foster accuracy in the calculation of claims required as evidence in forensic delay analysis (FDA) (Guévremont and Hammad 2020; El-Samadony et al. 2020). Compared to the traditional approach, BIM provides 48% savings during claim preparation through the review and analysis of computer-aided de- sign (CAD) drawings, quantity surveying, and estimation of changes (Guévremont and Hammad 2020). A BIM visual reposi- tory can be used for resolving issues in the extension of time (EOT) process and design tracking by creating a plugin (add-in) using a Revit.NET application programme interface (API) and Solibri Model Checker (Ali et al. 2020). All information concerning a de- lay event can be centralized by integrating the model with the international foundation class (IFC) schema model (Hammam and El-Said 2018). BIM reduces disputes through clash analysis, early collision detection, solving incidents (Koc and Skaik 2014), and specifying cause and effect for other activities (El-Samadony et al. 2020). A BIM-based claims management system can be implemented by translating contract provisions into computable rules

(Shahhosseini and Hajarolasvadi 2021). BIM with adequate recordkeeping can assist with delay claims by providing easy ac- cess to coordinated contemporaneous project data and 4D and 5D visualizations of a project at the inception stage. With BIM, users can effortlessly visualize delays suffered and their consequences, obtain timely data, and project a true picture of a risk event (Koc and Skaik 2014). Early visual communication provided by the 4D can be used for claim avoidance during the planning stage of a construction project. Constructability analysis, simulation, visualization, and comparison of planned versus as-built projects can be used to validate contractual dates (Guévremont and Hammad 2018). BIM clarifies the scope of work, estimates errors, and detects potential change orders in a design at the tender stage.

In the design stage, it draws attention to poor design quality, constructability issues, and clash detection in interdisciplinary designs (Sabet et al. 2018). BIM can help manage conflicts during construction value engineering (Khawaja and Mustapha 2021). BIM 3D visualization, clash detection, coordination, and QTO can prevent causes of claims such as errors and design alterations, deficient drawings and specifications, coordination problems, excessive change orders, and incorrect quantities (Ibraheem and Mahjoob 2021). BIM simplifies the claims management process by identifying potential claims, enforcing information consistency, providing data storage, and facilitating improved collaboration (Ibraheem and Mahjoob 2021).

Method and Materials

This exploratory study of the integration of BIM and claims man- agement in the construction process was conducted using a survey strategy that relied on a purposive sampling approach. Semistructured interviews are particularly well-suited to this approach, because researchers ask follow-up questions designed to probe more deeply into issues of interest to the interviewees (Hancock and Algozzine 2006). Interviewees are invited to express them- selves openly and freely and to define the world from their perspectives, not solely from the researcher’s perspective (De Vaus and De Vaus 2013; Omotayo et al. 2020). Semistructured interviews, using interview schedules, often provide much of the primary data com- pared to the structured and unstructured options (Runeson and Höst 2009). The interviews were conducted formally and, with the respondents’ written consent, were recorded. The formal interviews were conducted online using Zoom video conferencing software version 5.16.10 (26186). The interviews lasted between 45 and 60 min. Respondents were allowed to skip questions that posed confidentiality concerns. All interviews were conducted in English; consequently, there was no need for interpretation or translation.

Next, interview responses were transcribed before analysis. Sequel to selecting semistructured interviews as a data collection method, some questions addressing the issues of BIM in claims management were drafted to achieve the research aims of the study. The qualitative questions were sent to research practitioners and academics for validation in a pilot study in order to ensure their suitability for achieving the research aims. Some questions were reviewed and corrected according to the comments.

Research participants were identified by drawing up a list of firms registered under the Royal Institute of Chartered Surveyors (RICS), a professional body in the UK. The list indicated the firms' services rendered and organizational compliance with BIM. Overall, eight (8) interviews were conducted as primary data. Forty-eight (48) articles were collected as secondary data to supplement the analysis. Primary and secondary data were analyzed through text mining. The process of extracting 48 articles from the Scopus database involved the exclusion criteria being 2000 to 2022 for all peer-reviewed articles. An initial search query yielded 337 articles, which were manually reviewed by the researchers for relevance to BIM and claims management concepts. The search query was as follows: "BIM AND claims AND management AND in AND construction; construction AND dispute AND resolution AND digitalization."

Text Mining: Collocations

Text mining is a machine learning (ML) tool in built environment research. Text mining derives valuable insights from vast amounts of textual data, including articles, policy documents, reports, and social media posts (Kumar and Paul 2016). This data-driven pro- cess has radically transformed how researchers approach the field of built environment research, offering them the ability to uncover hidden patterns, trends, and concepts within textual data. These in- sights can enhance the decision-making, planning, and policy development processes, fostering more effective and sustainable practices within the built environment. An integral aspect of text mining in qualitative data is collocation analysis. Collocations are combinations of words that occur more frequently within a specific context (Kumar and Paul 2016). This concept extends beyond individual words to sequences of words, allowing researchers to capture subtleties and nuances in language that single-word analysis might overlook.

Collocation analysis is initiated by collecting and preprocessing textual data. This involves gathering text data from varied sources, such as academic articles, policy documents, and social media posts. The collected data are then cleaned and pre-processed, eliminating unwanted characters, punctuation, and numbers to ensure a consistent data set. The pre-processed data is tokenized into individual words, or tokens, using a tokenizer such as the natural language toolkit (NLTK) in RStudio, which was used in this study. After preprocessing, an appropriate collocation measure is chosen to gauge the strength of the associations between word pairs. Commonly employed measures include pointwise mutual information (PMI), T-score, chi-square, and log-likelihood ratio—each of which has strengths and weaknesses (Petrovic 2007). Next, n-grams—contiguous sequences of words—are generated from the tokenized text. When seeking collocations, the focus is usually on bigrams (n 1⁄4 2) or trigrams (n 1⁄4 3). In addition, stop words, which are common words that carry little meaning (e.g., “and,” “the,” and “is”), are filtered out. The chosen collocation measure is calculated for each n-gram after identifying candidate collocations. The n-grams are then ranked according to the value of the collocation measure; higher values signify stronger associations be- tween the words. Based on these values, a threshold is established or a certain number of top-ranked collocations are selected to focus on. The selected collocations are further analyzed for relevance and significance within the context of the textual data. These interpretations are paramount to informing research needs or business goals. The importance of collocations in text mining is multifold. Collocations enhance the performance of various text mining tasks, such as sentiment analysis, text classification, and information ex- traction (Cohen et al. 2013). Furthermore, insights into linguistics and sociolinguistics, enabling an understanding of language usage and cultural patterns, are produced through collocations (Ramos et al. 2019). Collocations have been used to create domain-specific dictionaries and ontologies that are useful in knowledge representation and organization. Our analysis applied collocations to extract bigrams and visualizations, such as dendrograms and networks for BIM and claims management, from the primary and secondary data.

The next section presents the interviewees’ profiles. The text mining collocation analysis was applied in this study because it is a machine learning approach for analyzing qualitative data in an unsupervised natural language processing approach (Radford et al. 2019: Petrovic ́ 2007). In comparison with manual content analysis and applications such as NVIVO QSR, text mining has the advantage of predictive analytics of texts with greater accuracy of findings (Egbelakin et al. 2023; Ramos et al. 2019). Hence, text mining was applied in analyzing the combination of primary data (interviews) and secondary textual data on BIM and claims management.

Interviewees’ Profiles

Table 1 presents the interviewees’ profiles and codes, highlighting their organization types, core competencies, and years of experience. The table summarizes interviews with professionals professionals in the UK about BIM and claim management.

The next section presents the text mining analysis of the data collected through primary (interviews) and from secondary sources (peer-reviewed articles). Both the interviews and the peer-reviewed articles were analyzed using text mining.

Table 1. Interviewees’ profiles

Code	Interviewee	Type of organization	Core competencies	Years of experience
AP	Associate professor of strategic IT in construction	Higher education	Computational and parametric modeling	22
AM	Adjudicator and mediator	Construction law	Consultancy	42
CCPM	Chartered cost and project manager	Consultancy	Cost and project management	12
QS	Quantity surveyor	Consultancy	Construction finance and advisory	6
PPCS	4D planner and project control specialist	Contracting	4D planning and project control	9
CCM	Chartered construction manager	Risk mitigation and dispute resolution Consultancy	BIM in construction and engineering	10
CE	Civil engineer	Civil engineering contractor	BIM for project planning and management	9
DAPS	Delay analyst and planning specialist	Consultancy	Advisory, quantity surveying, project planning, management and control, expert services (quantum and delay experts)	15

Steps in RStudio Text Mining Analysis of Interviews and Secondary Data

Step 1: The R script meticulously unfolds a systematic process of textual analysis. Utilizing an assortment of libraries, the script delves into each document's content, focusing on the treatment of paragraphic data. The first stage is text cleaning, in which extraneous punctuation and other noise is removed to produce a clean corpus.

Step 2: A tokenization process deconstructs the text into indi- vidual words and two-word phrases (bigrams) that frequently co- occur and expunges commonplace words (stop words). The text is then converted to a title case, preserving words that start with capital letters. The selection criteria for the bigrams involves an in-depth check for stop words, case sensitivity, padding, and mini- mum occurrences.

Step 3: A new corpus is generated following a meticulous cleaning process. Using “DocumentTermMatrix,” the corpus is transformed into a numerical representation that measures the occurrence of terms in the text.

Step 4: Co-occurrence counts are calculated by multiplying the transpose of the matrix with itself, establishing word associations within the text. The script then employs the LOGLIK measure to calculate co-occurrence statistics, identifying words frequently associated with a given term (e.g., “lesson”).

Step 5: In this visualization phase, association strengths, dendrograms, and network graphs for terms strongly associated with the selected term are produced. A correspondence analysis further illuminates the relationships between the terms.

Step 6: Significance testing is conducted using Fisher’s exact and chi-square tests to ascertain the statistical importance of the co-occurrences. This holistic approach provides comprehensive in- sight into the relational dynamics of the words within the text—all achieved through the meticulous R script.

Table 2. Collocation analysis for BIM and claims management

Term 1	Term 2	CoocTerm	PMI	X2	Phi	Significance
Building Information Modelling						
BIM	BIM	0	239	0.00	6.66	$p < 0.001$
BIM	Dimension	4	22	0.00	16.50	$p < 0.01$
BIM	Model	10	135	0.00	11.80	$p < 0.01$
BIM	Predict	3	11	0.00	18.70	$p < 0.01$
BIM	Used	9	117	0.00	11.30	$p < 0.01$
BIM	Linked	4	33	0.01	9.10	$p < 0.01$
BIM	Benefits	3	18	0.01	9.70	$p < 0.01$
BIM	Demonstration	3	20	0.01	8.30	$p < 0.05$
BIM	Implement	3	21	0.01	7.80	$p < 0.05$
BIM	Claims	17	370	0.02	6.30	$p < 0.05$
BIM	Parties	4	42	0.02	4.60	$p < 0.05$
BIM	Programme	4	45	0.02	6.00	$p < 0.05$
BIM	Issues	3	29	0.03	5.30	$p < 0.05$
BIM	Inception	2	13	0.04	4.60	$p < 0.05$
BIM	Stage	2	13	0.04	4.40	$p < 0.05$
BIM	Resolution	4	53	0.04	4.40	$p < 0.05$

BIM	Still	2	14	0.05	3.90	p < 0.05
BIM	Especially	3	33	0.05	3.60	p < 0.05
Claims Management						
Claims	Claims	0	370	0.00	11.60	p < 0.001
Claims	Mostly	5	31	0.00	12.90	p < 0.01
Claims	Management	7	63	0.00	10.40	p < 0.01
Claims	Dimension	4	22	0.00	11.50	p < 0.01
Claims	Global	3	15	0.01	8.80	p < 0.05
Claims	Laid	3	16	0.01	8.00	p < 0.05
Claims	BIM	17	293	0.02	5.80	p < 0.05
Claims	Dependent	4	33	0.02	5.90	p < 0.05
Claims	Traditional	3	19	0.02	6.10	p < 0.05
Claims	Expert	5	53	0.03	4.80	p < 0.05
Claims	Contract	7	93	0.03	4.40	p < 0.05
Claims	Notification	4	37	0.03	4.70	p < 0.05
Claims	Emphasis	3	23	0.04	4.40	p < 0.05
Claims	says	2	11	0.05	3.90	p < 0.05

Results: Text Mining through Collocations

Table 2 provides an analytical dissection of the co-occurrence of specific terms within a specified data set that combined the primary interviews and extracted secondary data. The analysis was biased toward terms related to BIM and claims management within the construction industry context because of the research aim. The first column (Term 1) corresponds to the initial term under scrutiny for its co-occurrence with the second column (Term 2). "CoocTerm" refers to instances of co-occurrence between Terms 1 and 2 within the data set. The fourth column (PMI) signifies the measure of as- sociation used in information theory and statistics to quantify the degree of association between Terms 1 and 2 (Thanopoulos et al. 2002; Tao et al. 2019). "X2" and "Phi" are statistical measures denoting the association between the two terms. "X2" is the chi- square statistic, and "Phi" is the phi coefficient; each provides in- sight into the strength of the association between Terms 1 and 2. The seventh column (Significance) corresponds to the level of statistical significance attributed to the association between the two terms. The analysis bifurcates into two key sections. The first part scrutinizes the co-occurrence of "BIM" with various other terms. The second part investigates the co-occurrence of "Claims" with other terms. For example, in the first row of the table, the terms "BIM" and "BIM" have zero instances of co-occurrence within the data set. This scenario accompanies a PMI of 293, a chi-square statistic (X2) of 6.60, and a phi coefficient (Phi) of 6.60. The statistical significance of the association between these terms is $p < 0.001$. This indicates that there is a less than 0.1% chance that the observed association is a random occurrence, underscoring the statistical significance of the relationship between the terms.

Similarly, the second row indicates that the terms “BIM” and “Dimension” co-occur four times and have a PMI of 22, a chi- square (X2) of 16.50, and a phi coefficient (Phi) of 16.50. The significance level ($p < 0.01$) indicates that the association between these terms is statistically significant at 1%. Table 2 identifies the relationships and associations between terms in the context of BIM and claims management in construction. The higher the chi-square and phi values, the stronger the association between the terms. The significance levels (p values) indicate the likelihood that the observed associations are due to chance; lower p values represent stronger evidence.

Correspondence and Network Analysis

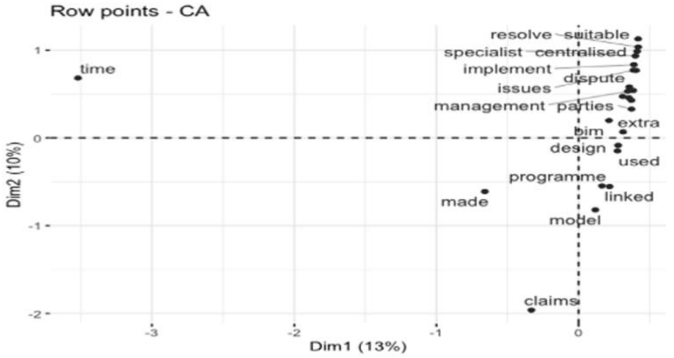
Correspondence analysis is a statistical technique to explore rela- tionships between categorical variables in a data set (Greenacre 2017). It involves computing expected frequencies, standardized residuals, and chi-square statistics for each cell in a contingency table and calculating the total chi-square statistic and the contribu- tion of each row and column. As indicated in Figs. 2 and 3, the row and column scores are computed next by dividing the contribution of each row or column by the total chi-square statistic and taking the square root (Friendly 2002). Last, the cosine similarity between each row and column is computed by taking the dot product of the corresponding row and column scores. This information can be used to plot the row and column scores on a biplot (scatterplot) to visualize the relationships between words, phrases, and documents. Using correspondence analysis, researchers can gain in- sights into the underlying structure of data and identify patterns and associations between variables.

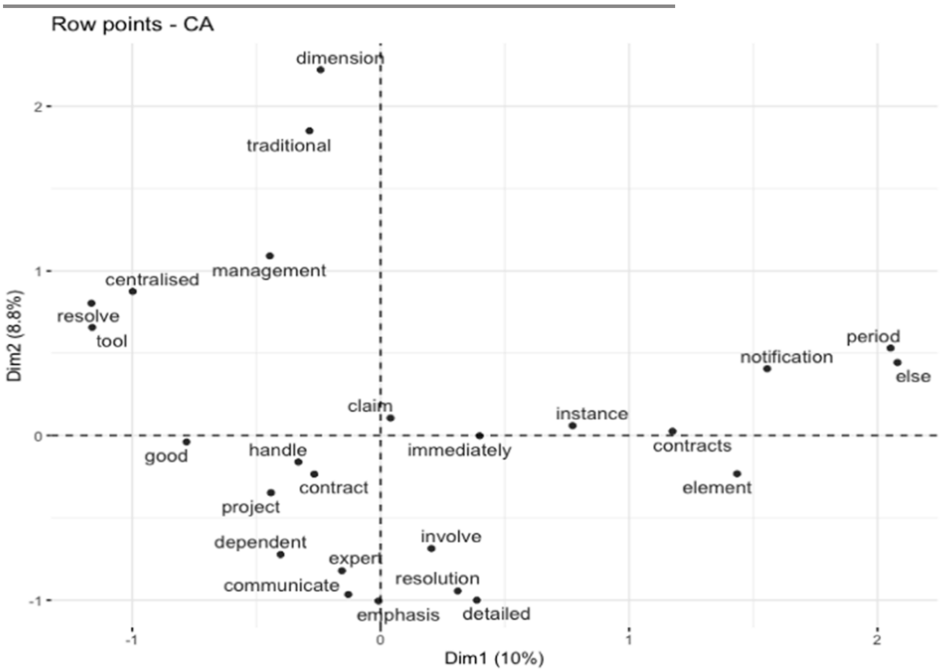
In addition, network graphs are used to visualize the relation- ships between words in collocations. Nodes represent words, and edges represent their connections (Fig. 4). The edge weight is based on either the collocation measure or the frequency. Network graphs help identify clusters of related words and reveal the underlying structure of the textual data.

The correspondence analysis (CA) charts and network analysis findings in Figs. 2–4 were extracted as the themes linking BIM with claims management (Table 3).

Discussion and Thematizing the Text Mining Results

Table 3 delineates four salient themes that traverse the relationship between BIM and claims management within construction projects.





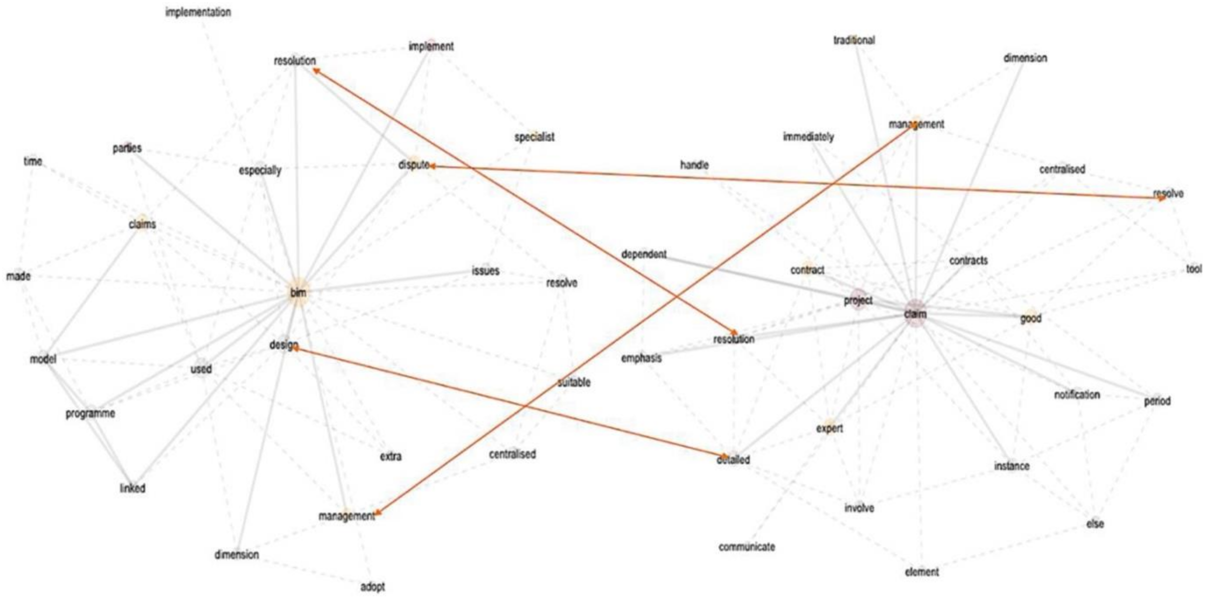


Table 3. Themes from CA and network analysis

Serial No.	Themes	Indicators from BIM	Indicators from claims
1.	BIM as a centralized platform for claims and dispute resolution	Parties, dispute, issues, centralized	Immediate, contracts, resolution, elements
2.	3D BIM, collaboration and contract documentation	Design, program, model, linked	Detailed, design, communicate, emphasizes, contract, expert
3.	Faster resolution of claims using BIM	Claim, time	Notification, period, claim
4.	Upskilling for BIM and claims management	Management, specialist, extra, implement	Traditional, centralized, management, tool, resolve

Moreover, it proffers indicators ascribed to each theme, emanating from BIM and claims vantage points.

Theme 1: BIM as a Centralized Hub for Claims and Dispute Resolution

In this theme, the indicators derived for BIM were “parties,” “dispute,” “issues,” and “centralized.” The indicators derived for claims were “immediate,” “contracts,” “resolution,” and “elements.” This theme posits that BIM can assume the mantle of a centralized nexus for managing disputes within construction endeavors. The theme alludes to the capabilities of BIM in amalgamating all the germane parties, fostering efficacious communication, and stream- lining dispute resolution processes. The centralization of information and processes through BIM paves the way to immediately and efficiently address issues, resolving disputes as an integrated element of a project’s lifecycle. According to Kassem et al. (2015), utilizing BIM presents immense untapped potential, specifically as a centralized platform for resolving claims and disputes in construction projects. Succar and Kassem (2015) concur, arguing that by integrating project data and facilitating stakeholder communication, BIM can enhance transparency, leading to significantly more efficient dispute management. As Azhar (2011) suggests, BIM has transformative potential that could reshape traditional practices in claims management and significantly enhance dispute resolution in the construction industry.

Theme 2: 3D BIM, Collaboration, and Contract Documentation

In this theme, the indicators derived for BIM were “design,” “program,” “model,” and linked.” The indicators derived for claims were “detailed,” “design,” “communicate,” “emphasizes,” “con- tract,” and “expert.” This theme sheds light on the instrumental role

3D BIM assumes in catalyzing collaboration among a project's stakeholders while also bolstering the fortitude of contract documentation. The theme indicates that through BIM, one can forge more meticulously detailed design documentation, improve communication channels, and mitigate potential disputes that can be engendered through contract-related issues. This invariably implies that with the integration of BIM, contracts can embody greater clarity and precision, providing stakeholders with a more robust understanding of a project's parameters. The advent of 3D BIM has yielded improvements in collaboration and the refinement of con- tract documentation in construction projects (Arayici et al. 2012). Sacks et al. (2010) indicated that BIM has enhanced the precision of communication among stakeholders by creating detailed 3D models and facilitating real-time information sharing—leading, in turn, to more accurate contract documents.

Fig. 4. Network analysis linking BIM with claims.

Theme 3: Expedited Resolution of Claims Using BIM

In this theme—expedited resolution of claims using BIM—the indicators derived for BIM were "claim" and "time." The indicators derived for claims were "notification," "period," and "claim." This theme indicates that BIM harbors the potential to accelerate claims resolution within construction projects. By streamlining the claim notification procedure and curtailing the temporal commitments requisite for resolutions, BIM emerges as a catalyst for more adept claims management. This culminates in not only financial efficien- cies but also in enhancing overall project timelines. Bilal et al. (2016) recognized BIM as a crucial tool capable of accelerating the resolution of claims in construction projects. BIM's ability to consolidate project data and visually represent a project enables stakeholders to easily identify discrepancies and address issues that may lead to claims (Motamedi et al. 2014). Furthermore, Oraee et al. (2017) argued that BIM's capacity to enhance communication and understanding facilitates quicker notification and resolution of claims. This ultimately leads to reduced delays and minimizes the costs associated with disputes. Accordingly, BIM can stream- line claims management processes and improve overall project outcomes.

Theme 4: Upskilling Imperatives for BIM and Claims Management

This final theme accentuates the indispensability of upskilling within the BIM and claims management domains. The indicators derived for BIM were "management," "specialist," "extra," and "implement." The indicators derived for claims were "traditional," "centralized," "management," "tool," and "resolve." As BIM per- meates the construction industry, it is imperative for professionals to cultivate the proficiencies required to deploy BIM efficaciously and oversee claims through this technological prism. The requisite proficiencies extend beyond mere technical knowledge and encapsulates a wider understanding of how BIM can be intertwined with traditional claims management approaches to revolutionize the way disputes are resolved. With increasing adoption of BIM in the con- struction industry, Barison and Santos (2010) pointed to a growing need for professionals to upskill in BIM and claims management. Liu et al. (2017) argued that the integration of BIM into project management processes necessitates the development of new skills and competencies for effective utilization in claims resolution. Furthermore, professionals must comprehend the technical aspects of BIM and its potential for enhancing claims management proc- esses (Gledson et al. 2016). Succar and Kassem (2015) proposed that equipping construction professionals with the necessary skills and knowledge would allow them to fully exploit BIM, leading to reduced disputes, streamlined claim resolution, and improved project outcomes.

BIM and Claims Indicators for a More Collaborative Construction Sector

Within the construction industry, there is a growing recognition of the potential of BIM, particularly 5D BIM, as a tool for fostering a collaborative environment (Azhar 2011). This is particularly rel- evant for a quantity surveyor, who can leverage BIM for improved cost estimation, enhanced communication and collaboration, and streamlined claims management (Arayici et al. 2012; Bilal et al. 2016). By identifying key indicators related to BIM and claims, quantity surveyors can proactively resolve disputes, mitigating con- flicts before escalation and ensuring more efficient project delivery (Motamedi et al. 2014). Key indicators may include discrepancies

in project data, miscommunications between stakeholders, and po- tential areas of dispute in contract documentation (Azhar 2011). By integrating BIM into their workflow, quantity surveyors can facilitate real-time information sharing, visual representation of projects, and improved collaboration among stakeholders, contrib- uting to more successful construction outcomes (Arayici et al. 2012; Azhar 2011). However, as Succar and Kassem (2015) noted, doing so requires a commitment to continuous learning and upskilling in BIM technology and a willingness to adapt tradi- tional quantity surveying practices to the evolving needs of the industry.

The intersection of BIM and claims management presents an opportunity for quantity surveyors to redefine their role in the con- struction industry and contribute to a collaborative and efficient sector (Azhar 2011). Although there are challenges to be overcome, including resistance to change and a lack of standardization, the benefits of BIM adoption in claims management, including im- proved cost estimation, enhanced collaboration, and streamlined processes, make a compelling case for its integration into quantity surveying practices.

The Need for an As-Built Intelligent BIM and Claims Management Application

As the construction industry has advanced, as-built intelligent BIM and dedicated claims management software applications have emerged. This combination offers unprecedented capabilities for claims management and dispute resolution (Arayici et al. 2012). As-built intelligent BIM provides a detailed and accurate represen- tation of the built environment, reflecting the exact conditions post-construction (Barison and Santos 2010). Integrating as-built intelligent BIM with dedicated claims management software appli- cations allows construction professionals, particularly quantity sur- veyors, to precisely identify discrepancies between planned and actual outcomes and form a solid basis for claim substantiation or refutation (Liu et al. 2017). These combined technologies support consolidating all claims-related information in a single platform, facilitating efficient data management, stakeholder communication, and systematic claims processing. Therefore, this technological fusion catalyzes improvements in claims management efficiency and enhances dispute resolution processes in the construction industry.

Contribution to Knowledge and Practice: BIM and Claims Management Framework

The adoption of 5D BIM can foster collaboration among quantity surveyors and other project stakeholders through access to a centralized information-sharing platform and real-time information. This reduces potential disputes and augments the overall efficiency of projects. The implementation of 5D BIM—by incorporating cost data into BIM models—enables quantity surveyors to visualize the financial implications of design modifications, leading to the preparation of accurate cost estimates and stricter budget control. This fosters an environment for informed decision making, mini- mizing the potential for cost overruns and claims. The integration of 5D BIM with the claims management process enhances claims resolution, leading to considerable time and resource savings. Quantity surveyors can easily identify discrepancies—provided that there is access to relevant and comprehensive project informa- tion. This allows for more efficient notification and resolution of claims.

Challenges for Quantity Surveying Practice

Resistance to evolving from traditional QS practices to 5D BIM can be mitigated through a shift in mindset that necessitates recognizing and appreciating the potential benefits of BIM integration. A lack of standardization contributes to the challenges faced by quantity surveyors, hindering the establishment of consistent practices and workflows. This issue warrants the development and promotion of industry-wide standards and best practices for BIM adoption. Because the construction industry is evolving toward 5D adoption, there is a growing need for quantity surveyors to upskill. Quantity surveyors need to understand the potential of BIM for improving the claims management process.

Recommendations for Quantity Surveying Professionals

Quantity surveyors should embrace BIM technology and commit to continuous learning to stay current with industry trends and developments. This commitment should extend to professional development programs, industry conferences, up-to-date research, and best practices. Quantity surveyors must champion, develop, and adopt industry-wide standards and best practices for BIM implementation. Consistent practices across the industry will facilitate the integration of 5D BIM with claims management processes. Active collaboration with other construction professionals, such as architects, engineers, and contractors, is vital for maximizing the benefits of 5D BIM integration. Such a collaborative approach will help identify and address potential issues early in the project lifecycle, minimizing potential disputes and enhancing overall project outcomes.

Construction organizations and educational institutions must in- vest in BIM education and training for quantity surveyors. For ex- ample, they should provide access to relevant courses, workshops, and resources to support continuous learning and professional development. Ensuring that quantity surveying professionals have the necessary skills and knowledge to use 5D BIM effectively in managing claims is crucial.

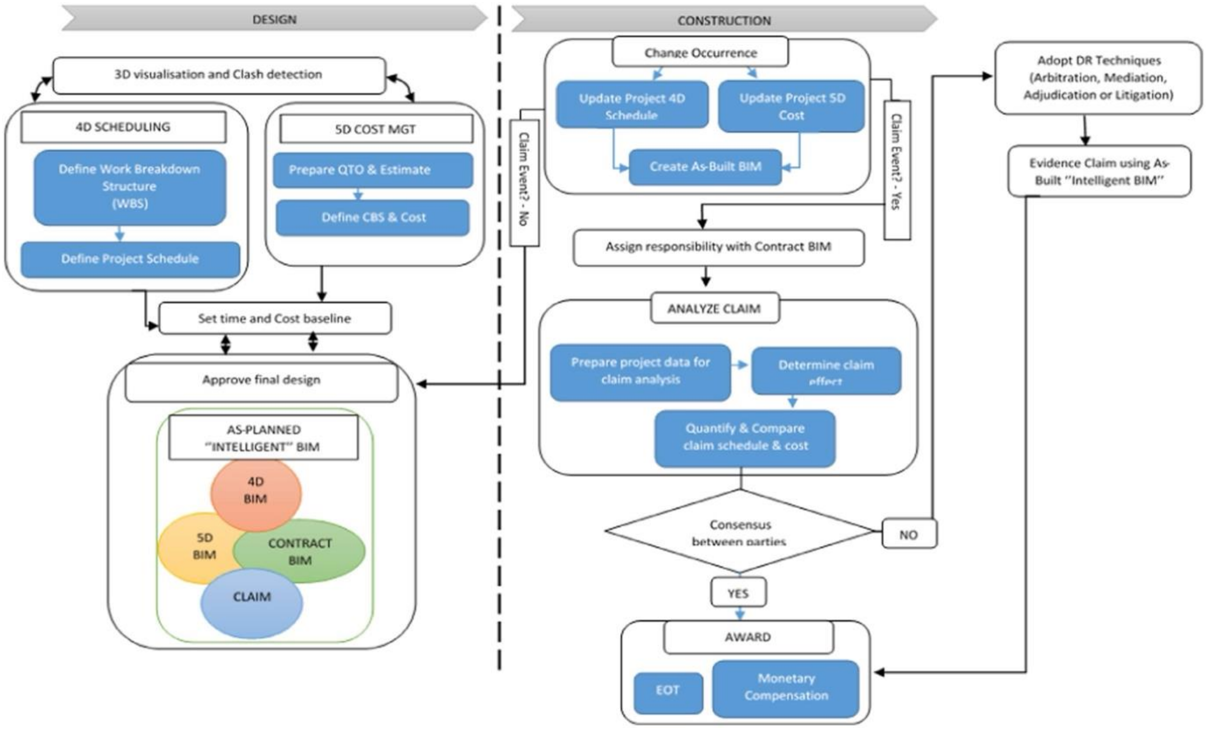
Guideline for Developing an In-House BIM-Enabled Claims Management Platform

The development of an in-house BIM-enabled claims management platform geared toward specific project and business requirements is encouraged through this study. Guidelines should address critical issues, such as data management, model sharing, and collaboration protocols. Such an approach ensures consistency and efficiency throughout the project lifecycle, as indicated in Fig. 5.

The road map in Fig. 5 illustrates how QS can utilize BIM to efficiently manage and settle claims in a BIM environment. The extension of a 3D as-planned model into a 4D model facilitates simulation of a project during a claim event and is helpful in ana- lyzing construction operations (schedule integrity and construction sequences). A 5D model would facilitate the payment of claims awards to prevent mistakes leading to nonpayment of justifiable invoice during construction stage.

Intelligent BIM, which is applicable for claims management, involves the integration of 4D, 5D; the automation of the contract conditions; and the inclusion of claim dimension by creating plug- ins. This is because the 4D can be used to reference a delayed event and simulate a project. The use of 5D BIM enables the valuation of a claimed component, attributing a cost to the claimed item. A claim plug-in is created to automate the claims process due to the repetitive nature of claim events. The claim plug-in facilitates the retrieval of claim-related contemporaneous records when needed.

Fig. 5. BIM-enabled claims management process.



The use of intelligent BIM enables timely notification of delays using color codes; showing discrepancies between as-planned and as-built models; and automatically adjusting contract budget. Contract parties can be notified of events within the BIM CDE. Intelligent BIM (as-planned) is adopted in the construction phase, and it can be used to produce an as-built BIM-enabled claims management platform that shows the real dimensions of building com- ponents. When a claim event occurs, an as-built report acts as a common legal tool that supports a contractor's claim for compensation. An as-built report shows the impact of a liable party's decisions and shortcomings on the active critical path activities.

The contract condition is consulted when a claim is identified, enabling the assignment of responsibility to the liable party. This can be viewed by all stakeholders through the BIM CDE. The claim can be visualized and valued (quantified) with an appropriate update in schedule and cost using the 4D and 5D models, respectively.

Conclusions and Limitations of the Study

There is an emerging need for an as-built intelligent BIM and claims management software application for the construction industry. This study presents a theoretical framework for developing a BIM-enabled claims management software for dispute resolution (Fig. 5). BIM-enabled claims management innovations offer a more sophisticated, streamlined approach to managing claims and dispute resolution, accurately reflecting the built environment post- construction and allowing precise identification of discrepancies between planned and actual outcomes.

This study delineated the implications of implementing BIM, particularly 4D and 5D BIM, for potential application to claims management and outlined the consequential effects of this application on the role of quantity surveyors. BIM enhances collabo- ration, improves cost estimation, streamlines claims management, and significantly fortifies quantity surveying practices. Its ability to centralize data and facilitate real-time sharing creates an environment that encourages efficient project delivery and mitigates disputes. Nevertheless, these benefits come with challenges, such as resistance to change, the absence of standardization, and the need for upskilling. The transition from traditional practices to technologically advanced methodologies may meet with reluctance among professionals. Similarly, a lack of uniform standards for BIM implementation impedes the establishment of consistent practices.

This study is not without limitations. First, although using a sur- vey strategy and semistructured interviews provided rich insights, doing so may have limited our ability to generalize the findings, because the views expressed are inherently subjective. Further- more, selecting firms registered under RICS for the interviews may not have fully represented the broader construction industry. Therefore, future research should address these limitations by employing a mixed-method approach and engaging a broader range of stakeholders. Although integrating BIM in claims management presents several opportunities for enhancing quantity surveying practices, the industry must address the associated challenges to harness its potential benefits fully. This shift requires a steadfast commitment to continuous learning, standardization, and adaptation of practices to the evolving needs of the industry.

Data Availability Statement

The data used in the analysis is available upon reasonable request from the corresponding author.

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