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BIM for Construction Site Logistics Management

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Abstract: Emerging Building Information Modelling (BIM) has been hailed as a revolutionary technology and information management process that facilitates collaboration and more efficient design and construction processes through innovative 3D modelling software, open access to information and multidisciplinary integration. The deadline of compliance to BIM level 2 on all public sector centrally procured construction projects has expired leaving many construction firms anxious to adopt BIM. Most common documented applications of BIM have been in the areas of architectural and structural design, quantity surveying, construction project management, and sustainability with very limited peer-reviewed studies on construction logistics management. The aim of this study is to investigate how BIM can be applied to construction logistics management. This study adopts a desk-top approach, with articles sources from renowned scientific databases such as ScienceDirect, Google Scholar and Emerald. The study culminated in the identification of benefits and barriers of adopting BIM for construction logistics management. Given only a desk-top approach has been used, the recommendation for future study is to build on this to conduct an empirical study using both qualitative and quantitative data. This will provide an in-depth understanding of the use of BIM for construction logistics management and open opportunities for further research.

Keywords: BIM, construction projects, logistics management, 4D model.

1. Background

Through the application of collaborative methods of working, facilitated through contemporary technology and advanced 3D modelling software, BIM innovates the processes used for the production and management of construction information. BIM provides an opportunity to virtually generate intelligent 3D model-based processes that gives architecture, engineering, and construction (AEC) professionals the insight and tools to more efficiently plan, design, construct, and manage buildings and infrastructure. By having the possibility to build the whole project virtually before physical construction begins, BIM adds a level of accuracy to both quantity and quality issues that overcome shortcomings found when traditional design methods are used (Zhang et al., 2016). This offers the possibility to make informed decisions in a virtual environment based on the results of various iterations. This virtual assessment or investigation of models is what has been termed “build before you build” (Kathleen, undated), “build it twice” (once virtually and once in reality) or “digital twin” (Grieves, 2014). The highlighted qualities of BIM is encapsulated in the definition of the BIM Task Group who defines it as “*essentially value creating collaboration through the entire life-cycle of an asset, underpinned by the creation, collation and exchange of shared 3D models and intelligent, structured data attached to them.”* (BIM Task Group, 2016). Through facilitating more intelligent uses of construction data, BIM enables waste to be stripped out of the construction process (BIS, 2013a). The open access to information that the technology offers and the subsequent collaboration this inspires, result in real-time distributed contribution from all parties to a construction project, leading to substantial advantages in the development of coordinated designs and construction sequences (Staub-French and Khanzode, 2007). Other authors have summarised BIM as a system that provides *‘the right information, to the right people, at the right* *time'* (Chapman, 2013; CIOB, 2017; Foy, 2016). Coincidentally Construction Logistics Management (CLM) is often described in a very similar way to BIM. Reading the literature, one will frequently encounter successful CLM practices explained as '*the right materials, in the right quantity, in the right place, at the right time*' (Gattorna and Day, 1986; Agapiou et al., 1998; Harker et al., 2007). Poor logistics management is one of the critical factors that affect the performance of construction projects (Al-Otaibi et al., 2013). Both BIM and CLM disciplines revolve around timely delivery of resources, either these are information or construction materials. Construction Logistics involve the co-ordination of deliveries to the site, the layout of the site itself, and the distribution of material resources from point of delivery to workface (Agapiou et al., 1998; Sullivan et al., 2011). The active management of these factors as the project progresses can have measurable positive effects on labour output, efficiency and waste reduction (Sobotka et al., 2005; Harker et al., 2007; Browne, 2015).

In July 2013, the UK Government published its Construction Industry targets for the year 2025 (BIS, 2013b). These included:

- a reduction in emissions by 50%;
- a reduction in costs by 33%;
- a 50%; reduction in overall delivery time from project inception to completion.

These changes will necessitate drastic modifications to the way both the design and the construction of structures are executed, and effective management of construction logistics can play a vital role in this evolution. Crucial to this is the provision of "*the right information, to the right people, at the right time" - the underpinning principles of BIM and CLM. Logistics is...one of the most important [site-based] activities, since workforce productivity levels depend upon the punctual delivery of mechanical equipment and materials, which ultimately affect the completion date of the project.* (Sullivan *et al.,* 2011, pp.31). Shakantu et al. (2008) determined the nature and extent of the current practice of logistics in the construction industry and to investigate the utility of reverse logistics in a construction context. Choudhari and Tindwani (2017) conducted a study aimed at assisting project managers in minimising the material logistics cost of road project by planning the optimal movement of aggregate across three stages of supply chain: sourcing, processing and distribution. Frazer et al. (2017) conducted a study that described the scope of the logistics strategy, the challenges faced in its implementation and the measures employed to make it a success on a 118km Elizabeth line across London, UK, part of the Crossrail project-Europe's biggest infrastructure project. Song et al. (2018) proposed a decentralized methodology for enabling the layout planner and the logistics planner to optimize the construction site layout planning and the construction material logistics planning P in an integrated model. To date, unlike in domains like quantity surveying (e.g. Abanda et al., 2017a; b), project scheduling (Nascimeto et al., 2017), construction risk management (e.g. Musa et al., 2016; Zhou et al., 2016) and sustainability assessment (e.g. Abanda et al., 2014; Abanda and Byers, 2016) very little study has examined BIM for construction logistics management globally as well as in the UK with the result that significant questions need to be asked. Why is BIM important for construction logistics management? How can BIM be applied to construction logistics management? What are the benefits and barriers implementing BIM on construction logistics management? Undoubtedly, BIM and CLM have synergies, not yet widely explored. Given that this study is exploratory, a desk-top approach was used to uncover the synergies and provide insights into the use of BIM for CLM. The main sources include the renowned peer-reviewed database such as ScienceDirect, Emerald and Google Scholar.

The remainder of this paper is divided into 8 sections. Section 2 is about construction site logistics management. Section 3 focuses on construction logistics plan. In section 4, logistics management techniques have been discussed. The application of BIM tools to construction logistics management is examined in Section 5. The focus of Section 6 is on the benefits of BIM for site logistics management. In Section 7, better management of construction logistics using BIM has been examined. Lastly, in Section 8, the barriers to BIM adoption in logistics management have been discussed; while the paper ends by a way of summary in Section 9.

2. Construction Site Logistics Management

Logistics in business is generally considered the movement, storage and delivery of materials and equipment for the purpose of ensuring the right item is in the right place at the right time (Agapiou et al., 1998). The term "Logistics" is defined by the Chartered Institute of Logistics and Transport as the process of designing, managing and improving supply chains, such as manufacturing, purchasing, storage and of course, transport (CILT, 2016).

Logistics management in construction involves the strategic storage, handling, transportation and distribution of resources, as well as planning of a building site's layout, and the active management of its evolution as necessary construction processes unfold (Sullivan et al., 2011). For the smooth running of construction site especially with regards to the movement or flow of material and equipment care must be taken to deal with conflicts of space and time between resource movement and storage, and dynamic building processes (Akinci et al., 1998). The fabrication and installation of permanent building elements must take into account the size of vehicle for transportation and material movement routes necessary for the development of the structure. This must be coordinated with consideration of the location, shape and size of fixed and temporary facilities during each phase of the site (Bortolini et al., 2015).

A number of methods are available for effectively managing the movement of materials to and around construction sites. These are outlined in the ensuing sections.

3. The Construction Logistics Plan

A best logistics strategy would typically evolve from a Construction Logistics Plan (CLP), developed at the outset of the pre-construction process by the main contractor. *The CLP acts as the catalyst for reducing the negative transport effects of construction work. A well-written CLP not only benefits the local environment but also saves costs by encouraging efficient working practices and reducing deliveries* (TFL, 2013). The CLP document illustrates site constraints, identifies opportunities to improve logistics efficiency, and defines the general logistics methodology for any development. It is progressively developed as the project planning process moves forward and becomes the central document the will be used for CLM techniques on any development project (Robbins, 2015).

CLPs…define the most efficient method of managing the logistics function…It seems astonishing–given the impact that logistics has–that a document defining its function is not commonplace… (Robbins, 2015, pp.67)

A brief outline of the content of a typical CLP, as specified by current policy documents (Croydon Council, 2012; TFL, 2013) is the following:

- **Overview of the Project**-A brief description of the development and general site location, as well as proposed site layouts and basic maps of surrounding roads and transport routes.
- **Introduction to the Supply Chain-**A brief description of primary products required for the development and their source, as well as the method by which they will be transported. A brief investigation of expected material waste, its removal and recovery.
- **Planning the Supply Chain-**This section contains the policies and procedures to be utilised by trade contractors and suppliers for reducing road traffic before and during the construction process. Some examples include:
    - **Materials**–A record of all the materials expected to be delivered to and removed from the site and their predicted mode of transport;
    - **Consolidation Centres and Pre-fabrication** (aka. Off-site Manufacture);
    - **Integration with neighboring sites**–Details of any potential delivery consolidation available through combining loads for separate sites situated close to each other. Outlines the processes to be shared and which sites will be collaborating with each other;
    - **Route Planning**–Details of the specific routes by which vehicles will arrive and leave including:
        - Strategic Access Routes–Specific road networks that should be utilised for vehicles arriving from outside a busy city centre to reduce local traffic congestion and minimise local air quality impact
        - Local Access Routes–Details of routes to be taken in the immediate vicinity of the site, or by local distributors and their links to the Strategic Access Route.
        - Unloading points and pit lanes, vehicle holding areas, and vehicle access gates on the site perimeter.
        - Any consideration of safety issues pertaining to the specified vehicle routes.
        - Local constraints on vehicle and pedestrian foot traffic, potentially affected by prescribed routes.
        - Swept Path Analysis (External)–These illustrate the computed paths and turning circles of various heavy goods vehicles. The Swept Path Analysis highlights where tight turning manoeuvres are required on traffic routes to, or away from, the site.
- **On Site Arrangements-Logistics Layouts and Site Plans-**Further to maps dictating preferred routes to site, a number of site layout drawings will be incorporated into the CLP document. These layouts will detail locations of:
    - Unloading points and site access gates for vehicles and pedestrians
    - Common User Plant such as:
        - Goods Hoist locations
        - Tower Crane locations
    - Segregated vehicle and pedestrian routes on the site
    - Welfare facilities for site staff
    - Swept Path Analysis (Internal): The same analyses as detailed above, but for turning manoeuvres into or within the site.
    - Site Storage and Security (if applicable)
    - Secure Bicycle storage (if applicable)
- **Staff Travel Plan-**This section of the CLP will detail the proposed routes to site for the staff working on the developments. The staff travel plan will encourage the use of transport options that keep congestion around the site at a minimum, such as public or shared transport and cycling initiatives.

4. Logistics Management Techniques

The preparation of the CLP documents described above will guide the logistics management techniques used on projects and present a key tool for the Logistics Manager to co-ordinate the movement of assets to and around the project (Brown, 2015). The specifics of the logistics strategy will be continually developed and clarified to ensure optimum efficiency in the management of material and asset movement. The specific techniques available are outlined in the ensuing paragraphs.

4.1. Delivery Management Systems

A Delivery Management System (DMS) is an important platform for managing the assets arriving to a site, and offers contractors and managers clear visibility of planned and actual deliveries to the development (Waddell, 2015). The DMS is typically a software-based scheduling system used to effectively organise and manage all deliveries to a construction site.

Many different software systems exist for delivery management; typically those used within a construction setting will administrate the following information:

- Brief details of the material, component, or plant items being delivered
- Vehicle type, size, and weight
- Goods supplier, and location of origin
- Recipient of goods being delivered (i.e. specialist trade contractor or installer)
- Vehicle registration plate number and driver information
- Vehicle safety accreditations (such as Fleet Operator Recognition Scheme-FORS) and associated registration numbers

The first three elements of data listed above allow many DMS programmes to automatically calculate the carbon emissions associated with each delivery, which contributes to calculating the overall carbon footprint for a project. Typically, a delivery request will be made by the supplier or installer, detailing the above information, which is received by the individual overseeing the DMS. The request will then be approved or denied depending on the information provided, the expected installation date of the materials, and the available storage space. An effective DMS will allow logistics managers to reduce the occurrence of double material handling, redundant movement of materials and excessive site storage through acute control of all assets arriving to a site (Ballad and Hoare, 2015; Sullivan et al., 2011).

4.2. Just-in-Time Deliveries

Just-In-Time deliveries (JIT) are a well-known and commonly used procedure in construction logistics management. JIT entails delivery of materials and/or equipment made at a time as close as possible to the moment they are required for use. This enables tasks to be executed without delay while substantially decreasing the requirement for on-site material storage. The benefits of JIT delivery include a decreased risk of damage, and loss of construction materials and equipment, as well as a reduction in both congestion and safety risks (Harker et al., 2007). The effectiveness and efficiency of JIT deliveries can be further improved by the introduction of a Construction Consolidation Centre for material and equipment deliveries (Lundesjo, 2015).

4.3. Construction Consolidation Centres

Transport for London (2016) defines a construction consolidation (CCC) as an *appropriately located distribution facility, where multiple bulk material deliveries are stored and transported to construction sites.* A CCC presents a single point of storage and administration for all deliveries arriving to a site. Loads can be delivered to the CCC in bulk and stored safely and securely. The daily needs of the site are then fed through consolidated loads, serving multiple trades at a time. This results in a significant reduction in the volume of daily site deliveries (Lundesjo, 2015). In large cities where traffic is heavy, a CCC presents an opportunity for freight to completely avoid entering the city centre by situating the CCC in an outlying district, reducing freight traffic to site by up to 70% (Lundesjo, 2011). Additional potential CCC benefits identified by Lundesjo (2011) include a 6% increase in labour productivity (circa 30 minutes per day), and a reduction of material waste totalling between 7-15%.

4.4. Materials Distribution Teams

Further compounding the effectiveness of the CCC, (however not necessitating a CCC) is the introduction of a site-based materials distribution team (MDT). This crew is either employed directly by the main contractor, or provided by a SLC. The MDT is equipped with mechanical handling plant and is situated on a construction site for the specific purpose of safely transporting goods from the point of delivery, to as close as practicable to the workface. This means that *trade contractors are left free to concentrate on their core tasks, without worrying about the co-ordination and supply of goods to site, nor the need for their specialist trade operatives, to be diverted away from production* (*Harker* et al., 2007). This drastically reduces trade contractor involvement in material movement further potentiating improvements in overall site productivity levels.

4.5. Demand Smoothing

Demand Smoothing constitutes a further logistics management technique available to site coordinators, representing an opportunity to both reduce freight requirements and improve labour output, by minimising delivery frequency through a comparison of expected material and labour demands against the forecast project activity programme. This is achieved by reviewing *project activities in the entire chain and identifying whether the performance can be "smoothed" to decrease transport resourced, materials and labour needed to carry out the activity* (Lundesjo, 2011). By moving construction activities that do not feature on the critical path within their project programme float periods, a "smooth demand" for each resource can be attained (Woodward, 1997).

4.6. On-site Marketplaces

Both Lundesjo (2011) and Harker et al. (2007) in their respective Waste & Resources Action Programme (WRAP) publications refer to the "On-Site Marketplace" as an additional logistics technique. Harker *et al.* (2007) describe the On-Site Marketplace as *a temporary storage area for consumable materials, fixings and small tools that are widely used and shared between a number of trade contractors working on-site.* However, in researching the use of an On-Site Marketplace as a functioning system on previous construction projects, the lack of results beyond these two publications, and those directly referencing them, suggests that the use of this system on UK Construction sites is very rare. Harker (2016) comments that there had been *difficulty in finding good practical people with experience of Market Place implementation* when co-authoring and project directing the original 'Material Logistics Plan' WRAP publication in 2007. This lends credence to the assumption that this logistics management technique is seldom encountered.

4.7. Tagging and Tracking

The WRAP Material Logistics Plan also mentions specific Information Communication Technology (ICT) systems as a logistics technique. Tagging and tracking of goods from manufacture, to distribution, to assembly, and finally installation is a potential option for controlling asset distribution efficiency (Harker et al., 2007). The most common methods of tagging goods are through the use of a barcode or RFID (Radio Frequency IDentification) tag (Sullivan et al., 2011). Other means of wireless data transmission such as Bluetooth, UWB, or Zigbee can also be used to tag goods and trace material movements (Song et al., 2007). By feeding the data collected back into the system, the theory is that a logistics coordinator capacitates a greater control over movement of materials throughout the transportation process by identifying and correcting inefficiencies in the process. However, Sullivan et al. (2011) point out that the fragmentation of the construction supply chain makes it difficult to introduce such a system early enough in the process to have any value. Equally barcodes simply cannot hold enough data to be useful in construction logistics, and that, although RFID systems are valuable for retail logistics where there is high product duplication, tagging bespoke construction materials presents a huge difficulty. Combined with the high cost of introducing such ICT systems *materials tracking remains an ambition rather than a reality at the time of writing [*which*] seems likely to endure, unless there is a radical change in construction's core processes* (Sullivan et al., 2011).

4.8. Off-site Manufacture

Off-site Manufacture (OSM) is a technique considered paramount to efficiency and sustainability improvements required within the UK Construction Industry (Dunlop Taylor, 2010) and constitutes an increasingly popular technique of both improving manufacturing quality and reducing the load on construction freight and site traffic. Smaller construction components are assembled off-site rather than in-situ, and delivered to site as larger composite elements for installation onto the structure. Through the prefabrication of these construction components within a warehouse or factory environment, a number of benefits can be realized (BIS, 2013b). These can include:

- *greater precision and quality,*
- *reduced overall manufacture/assembly time*
- *safer and cleaner working conditions*

According to Gibb and Isack (2003), other benefits include:

- *reduced multi-trade interfacing,*
- *a reduction in on-site workforce numbers,*
- *reduced need for material transport and on-site storage.*

The nature of OSM means that the decision to incorporate this technique into the general construction process must be made early in the design stages, as building components must be conceived in a way that facilitates their assembly away from site. This approach therefore is already in process by the point at which the above delivery and logistics management techniques are being formulated. This results in the prefabricated components simply being managed alongside remaining materials and building components within the greater construction logistics strategy.

5. Application of BIM tools to Construction Logistics Management

BIM software can be applied to construction logistics in a number of ways. 3D platforms allow complex logistical strategies to be communicated quickly and clearly. The addition of time data in the form of 4D BIM, allows the administration and manipulation of both available space for material movement and storage, and the coordination of plant installation and removal, to be effectively managed. The following sections outline some of these applications.

5.1. Creation of 3D Site Layout Plans

Contemporary BIM design software packages facilitate quick and simple production of three-dimensional site layouts. Accurate 3D plans of proposed structures can be populated alongside detailed 3D representations of the required common user plant such as hoists, and tower cranes. (Hardin and McCool, 2015) Site access points, material storage areas, and occupant welfare facilities can be represented in a manner that is easy to understand. Where site space is limited, this allows the available area to be utilised to the best capacity.

5.2. 4D Coordination of Temporary Site Installations and Common User Plant

The benefit of a clear and detailed visualisation of the site layout, offered by the 3D BIM tools described above, is fortified by the addition of time data. The unification and alignment of 3D designs and construction programme information is known as 4D BIM. 4D BIM facilitates the production of detailed construction simulations to be prepared during the preconstruction phases, allowing designers and project managers to accurately envision the proposed programme works in acute detail. This process is applied to the logistics management process also, allowing the project management team to coordinate temporary logistics installations with the dynamic environment typical of an active construction site. The installation, movement and subsequent removal of common user plant, site perimeter hoarding, site access gates, loading bays, and other temporary logistics provisions, can be easily simulated alongside animations of the proposed construction of a new building.

6. Benefits of BIM for site logistics management

There are clear benefits to the application of BIM systems to construction logistics management described in the previous section. These benefits are outlined below.

6.1. Improved Understanding of Logistics Information

The presentation of logistics information through a three-dimensional platform provides a fidelity that is not available through 2D information alone. This brings the benefit of improving the comprehension of site layout data, allowing complex logistics processes to be more easily interpreted by individuals without a construction or logistics background (Zhang et al., 2001; Bortolini et al., 2015). Increasing the ease at which proposed logistics plans can be interpreted reduces the effort associated with identifying both issues and opportunities associated with the logistics proposals.

6.2. Improvement of Site Safety

An improved understanding of logistics information brings with it benefits to health and safety on the live construction site. The use of a 3D model for logistics planning offers improved clarity in the comprehension of proposed logistical processes, allowing health and safety risks, that might be difficult to identify using 2D information, to be quickly spotted. Furthermore, site operatives can be quickly briefed with well-defined and easily understood information. This reduces the occurrence of elements of the logistics plan that are open to interpretation, reducing the hazards associated with inaccurate construal (Zhang et al., 2001; Bortolini et al., 2015).

6.3. Improved Effectiveness of Layout Planning (such as Avoiding Time/Space Clashes)

The 4D BIM model allows those coordinating the project greater control over the proposed schedule of construction works, and interactions between logistics and construction operations. The clarity added by 4D BIM based logistics, allows planners to quickly identify potential issues where a scheduled order of works conflicts with proposed logistical arrangements. The advantages of spotting these conflicts prior to their realisation on site, leads to improved site efficiency and reduced cost (Kensek, 2014; Bortolini et al., 2015).

6.4. Improved Efficiency of Logistics Planning

With the assistance of 3D information that is reflective of the expected site environment, and the associated improvement in comprehension, inconsistencies are quickly highlighted. Furthermore, clash detection tools that accompany BIM software packages aid this process by quickly identifying conflicts. A three-dimensional simulation results in easier to identify solutions, reducing the time associated with reviewing and revising logistics proposals.

7. Better Management of Construction Logistics using BIM

In this section, the different applications of BIM for logistics management will be examined.

7.1. Systematic Revision of 4D Site Plans

Further advantages are potentiated through consistent revision of the 4D BIM model beyond the pre-construction phases. The dynamic nature of construction sites results in evolving site conditions that may not be representative of the 4D model created prior to commencement of works. A policy of systematic review and adjustment of the model, during construction works, can result in improvements in site efficiency, and avoidance of time/space conflicts that would otherwise not be forecast by an outdated model.

Reverting back to "traditional" logistics management methods utilising 2D information increases the risk of potential issues being missed, and seeing realisation on site.

7.2. Collaborative Involvement in BIM Based Logistics Co-ordination

The improvements offered by utilising an up-to-date model as a central point of reference for logistics management and coordination can be further reinforced with input from specialist contractors and trades. Encouraging assessment of the proposed plans from those knowledgeable in a diverse array of construction disciplines can offer insight into potential issues that may not be immediately obvious to those overseeing the general project and logistics management of the development. This collaborative involvement can simply be in the form of regularly organised meetings, where trades involved are invited to review the imminent project works, and logistics arrangements, through the 4D model. Viewing the simulation alongside their peers, allows trade representatives, with an acute understanding of their own logistical requirements, an opportunity to both identify potential problems. Potential solutions can be proposed alongside those individuals coordinating the works that they are interfacing with.

8. Barriers to BIM Adoption in Logistics Management

8.1. BIM Adoption among Site Staff

The predominant focus on the applications of BIM to design management and cost control has led to a marginal adoption among site-based project management staff. 4D BIM logistics models produced at the outset of the project are infrequently utilised to coordinate logistics processes following commencement of the scheduled works, instead reverting back to management of construction logistics via 2D information.

8.2. BIM Training among Site Staff

The minimal adoption of BIM among site-based staff is no doubt a result of minimal training of site staff about the effective use of BIM software. Reliance on a small number of trained individuals such as BIM coordinators, BIM managers, and project planners to manipulate both 3D and 4D models during works, means that the use of BIM for logistics management is not as widespread as it perhaps could be. Only through a policy of training for all site staff will the applications of BIM to logistics management and their subsequent advantages be realised.

8.3. Involvement from Specialist Logistics Contractors

It seems that specialist logistics contractors are seldom invited to provide their expert insight into the logistics proposals and 4D BIM based logistics plans are rarely distributed to these contractors in a format that allows detailed scrutiny.

Considering their expertise and experience, as well as the proprietary logistics management systems at their disposal, there could be considerable advantages to engaging with these specialists earlier in the process. Inviting early participation would provide a greater clarity of the rationale behind particular decisions made on the management of various logistical elements.

9. Conclusions

The discussions in the preceding sections demonstrate that a robust and well thought out logistics management strategy is critical to securing optimum construction site efficiency and safety, and decreasing waste. It is also apparent that BIM has a number of applications to both the logistical management of materials delivery and distribution, as well as dynamic site layout planning, some of which are already being utilised on large developments in the UK.

The increased adoption of BIM will result in the UK construction industry moving incrementally closer to government performance targets; however it is possible that much more could be done to accelerate this improvement. Through an enhanced adoption of construction logistics management techniques fortified by BIM based systems and working procedures, acceleration in this evolution may be realised. This can be achieved, in part, through establishing a policy of BIM software training for site-based project management staff. Increasing the proficiency in the use of BIM software systems will encourage more frequent and consistent use of the 4D models that are already being produced for many construction projects, this improved method of site coordination and control will subsequently feed into more effective, efficient and safer logistics management processes.

The purpose of this research was to draw a broad picture of the current status of the relationship between CLM and BIM and the issues affecting adoption and application. Based on a literature review, this research has highlighted a number of topics including, benefits and barriers of BIM applications to CLM. As part of further study, future study should build on this to conduct comprehensive quantitative and qualitative research to gain and understanding of using BIM systems to manage construction logistics. Furthermore, the above research encourages further inquiry into whether logistics efficiency can be enhanced through an improvement in 4D BIM model interaction among site-based staff.

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