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# Digital Twin: A new Technology for Future Building Sector

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# Abstract

The building sector's historically sluggish adoption of digital technologies, due to these results are ineffective workflows, frequent cost overruns, and delays. Moreover, these challenges are exacerbated by the fact that it is a disjointed organization due to market forces. Through the promotion of innovation and enhanced collaboration, the digitalization and shift towards Industry 4.0 can potentially increase the productivity and efficiency of construction significantly and reduce the number of the information gaps and inconsistencies in data. The motivation behind the study is the fact that the digital twin-technology may be applied at different stages of the building, starting with a simple design, all the way to project delivery. Existing studies indicate the innovative impact of digital twin technology on ensuring environmental sustainability and innovative building approaches. These virtual replicas are important in simplifying the manufacturing processes in industries through synchronization of social interactions and production. The analysis in depth, the applications of the digital twin technology to the construction industry demonstrate how the technology can be used to accelerate the coordination process and can be used to facilitate the process of sharing the data between the interested parties. Landlords are driving the digitization of collaborative innovation processes in construction as they become more aware of the value of digital twin technologies in local environment. Enhancing asset quality, optimizing project delivery, and promoting social sustainability are all achieved by including digital twin technology from the beginning of a project and maintaining its use throughout the design phase. With the growing connection between sustainability objectives and technology, the construction sector is poised for a profound shift.


# 1. Introduction

The rise of Industry 4.0 and related initiatives across different sectors, such as Smart Cities. Engineering, and manufacture, serve as excellent illustrations of the swift progress in technology that has occurred recently [2]. These include Manufacturing 4.0 [10], Education 4.0 [8], Mass personalization [9], Mining 4.0 [10], Real Estate 4.0 [6, 7], Building 4.0 [3], and Construction 4.0 [4, 5]. Integrating digital and physical worlds is essential to the Industry 4.0 idea. Notwithstanding these developments, the building sector faced various issues, the most pressing of which was the urgent need for improved environmental sustainability as well as higher levels of output and operational effectiveness. Digitalization and information technology have been major forces behind the growth of several industries in recent decades. To fully reap the future benefits of Industry 4.0, the building sector must find creative solutions to a specific set of challenges. In this instance, For the building sector to continue growing and being eco- friendly, it becomes necessary to address environmental issues and enhance overall operational effectiveness [11]. It is a part of the latest phase of the Industrial Revolution, which builds upon technological advancements on par with the revolutionary advances in automation, electrification, and mechanization that preceded it [12].

# 2. Literature Review

A very fragmented manufacturing process is a characteristic feature of the building sector which leads to a slow uptake of technology. Both of these characteristics are the reason why the sector lacks competitiveness as a whole [13]. Although the emerging digital technologies will have huge long term payoffs, the industry is not yet ready to adopt the new technologies as suggested by Columbus [14]. Blending styles and fields of construction.

Digitization and information technology can be used to improve performers, participants and Concerned parties at all the levels of project execution. Love & Matthews [15] argue that to achieve the value and benefit of technology, behaviour, practice, expectation, relationships and change in strategy of the company need to be adjusted.

Gunderson [16] believes that technology plays an important role in ensuring the existence of a symbiotic relationship between the society and the firms, more so in their ability to impact the environment. Technology should be assessed accordingly with regard to such intricate relations [17, 18]. Building Information Modelling (BIM) is an important device to the building industry amid the digital transformation. The vast majority of the recent studies have focused on a number of methods to enhance this technology. The 3D models developed nowadays, as described by Boje et al. [19], are not simply models since they also hold digital tools that enable data mining, communication among a large number of Concerned parties, and specific information at the component level. Lim et al. [20] define the term digital twin to refer to an approach that has been extensively adopted in business world to conduct mathematical modelling, simulation and optimization. It helps in exchanging information between the internal and external Concerned parties as far as smart manufacturing is concerned [21].

The concept of digital twin technology that connects the parts, devices and mechanisms to the specific architecture is becoming more popular in the global debate of urban planning [22]. In the case of national and urban sceneries being represented with the help of digital twin, the growing consensus is that construction industry may be revolutionized. This will involve virtual testing of complicated systems before actual implementation into the physical life and real time data analysis [23]. The main goal of the provided research is to participate in a profound investigation of the suitability and viability of the implementation of the digital twin technology into the building surroundings and functioning may make the sustainability more complete, the operational effectiveness more intensive, and the productivity higher. Our study was motivated by the background issue of the development of the sphere of building sector and the implementation of digitalization [13]. The use of digital twin technology that will be applied in the whole process of constructing a building is still subject to research. This study seeks to generalize its review with the literature on urban planning, construction sites, and site logistics in their review of digital twin technologies in the context of built environments, intelligent buildings, and smart cities.

# 3. Methodology

The current work is carried out in accordance with the principles of systematic reviews, outlined by Saieg et al. [24]. The systematic review methodology allows the research team to locate, filter and review all the literature available which is relevant to a predetermined standard of quality, a process which Booth and Papaioannou, (2012) emphasize. Among the principal advantages of adopting this procedural framework, there is the fact that it imposes a strict and standardized investigative protocol to the area of interest as emphasized by S. Li et al. [25]. Subsequently, one can make the results transparently free of subjective bias, which is the quality this approach has guaranteed, according to Jesson et al [26]. The method has a number of problems. Significant studies with non-significant results and articles that are not written in the English language will be overlooked because most journals tend to publish papers that contain significant impacts [25]. The Fig. 1 is the outline of this extensive systematic review.

3.1.1. Research approach and the choice of studies.

3.1.1. Data Source Selection

The current review follows the principles of conducting a systematic review [24, 25] by utilizing a systematic approach to the analysis of a certain amount and quality of studies related to the digital twin technology and construction 4.0 (2) to provide readers with a clear, objective, and standardised technical roadmap that includes information about the database selection, retrieval of studies, and the criteria of target studies selection; and (3) is reproducible and scalable. The key elements of this systematic strategy include; (1) development of a question; (2) identification of relevant studies; (3) selection and assessment of the relevant studies; (4) content-analysis of the relevant studies; and (5) summary of the findings and conclusions [25].

The researcher used Scopus databases to search relevant literature and some excellent works that explain the state of digital twin technology and building 4.0 in New Zealand were found in foreign publications. Thus, the objective of our study is to explain the flaws of the digital twin technology. Particularly, authi would be concerned with establishing their contributions and potential outcomes. The datasets of S. Li et al. [25] were therefore deemed particularly useful to our study owing to their massive scope and academic bearing. We did not decide to select Scopus as our primary source randomly. It has an amazing coverage of 15,000 journals published by 4000 publishers, including academic giants in terms of abstract and citation collections.

The choice of literature was made to include the publications published between July 2023 and July 2018, which will ensure the corpus of data will be substantial and exemplified by the academic rigor to ensure a thorough picture of the applications of digital twin technology in the building industry.

3.1.2. Peer Retrieval

From January 2023 through July 2023, a monthly search of the databases was conducted using the same search methodology. The Scopus criteria consisted of the phrases "title," "abstract," and "keywords" along with the keyboard combination "Digital Twin" AND "Building sector" OR "BIM".

It was essential in any academic research to thoroughly review the body of existing literature to collect as much information as possible about pertinent studies. The first step of our data retrieval process was

a thorough gathering from three different databases, with a focus on studies that explained how digital twin technology was implemented in the construction sector.

Author carefully applied filters to obtain the most pertinent outputs. This article highlighted what appears to be a vacuum in our sophisticated retrieval process: there is a noticeable lack of literature on lean construction in the New Zealand setting, indicating a topic that need more in-depth investigation. After the dual-phase data retrieval, two independent researchers carefully evaluated the remaining papers to guarantee rigor and reduce bias. This required a detailed examination of the publications' principal text, abstracts, titles, and keywords.

Author used both inclusion and exclusion criteria to reduce the total number of papers taken into consideration [25]. The requirements stated that any literature that was redundant should be removed, as should any that had nothing to do with applying digital twin technology to the construction sector. Lastly, any material that merely alluded to the concept of digital twin technology but not delved deeply into it had to be eliminated. The evaluation results were classified into 3 categories based on the following standards: not relevant, somewhat relevant, and relevant. First, two researchers talked about the literature that had variable evaluation results and was categorized as either pertinent or not pertinent, as well as the material that was categorized as somewhat relevant. Next, they tried to come to a consensus over what ought to be included and omitted from the study. The members of the lean construction team spoke and ultimately came to an understanding over the literature on which they could not agree. Table 1 is a represent the initial search in the Scopus database.

The first search yields a set of papers, book chapters, and conference papers. The aforementioned things were subsequently removed, with the exception of the articles. Thus, the search was restricted to articles only. As a result, after the first purification process, 246 publications were retained as articles, as shown in Fig. 2.

Table 1
Initially received publications for Insight based on the quantity of search results

| **Search engine and Database** | **Keyword** | **Research (No of articles)** | **Limit to** | **Document Type** |
|---|---|---|---|---|
| Initial Search Results | | | | |
| Scopus | “Digital twin and Building sector” Or BIM | 246 | Title, abstract and keywords | Conference Papers, Books, Book chapter, and article |
| Removing Duplicates | | | | |
| Scopus | “Digital twin and Building sector” Or BIM | 133 | Title, abstract and keywords | Conference Papers, Books, Book chapter, and article |

# 3.2. Content Analysis

The clusters of the topic examined by the research team were aimed at assessing the contribution of the articles to the formation and possible further content direction in New Zealand. Having reviewed the 130 selected publications, the team found out that the research covered a broad array of topics, such as the following: Although some of them discuss the concepts, principles, technologies, and methodologies involved in lean construction, others examine how the digital twin technology is applied to provide supply chain management, construction 4.0, and other scholarly topics [25, 27]. The factors that affect the use of digital twin technology in the building business are analysed by some and the effectiveness of digital twin [13, 28] is investigated by others. The 130 selected papers were then encoded upon reading their titles, abstracts and keywords lists. In case, the necessary data that could not be located through the title, or abstract of the article, or the keywords, the whole text had to be read and coded. These articles were handled using Microsoft Word [29, 30]. The articles were organized into one page with all the articles that had a similar subtopic and each article had a subtopic color-coded according to the category it belonged to. Four distinct subject matter groupings were identified during the in-depth analysis of all the 130 articles. The main aspect of the coding was the critical elements of the material and information in the literature. There were four important parts of information that were coded: (1) paper title; (2) the name of the author; (3) publication date; and (4) the title of the journal the article was published in. The issues that were discussed in the literature about studying the digital twins technology were grouped into four groups that included: (1) theory and application of digital twin technology (2) application of digital twin technology in the research areas in the building sector (3) factors that influence the digital twin technology, and (4) evaluation of the impact of the digital twin. Each cluster of subjects was divided into several subtopics. The coding and classification should also be consistent in order to make sure that the content analysis can be accurate [30, 31]. It was due to this that a researcher with a lot of experience in using digital twin technology in building sector facilitated a training session in this study that involved two coders engaged in coding activities and a systematic training aspect.

# 4. Findings

## 4.1. Industry 4.0 and Construction 4.0

Industry 4.0 or the first phases of the fourth industrial revolution are already underway in the world in various business realms, as Popkova and Zmiyak [32] note. According to Khan et al. [33], the fourth industrial revolution, also known as Industry 4.0, is characterized by the high level of digitization and the utilization of big data and process automation. This is contrary to other three past industrial revolutions which have introduced new technologies. According to Popkova and Zmiyak [32], the fourth industrial revolution, or Industry 4.0 is different as compared to other industrial revolutions in a myriad of previously unseen aspects, including that there are no people or manual decision-making processes involved in the systems.

According to Popkova & Zmiyak [32], Bonnet and Westerman [34], Khan et al. [33], and others, the automation of processes is a key to the success of Industry 4.0. Digitalization development has reached the phase of digital enablement and support already and it is finally at the phase of digital control that

unites and binds the digital and physical world, as defined by Qi et al. [35]. The Industry 4.0 is founded on strongly defined siX design notions by Khan et al. [33]. Widened communication across technology and human, or interoperability, is the capability to operate with the recently developed technologies such as Cyber-Physical Systems (CPS) and the IoT. Virtualization is the visualization and replication of activities in the real world in the digital world (2). (3) Decentralization refers to the procedure that involves the replacement of CPS systems that can make decisions independently with those that previously had to be given approval by a centralized authority. (4) Real-time capability is the capability to utilize real-time data acquisition to examine and find problems in systems and processes. (5). Service orientation is used in decision making by the operators and managers as well as customers using CPS-connected services. (6). This is termed modularity [33] when it is possible to quickly add new machines, processes, and modules. Sawhney et al. [36] gave an outline in support of Construction 4.0. It applies Industry 4.0 design models to the construction industry. The next construction 4.0 definition provided by the authors is as follows: Construction 4.0 is a model that connects the digital layer, comprised of BIM and Common Data Environments (CDE), and the physical layer, comprised of the asset throughout its entire life, through CPS, the IOT, data, and services. This establishes a networked environment, where organizations, processes, and data are incorporated in an efficient manner to design, build and run assets [36].

In order to understand the numerous layers which comprise Construction 4.0, one should possess a deep knowledge of the technology which facilitates such transition [37]. Although the other papers in the corpus look at diverse technologies of Construction 4.0, in this article the researchers look at nine technologies commonly cited in the current research corpus [38]. All these technologies are outlined in the short paragraphs that follow, in a manner in which the technology enables the user to passively view the information presented to them; augmented reality (AR) is an information aggregator, as well as, a publishing platform of data. Virtual reality (VR) involves the use of headgear with 360-degree vision that provides users with an intensive virtual experience and introduces a distinct degree of expertise to the users [39, 40].

Compared to standard Building Information Modelling (BIM), Integrated Building Information Modelling (iBIM) is seen as being at a higher level. Robots that can perform or mimic human behaviours are used in robotics. Additive manufacturing, refer as 3D printing, is the process of turning a computer-aided design (CAD) model into a complex, real 3D object [41]. The term artificial intelligence (AI) describes the capacity of a computer program to mimic human cognitive function [37]. Drones, also known as unmanned aerial vehicles (UAVs), are small, unmanned aircraft that may be operated from a distance.

Based on common and compatible communication protocols, the Internet of Things (IoT) is a dynamic, worldwide network infrastructure with self-configuring capabilities [37]. The phrase "Internet of Things," which is frequently shortened to "IoT," is a combination of the terms "Internet" and "things." The Internet is a massive, worldwide network of linked computer networks that serves billions of people worldwide by using the standard Internet protocol suite (TCP/IP) [42]. With millions of private, public, academic, corporate, and government networks of all sizes connected by a variety of optical, wireless, and

electronic networking technologies, it functions as a network of networks. The term "things" refers to a wide range of recognizable items or entities in the physical world. These can be commonplace objects like electronics and high-tech products, or they can be more unusual objects that aren't always thought of as electronic, like food, clothes, furniture, materials, parts, equipment, merchandise, specialized items, monuments, works of art, and the various aspects of commerce, culture, and sophistication that are all around us [43]. One definition of big data, according to Bilal et al. [44], is the capacity to handle vast volumes of data and extract insightful knowledge from it. Large datasets with a variety of complex structures and large sizes are referred to as "big data," which poses storage, processing, and visualization problems for later steps or results [45]. At the initial stage of Construction 4.0 integration activities, a life-cycle view on technology utilization is taken into consideration. A project moved on to the design, construction, and facility management phases after the initial planning stage. Eadie et al. [46] state that integrating technology at the right point in a building project's lifespan allows for the full use of that technology. Teisserenc & Sepasgozar [18] state that improved communication and interaction amongst the Construction 4.0 technologies are necessary for the second phase of integration efforts.

As per the findings of Aleksandrova et al. [47], the all-encompassing integration of digital technology signifies a noteworthy model change in the building process, establishing a cohesive digital ecosystem. The shift to Construction 4.0 calls for modifications to both methodology and thought processes. The development of digital technologies and their adaptation to the needs of the building sector are extremely dynamic, expensive, and highly customizable [37]. Furthermore, educating employees and workers to adjust to their new roles is necessary when deploying new technologies. As a result, integrating the new technologies into daily operations and making them usable for a variety of projects is the only method for construction companies to generate excess value [48]. Rather of taking the more traditional project-oriented approach, one must embrace a process-oriented perspective in order to successfully shift to Construction 4.0 [49]. On the other hand, this change in perspective forces construction companies to digitize the processes they currently employ, which creates an additional obstacle for two reasons: 1) Not all procedures can be instantly digitalized, and 2) Most current procedures were developed pas years the currently available digital technologies were even imagined. Because of this, all of the current procedures must be redesigned to accommodate the mentality change and enable the construction organizations' transition to Industry 4.0. A comprehensive framework for Construction 4.0 is also presented by Sawhney et al. [36] and is built on the concepts that drive Industry 4.0. Using digital technologies, the digital layer serves as an interface to connect several physical layers. As a result, a strong connection is made between the real and digital worlds.

The authors stress the value of Common Data Environments (CDE) and Building Information Modelling (BIM) in creating a DT [50]. While Building Information Modelling (BIM) allows for a model-centric approach and visible 3D connectivity, CDE offers a continuous stream of data and data management [51–53]. Throughout the complete life cycle of an asset, from its conception to its demolition, these digital layers support downstream activities in addition to aiding in the design and construction of the asset itself. This remains valid even after they have given their approval for the planning and execution of an investment [2].

# 4.2. Technology in Construction

Conducting an effective examination into corporate management requires taking into account and critically analyzing the role that technology plays [16, 17]. Depending on the many technological theories, this role of technology may change. According to Orlikowski & Scott (2008), organizational activity is typically constructively interwoven under certain conditions. Because of this, technology cannot be understood in isolation from its context, significance, and effects. Ideas should be flexible and frequently evolve to keep up with the advancement of technology and the application industry [54, 55]. This will guarantee that technical innovations are not associated with any intentions or attributes. As the relationship between technology and work in organizations has not yet been conceived, a more advanced theoretical lens will eventually need to be created. Understanding the integrated, diverse, and always changing role of technology probably requires drawing from a variety of technological perspectives and conceptual frameworks.

According to Gunderson [16], technology's overt presence may eventually fade as it gets increasingly integrated into society. This gently alludes to the intricate relationship between technology and the social consequences that follow. Similarly, Lee et al. [56] contend that even in cases where the technical component is not directly linked to organizational functions, theoretical frameworks that study the effects and dynamics of technology provide insightful glasses through which to see the world. According to this model, technology transcends its physical form to take on the roles and purposes intended for it. Therefore, the idea of digital twin technology should not be understood in terms of its technological architecture alone, but rather in terms of its potential for interaction with organizational processes and its applicability to current and future construction methodologies. Orlikowski & Scott [57] state that the focus on technology in organizational study is often motivated by the ways in which technology interacts and influences the field. Gunderson [16] asserts that technology affects how societies engage with their constructed and natural surroundings, as well as how organizations interact with one another. Although digital twin technologies are becoming more and more incorporated into different situational practices, they have not yet become widely accepted as a crucial component of organizational operations in the building sector.

According to Peine [58], a technological model can explain some aspects of how technology develops in response to particular circumstances, but it is unable to explain how innovation occurs overall. Peine (2008) characterizes it as a technological model with a prevailing design, mutual obligation, and mentality. Scientific models, which are expected solutions to a problem that are widely accepted by all Concerned parties, are the source of this concept. If the dominating design has been correctly developed throughout an industry, the technological model can represent the cumulative technical advancement within that industry quite well. However, it is more difficult to coordinate around a shared commitment and mindset. Peine's [58] description of the technological model is similar to that of Cantwell & Hayashi [59]. They characterize it as the similarities among a collection of innovations and discoveries that take place throughout time and at a period when organizational procedures and scientific concepts are similar. The model shifts and the integration of key technological aspects and novel forms of

information, institutions, and production variables serve as the best illustrations of process of invention and societal evolution. These technological, socioeconomic, and political models may be applied in the manufacturing industry, in technological domains, or in society, claim Cantwell & Hayashi [59].

## 4.3 Digitalisation in the Building sector

In the building sector, there is currently a clear differentiation between companies that have adopted digital technologies and procedures. Building Information Modelling (BIM), Tekla, and other CAD-related apps are a few examples, along with others that still depend on more traditional methods. This "digital divide" can be attributed, according to Ayinla & Adamu [60], to a number of distinct limitations and constraints that companies face while seeking to apply digitalization. Ayinla & Adamu [60] looked into the idea that an organization's adoption of digitalization is heavily influenced by financial reasons. The government, project owners, or customers may place external demands or obligations on this procedure. Governments are increasingly requiring the use of BIM, especially for larger contractors, and as a delivery format, according to Bosch-Sijtsema et al. [61]. This has increased the quantity of digitalization in projects [54].

For SMEs, however, the adoption of BIM has happened more gradually. This purported value states that the main determinant of whether BIM is deployed or not is BIM [61]. While non-users do not appreciate the value in technology to the same extent as actual users, the latter strongly believe in its benefits and support its use. Additionally, despite the creation of regulations that strengthen the need for BIM, small and medium-sized firms (SMEs) are impacted by the implementation of BIM since they lack the resources to invest in BIM technology to the same extent as larger players. Two of these barriers include, according to Dainty et al. [62], the cost of software and training. The ability of companies, especially those built with "innovation thinking" as a guiding principle, is crucial in evaluating the influence of these factors, claim Ayinla & Adamu [60]. The digital gap is more prevalent in larger firms, as specific employees are impacted by the skill and motivational barriers associated with BIM, according to Dainty et al. [62].

According to Davies & Harty [63], a person's willingness to adopt BIM is correlated with how they see the technology's potential to help them in their field of work. Workers' decisions on whether or not to adopt BIM will be influenced by their newly developed understanding of what constitutes performance in their current role and how implementing BIM will either enhance or diminish that performance [64, 65]. There is still variation in the level of true digitalization, even among those using digital tools. For example, some organizations think that their digitalization criteria may be satisfied by only moving from paper to digital documents. But the industry's digital transformation involves a much more complex set of conditions, and in order for companies to evolve and achieve saturation, they must yield to pressure from both the inside and the outside [66, 67]. Bosch-Rekveldt et al. [68] state that the construction sector is unique in a number of ways. Its organization, for instance, is project-based; large construction projects might take decades to complete, while smaller construction projects operate almost exactly like separate businesses. In hierarchical organizations, project managers perform a role similar to that of the chief executive officer.

Compared to other industries like manufacturing, the building sector is said to have a vertical structure, which limits the exchange of knowledge and data between projects [55, 69].

## 4.4 The idea of Digital twin

Digital twins are a very recent notion that is constantly changing. However, since the 1960s, the idea which came about as a result of NASA's space missions has been used in a number of sectors[70]. The DT model phrase was credited to Dr. Michael Grieves in 2002. Nonetheless, since the 1960s, the idea has been used in a variety of businesses. Despite the traditional definition of DTs, one approach to conceptualize it is as the integration of a physical thing, its digital representation, and the ways in which both are interconnected. When there is a bidirectional relationship between the two, a true DT is completed, providing a legitimate and accurate representation of the physical asset [71]. Depending on the use, the physical and digital products' connectivity may change. However, when there is a link between the two in both directions, a true DT is produced. Because of its enormous potential benefits, the notion of DTs is especially relevant to the building sector. The idea of digital twin technology is seen in Fig. 3.

However, there are a variety of definitions of DTs in this industry because there isn't one that is widely acknowledged. It is necessary to look into these often used definitions. A DT technique is defined as an integrated multi-physics, multi-scale, probabilistic simulation of a complex product by Glaessgen & Stargel [72]. To simulate the life of its corresponding twin, this simulation makes use of the greatest physical models currently available, sensor updates, and other similar features. A cyber-physical system product lifecycle model, according to Schroeder et al. [73], is a virtual representation of an actual product that includes data about the product from the beginning of its lifecycle to its disposal. Leng et al. [74] describe the linked representation as a digital twin technology of the machine that runs on the cloud platform and simulates the state of health by combining other physically accessible knowledge with data-driven analytical algorithms. The Centre for Digital Built Britain (CDBB) proposed two distinct definitions of a DT in its Gemini Principles: the first highlighted the model's dynamism, while the second highlighted the model's strategic significance. A dynamic model of an asset is one that gives real-time control to its physical twin in the form of live data flows from sensors, receiving current performance data from the physical twin and feeding it back [75]. By employing corporate plans to a system model for the system's static strategic planning reacts to the physical twin through the capital investment, using imputed long-term data from the physical twin.

Fig: 3 Digital twin Technology

Adopting Digital Twin Technology solutions is becoming increasingly common as the demand for increased efficiency and competitiveness in construction develops [13]. This entails the integration of several Industry 4.0 technologies specifically designed for building environments [76]. The application of Industry 4.0 technologies to the four fundamental components of DT is covered in detail in the following sections. These characteristics include data collection, data processing, modelling and simulation, and enablers for decision support [13].

### Modelling and Simulation

The core elements of DT technologies are modelling and simulation. Both make use of high-fidelity 3D models and simulations to offer intricate visual aids for assessing specific scenarios and verifying automatically generated solutions. These features work in concert with the other construction-related technologies shown in Table 2.

### Data processing

It is essential to managing the enormous volumes of heterogeneous, real-time data that are gathered. In order to obtain useful information for modelling and analysis, raw data must be converted and treated. A review of the facilitating technology tools used in different academic works to address issues unique to the construction sector is given in Table 3.

### Enablers for decision support

An essential component of construction systems, decision support gives them the ability to manage disruptions and guarantee seamless lifecycle transitions. The key to this capability is the implementation of diverse tools and methodologies for semantic solution generation, as shown in Table 4. The importance of AI in decision support is emphasized, and particular AI domains are crucial in this regard.

### Data acquisition

The data acquisition procedure starts the process of extracting raw data, and it ends with the transfer of information to a database or cloud-based server. Table 5 lists the main technologies and the construction applications that go along with them.

When it comes to advanced building, the procedure is all about carefully digitizing resources and assets to create a virtual environment [79, 80]. Collecting data from many sources, having two-way real-time connectivity for monitoring and control, and facilitating smooth cyber-physical information interchange are all part of this comprehensive digitization. Following industrial communication protocols, a variety of sensors and communication devices are used to collect physical data at construction sites. Mapping this data onto cyber entities is made easier by methods like point cloud mapping and BIM modelling [87]. To guarantee correct representation and simulation of construction activities, a variety of techniques are used in the cyber component, including point clouds, 3D models, simulation, and BIM [86, 89]. In order to convert raw data into useful information and knowledge, the following computational and data processing layers are essential. By handling data, storage, retrieval, and modules related to analytical processing, this is accomplished. To create meaningful relationships between data nodes and easily integrate diverse data sources, data fusion and semantic modelling are used [90]. The functional layer is locating essential construction applications and adding domain-specific knowledge, such as stakeholder preferences, safety measures, and regulations [91, 82]. End customers are provided with this carefully honed knowledge via user-friendly graphical interfaces. These interfaces enable users to apply system-

generated solutions while interacting with and managing physical assets. Certain construction issues can be successfully dealt with and overcome by incorporating these modules [84].

## 4.5. The transition from Bim to twin

In the construction context, Design-Build (DTs) refers to a conceptual strategy that improves the process of sector selection by utilizing a variety of technology tools, including Building Information Modelling (BIM) [51, 53]. As per Linderoth [91], BIM is currently the digital modelling technique that the building sector has adopted to the greatest extent. It has been in use for a very long time to create 3D asset representations. However, BIM has changed over time to allow for greater integration since the introduction of the Industry Foundation Classes (IFC) standard. One of the primary benefit of BIM technology, according to Petrova-Antonova & Spasov [92], is that it provides a semantic 3D model that serves as a database of asset data.

Table 2
Modelling and simulation in Building sector.

| Technology | Construction Application |
|---|---|
| Building Information Modelling (BIM) | Disaster planning and damage inspection capabilities are essential for improving structural health monitoring (SHM). By combining these elements, the SHM system can more effectively anticipate and address possible structural problems, guaranteeing security and lessening the effects of calamities.[64, 65]<br><br>Facility management enhances building lifecycle management (BLM), comfort, and energy efficiency. Add anomaly detection, maintenance, and decision support systems.[51, 53]creating and maximizing resources. Lean manufacturing and configure-to-order techniques can be used to automate construction-related production processes. Make the most of the precast components' production. Develop enduring habits.[77, 78] |
| Virtual/Augmented Reality | The collaboration of robots and humans. facilitates asset management and two-way communication, which eases task planning and supervision.[39]<br><br>Urban planning and design. Multiple viewpoints and usability assessment from non-expert participants in the construction process.[39] |
| Point Cloud | asset design and visualization. uses LiDAR, gestalt design principles, and as-built reconstruction approaches to create city and building models; models are categorized using ML/DL-based point cloud interpretation[55, 69].<br><br>It looks at a structure's degree of establishment, projects potential harm to a structure, and evaluates services for digitally rendered structures in a virtual reality setting[54, 55]. |
| Simulation | Optimizing the structure's architecture. The time and cost of developing prototypes may be reduced by using high-resolution analysis and parametric geometric modelling[66, 67].<br><br>Enhancing the performance of buildings. Turn on infrastructure visualizations to keep an eye on the environment and electricity[64]. |

Table 3
Data processing in building sector

| Technology | Construction Application |
|---|---|
| Blockchain | project management. increased automation and intelligence development [79].<br><br>enhancing the performance of buildings. Boost the energy efficiency of the new and old structures[80]. |
| Data Mining | Form enduring behaviours. builds an intelligent platform with blockchain integration to support built-up residential buildings[81].<br><br>Project management. Improve service, cooperate with Concerned parties, and implement contracts to increase efficiency[56]. |
| Modelling | creating and maximizing resources. Equipment reconfiguration or re-installation should be allowed to handle interruption of any kind. Find a panorama where the localization mistake is at least one meter. Increase the assets' representation[49]. |

Table 4
Decision support enablers in the building sector

| Technology | Construction Application |
|---|---|
| Machine Learning | surveillance of construction machinery. Examine an asset's performance under different scenarios[82].<br><br>optimizing construction on-site. Maximize the timeline for the construction process and the structures that make up the building[83].<br><br>authority over security. Construct a security system and DT-based interior safety management system for a three-story elevator in a commercial building[84]. |
| Computer Vision | Facilities management includes movement recognition for maintenance tasks and the restoration of 3D structures from CAD drawings and street view images[41].<br><br>bridge maintenance system. Using image recognition can enhance inspection processes[85]. |

Table 5
data acquisition Building sector

| Technology | Construction Application |
|---|---|
| IOT | Enhancing the surveillance of structural health (SHM). Preventive maintenance for infrastructure ought to be covered[86].<br><br>enhancing the performance of buildings. Incorporate energy efficiency, enhanced FM system, sustainability assessment, and interior safety management into the BLM process[87]. |
| Wireless sensor Network | To lower building expenses, improve energy efficiency and lifespan management[88].<br><br>It enhances structural health monitoring by utilizing cyber-physical systems (SHM)[89]. |
| Social Media | Enhance the construction lifecycle management process. Included are the plan, design, building, and utilization elements[90]. |

However, BIM data may not be readily integrated into other systems, including IoT devices, due to a number of organizational, informational, and technological challenges [41]. One potential answer to this issue is the creation of a CDE in conjunction with BIM, which allows for the semantic integration of various datasets, attributes, and examples [41]. This model for system architecture offers a significant chance to enhance decision support, especially in the design stage of the lifecycle.

Integration issues still exist, preventing valuable data and information from being connected to other systems, even with current advancements. According to Camposano et al. [93], the concept of DT has emerged as a viable solution to address the difficulties. Although DTs and BIM are comparable in that they both allow for the creation of 3D renderings of assets, DTs offer greater complexity and integration opportunities due to their emphasis on creating a platform that is user-centric and human-cantered. Assets are visualized in three dimensions using BIM.

Camposano et al. [93] state that whereas BIM focuses mostly on the object, DT focuses on representing how people interact with the asset. Given the widespread adoption of BIM, it is recommended that the DT idea be used in conjunction with a range of potential applications that BIM can offer to the building process. Clash detection, visual communication, scheduling, safety management, quality control, cost estimation, construction simulation, and site monitoring are a few possible uses [94].

A key element that makes many aspects of the building and building sector possible is the digital model. However, overcoming the constraints of BIM's integration capabilities will be necessary to fully utilize these functionalities. As a result, it's necessary to develop more integrated platforms that can seamlessly connect with numerous other systems and operations [95]. The ultimate goal of digital transformations is to reach the highest level of digital maturity that is humanly possible. But since there isn't a single example of a DT that has realized all of its potential, it's difficult to determine whether a DT has [93] reached its maximum potential because the concept of DTs isn't fully defined.

Furthermore, as the use case is what defines maturity, the asset to which a DT idea is implemented directly affects how mature it has become. There are numerous ways to interpret the term because there isn't a single, widely accepted definition for it. various Concerned parties therefore have various requirements for the kind of connection they require and the data that needs to be sent to them. As a result, it is crucial to ensure that the implementation of DT benefits every stakeholder in the building sector [95].

The abundance of dynamic data that digital twin technology could handle, its meaning (semantics), and its continuous acquisition of knowledge about the physical world would ultimately constitute its additional values [94]. Given that a digital twin technology would mimic the real world, this would be the case. Because of the more intelligent and effective construction process and the more capable lifecycle management, this has long-term positive effects on the built environment. Decreases in carbon emissions, lifecycle costs, and asset resilience would all naturally follow from a society that becomes more environmentally conscious [94].

Because of the possible benefits to industry Concerned parties, the government recognizes the potential advantages of implementing Design Thinking (DT) concepts to modify the built environment. As stated in the Gemini principles, which outline the UK's strategy for using digitalization in the industry, everyone is aware that digital transformation is taking place. The government plans to support the transition in its entirety through a variety of aid programs.

## 4.6 Smart construction site

Digital twin technology may be implemented by site managers to streamline the construction process on the construction site. Radio frequency identification (RFID), augmented reality (AR), the Internet of Things (IoT), virtual reality (VR), and other digital tools can be used to monitor and oversee building site projects [79]. Using technologies like data mining and process modelling can provide insights on various issues, including material logistics, workflow management, and cost prediction. Unmanned aerial vehicles (UAVs) and other imaging vehicles may be used to compare the construction process with the structural model, allowing for a more precise assessment of the site's progress. A list of potential integrations of blockchain technology into different building stages was published by Kifokeris & Koch [96]. Studies have indicated that the utilization of digital models facilitates the early identification and mitigation of safety issues and possible hazards in the workplace [94, 97]. By anticipating potential risks associated with building stages and machine operations, personnel in construction and machine operators may find value in mixed reality simulation.

By using virtual reality (VR) to train on specialized construction activities, such constructing and dismantling tower cranes, the dangers associated with hands-on training are substantially reduced. As per Zhang et al. [98], the incorporation of hazard-detection algorithms with Building Information Modelling (BIM) enables the accurate identification of fall hazards, hence augmenting building site safety. Moreover, Zhang et al. [98] stressed that, as not all building components may be fully modelled in the early stages, frequent revisions to the algorithm-generated safety plans are necessary. This suggests

that there can be discrepancies between the model's stated assumptions and the actual practice of construction activities, necessitating regular algorithm modifications. Boje et al. [94] suggested that the digital twin technology model be used to handle comparable issues by connecting sensors to live activities for location tracking and worker monitoring in order to detect and avert potentially unsafe scenarios.

A lightweight digital twin technique designed for industries not usually associated with high technology has been developed by Greif et al. [99]. This digital twin technology is used with several sensors to track parameters including quantity, time intervals, and silo utilization.

After data collection, planned silo rotations and limitations on truck transportation are combined. The research is carried out in the framework of a supplier of bulk materials. This composite data is analysed by the digital twin technology using artificial intelligence and other algorithms, enabling a detailed assessment that takes historical and contemporary data into account. Based on this data, it then suggests the best courses of action and determines dividends for each unique client. Consequently, the operators can choose to accept the proposed course of action exactly as it is or modify it. Knowing the position of its equipment and the total fill amount at all times helps the firm become more predictable and efficient. The logistics and success of the construction project may be achieved, according to Kifokeris & Koch's [96] study, When material, information, and financial flows are smoothly and transparently integrated within supply chains, blockchains are recommended as an appropriate technology to validate these attributes. This is due to the necessity for accuracy and dependability in managing these flows, along with the demands for transparency and accountability, as noted by Boje et al. [94].

# 4.7 Built environment.

The conventional understanding of the building, engineering, and architecture sectors has recently changed to include facility management and operation under their purview [100]. This establishes a connection between key construction building Concerned parties, allowing for a broader perspective of the created environment's life-span and a reconsideration of the workflow across the entire delivery process [101]. The industry is often referred to as AECO (engineering, construction, architecture, and operation) or AEC/FM (architecture, engineering, construction, and facility management) in studies on digital twin technologies utilized in the existing context [102, 103]. Urban Planning's earlier study on digital twin technology [104] brought attention to this technology in relation to the built environment [102]. Deng et al. [102] suggested an evolutionary ladder for the established environment. Building information modelling (BIM) was replaced in the plan with digital twin, which augment BIM with simulation, sensors, and artificial intelligence.

A structure's capacity to reach the digital twin technology ladder category makes it easier to engage and communicate with established surroundings. According to Deng et al. [102], the next generation of digital twin technology is scalable, enabling real-time data sharing between buildings at the level of individual buildings, multi-building communities, and even entire cities [2]. However, the current corpus of

study only addresses a number of impractical aspects and important concepts associated with the digital twin technology of the next generation. Typically, the BIM level is divided into several stages, including the designing, structure, and operating portions [105].

On the other hand, the sophistication of simulation techniques makes it possible to accurately assess energy performance, which makes it easier to simulate construction processes in the future [102]. The granular control of energy operations, spatial deployment, and thermal comfort settings are improved by integrating the IoT. This feature facilitates the construction process and allows for the thorough evaluation of risks on both an individual and group level. Artificial intelligence (AI) is used to enhance these monitoring and simulation procedures, providing real-time predictive analytics [106].

# 4.7.1. Buildings

The transition from BIM to digital twin technologies for asset, activity, and repair management was described by academics [2, 41, 102]. There are various shortcomings in the asset management process while using BIM. These categories include the degree of coordination between the many technological factors requiring LOD and detailed information, the management component that integrates the flow of work and education, as well as standard-setting that aims to harmonize various processes, technologies, and developmental phases by guaranteeing disciplines [106]. The digital twin technology is more information-rich and has a greater analytical capacity than BIM [107]. The digital twin technology also needs to fulfil the requirements for interoperability, intelligence, integration, and efficiency. The level of a digital twin technology that corresponds to the building and infrastructure level is called smart asset management in the construction process, encompassing the procedural and repairing phases [108].

A number of stages, including designing, building, retrofitting, and maintaining a structure, as well as managerial and quality assurance level reports pertaining to DT technology, are already in existence during the construction process [109]. A framework for digital twin technology has been defined as scalable from the administrative to the building and societal levels within the framework of a case study of a university campus. The framework consists of several levels, including those addressing data integration and models, transmitting, digital modelling, and data gathering [110]. It is preferable to take the digital twin technology subset, the neighbourhood, and the city into account while analysing the infrastructure and digital twin technology of a building. This relationship may lead to a better understanding of the social and economic effects as well as chances to enhance city services like transportation and waste collection. The service layer of the dynamic building and city digital twin includes transportation, space deployment, health and safety, electricity, events and failure forecasts, asset and environmental management [110].

# 4.7.2 Cities

IoT, it need to do with intelligently managing construction systems, is suggested to be used for a variety of construction scenarios by Yang et al. [111]. Digital twin are not discussed by them. High energy efficiency is predicted for intelligent buildings, which will contribute to energy conservation, provide

smart services to develop a sustainable city, manage energy, and enhance the value of an IoT environment chain. Similar to this, Woodhead et al. [112] also suggested that an IoT network's primary ecosystem component keeps working long after a building project is customarily completed. Furthermore, Yang et al. [113] recommend that in order to enhance investment incentives and the advancement of relevant technologies, governments give top priority to the removal of regulatory bottlenecks and the provision of rules, user privacy, and security. According to study by Lehner & Dorffner [114], DT technology for metropolitan settings can be successfully scaled to benefit both Concerned parties and inhabitants, from specific structures or neighborhoods to entire cities. In the meantime, Deren et al. [115] support the creation of such city-scale digital twin technology through the convergence of artificial intelligence and human expertise with the goal of improving urban management protocols. In order to achieve the best possible energy use, sustainability objectives, and operational efficiency, this digital twin technology needs to work in harmony with smart city infrastructural frameworks that cover transportation, meteorology, and energy distribution, among other areas.

# 4.8 Project Delivery

A proposal has been made in the industry to implement smart contracts [116]. A study was carried out in this specific use of blockchain and digital twin technology to safeguard intellectual property rights (IPR) and maintain confidence among different Concerned parties [117]. This was achieved by proving that the work produced by a subcontract producer's machinery falls within the agreed-upon tolerance levels, hence establishing the final product's quality[118]. According to their research, any new form of collaboration must first create a predetermined level of confidence. The company that is the owner of the copyright rights is necessary to grant access to confidential data to the organisation performing the contract, and the contracting company is obliged to furnish details regarding the functioning of their manufacturing processes [99]. By providing accessibility for all Concerned parties regarding the advancements being made through the use of machines and the use of block-chain technology to confirm the proper usage of information, trust can be established and maintained across various businesses, according to Nielsen et al. [116, 119]. Furthermore, they contend that the trust does away with the requirement for attorneys to examine and approve contracts. A blockchain-related framework is proposed and verified by Rawat et al. [120] to facilitate the project's integrated delivery. They also provide an explanation of the growing body of research on smart contracts in the building sector [121This is done, in part, to ensure that the results of the study conducted by Nielsen et al. [116] are reflected. As a result, trust is established and maintained among clients, vendors, and subcontractors, enabling milestone payments to be legitimately linked to actual work completed on the project.

Dounas et al.'s study [122] examines how blockchain technology and BIM interact, describing how both technologies authenticate and document how building designs change and evolve during construction. Similarly, research conducted in the sector of building by Kifokeris & Koch (2020) emphasizes the function of blockchain in facilitating smart contracts. They do point out that there aren't many instances of this technology being used successfully. The significant danger of information attrition is highlighted by Mahmoodian et al. [123] at different points in a construction project, especially while moving from the

building phase to the operating phase. Waqar et al. [124] contribute to this discussion by offering a timetable that outlines the procedures for information linking between several models, resulting in an operational BIM that gathers the necessary information. It is agreed upon by Tchana et al. [22] that different models need to talk to one other. To safeguard traceable decisions and the model record, they advise, however, linking the used models using digital twin technology (Zhang et al., 2022). We'll take this action to guard against data loss or overwriting. The actual value of digital twin technology utility technologies only becomes evident when employed from the production stage to asset management, according to a study by Love & Matthews [15]. The adoption of digital technology by asset owners and organizations is recommended by Love et al. [125]. In order to enable real-time operations and maintenance procedures and provide a more successful and efficient turnover of the asset, asset owners may specify at handover that a digital twin technology be used (Wu et al., 2022). It is better to adopt digital technologies out of need and desire than to be pressured or inundated with the newest technology [126]. The advantages of practice and lifecycle implementation amplify the automation, extension, and transformational changes that result from the installation of digital technology. Before starting to build a structure, a number of different players look into the required parts [127]. When it comes to planning the municipality's internal expansion as well as the future development of real estate enterprises.

In order to make sure the proposed project complies with municipal standards, this stage of the process may automatically compare the design digital twin technology with current development plans very early in support of construction [128]. Upon completion of the model, the project can proceed to the next phase, which involves obtaining a building permit [129]. In both the planning and building phases, the initial design is altered to function as a model for the completed project.

Creating a link between the building and the neighbourhood around it guarantees smooth logistics. It enables the pursuit of automatic maintenance of the building based on events that occur close to its location in the future and the structural progress that is being made [130, 131]. If data is organized then that all parties can easily see it, there will be less conflict at the construction site and in other ongoing neighbourhood activities [132]. A final inspection is carried out during the project delivery phase to guarantee that the building meets all specifications and expectations. As of right now, the building functions as an integrated digital twin that is operationally visually connected to the city (Li et al., 2021). Through the use of secure authentication procedures and blockchain technology, Concerned parties at various levels are able to access generated data from the building as well as contextual information.

The development of complex sensor systems is inextricably linked to advances in technology and system architecture. These cutting-edge systems, which have robotics, GPS, and cellular networking capabilities, make it easier to collect data in difficult and complex locations by using advanced miniaturization and integration techniques (Wu et al., 2022).

Implementing AI-enhanced functions, such as machine learning (ML), computer vision (CV), and optimization algorithms, significantly improves process efficiency and results in better analysis and

solutions (Zhang et al., 2022). Moreover, by adding additional project issues inside the same platform, multi-function and integrated Digital Twin Technology (DT) systems aim to enhance operational performance. This includes environmental monitoring, safety management, and building evacuation [133].

DT systems operate more functionally when their deployment is broader, providing industrial relevance and fully addressing pain points [134]. In order to support a sizable administrative system and urban planning, city-scale DT systems move the emphasis from building-oriented solutions to virtual cities' mapping and management. The circular economy is still essential to contemporary building methods because of its dedication to sustainability [131]. Throughout a building's full existence, which includes construction, operation, and eventual decommissioning, it aspires to resource conservation, emission reduction, and efficient waste management. Lean principles incorporated into prefabricated manufacturing frameworks reduce their impact on the environment and increase efficiency [132]. When subjected to temporal analysis, digital twin (DT) technology can enhance scheduling, reduce interruptions, and limit delay risks—all of which have the potential to completely transform project management. Thorough economic assessments ensure the financial viability of the selected firm model (Li et al., 2021).

Moreover, the resilience and robustness of building endeavours are improved by combining DT systems with other cutting-edge techniques that come from earlier research on complicated environmental route planning and Building Information Modelling (BIM)-enabled detecting tools [130]. This multifaceted strategy signals a model shift in the building industry by opening the door to the augmentation of DT functions. The benefits of applying digital twin technology are categorized along six major dimensions, as shown in Table 6: Method, Milieu, Measurement, Material, Machine, and Manpower.

According to Table 6 represents, all tangible assets related to machinery and equipment utilized in the building sector, like trucks and cranes, are included in the machine aspect. It is now standard procedure for high-value assets to adopt Digital Transformation (DT) technologies in order to increase efficiency and reduce malfunctions during the course of their operational life. Conversely, the human workforce—which performs a variety of tasks during the construction phase, from machine operators to designers—is known as the "manpower" component.

A new study mostly concentrates on the on-site building stage, despite the quick acceptance of digital twins in the building process. Even while material performance and tracking—which includes raw materials and intermediate products like precast models—have made significant strides, more research and development can still be done. The measuring element effectively transforms drawing information into precise descriptions and amounts, which is highly helpful in evaluating the value, cost, and price of building work. In order to ensure speed, dependability, and sustainability in the creation of infrastructure in a digitalized society, this procedure is essential.

Table 6
Benefits of digital twin technology applications categorized by construction lifecycle stages.

| Applications categorised | Lifecycle Stage | Construction Function | DT-Enabled Benefits |
|---|---|---|---|
| Methods | Design & engineering<br><br>Operations and maintenance | Construction logistics<br><br>Quality evaluation<br><br>Sustainability enhancement<br><br>Safety management | -Enhance the way that safety is managed on building sites by assessing hazards, employing preventative risk management techniques, and analysing risk variables.<br><br>- Enable blockchain for traceability, incorporate the intelligent product-service architecture, and facilitate data synchronization[99, 117, 119]. |
| Milieu | Operations & maintenance | Monitoring construction sites<br><br>Keeping an eye on building occupancy<br><br>Managing indoor environments<br><br>Developing smart cities. | - Enhance safety oversight on building sites through threat assessment, proactive risk management, and risk factor analysis.<br><br>- Boost digitization of construction by automating the detection and tracking of site and assembly progress.<br><br>- Simplified public explanation of policy, urban planning, and administrative operations through digital prototype analysis and visualization.[129, 135, 136] |
| Measurement | Operations & maintenance | Tracking greenhouse gas emissions<br><br>monitoring construction sites; monitoring structural health. | - Provide future models for the continuous and real-time use of SHM, including failure prevention, structural damage detection, safety assessment, and support for maintenance work.<br><br>The ability to create energy<br><br>saving and emission-reduction plans is enhanced by real-time GHG emissions monitoring[118, 121, 123]. |
| Material | Operations & maintenance<br><br>Decommissioning<br><br>Design and engineering | Tracking material information<br><br>Recycling and reuse<br><br>Reliability and reaction tracking<br><br>Optimizing the structure design | - By offering more accurate models, the design validation of the 3D-printed modules is supported.<br><br>- Boost building material traceability and radiological detection.<br><br>- Direct material flows toward a sustainable material flow by using quantitative analysis.[126, 128] |

| Applications categorised | Lifecycle Stage | Construction Function | DT-Enabled Benefits |
|---|---|---|---|
| Machine | Operations & maintenance | Management of assets and safety<br><br>Automated assembly of robots<br><br>Control of intelligent equipment | - Use concurrent perception modeling to improve robotic building and generative design;<br><br>- Strengthen the security mechanism for the digital triplet's more confident object detection. enhances context observation for the purpose of applying robot control strategy[130, 132, 137]. |
| Manpower | On-site construction | Training for workers<br><br>Safety of workers | - Use a virtual practice platform to lower training risk and enhance learning outcomes for professionals in the building sector.<br><br>- Synchronize data to handle risks in complex and dynamic circumstances[133, 134, 138]. |

For operations to run well, data about actual objects and target environments must be gathered and monitored. The milieu component provides information about the physical environment in which building activities take place by taking into account ambient data, terrain type, and surrounding layout. As shown by Jiaying Zhang et al. [136], combining DT with the degree of detail extension in Building Information Modelling (BIM) provides a strong framework for efficient on-site building site monitoring and management. The Method aspect includes efforts to increase building and construction efficiency. When planning and engineering structures, planners and architects can reduce their environmental impact by using a realistic strategy called building form optimization. As a result, the incorporation of technologies is causing a considerable transformation in the building sector. In order to fully realize its potential, scholars and professionals in the industry need to broaden their scope beyond the on-site phase, investigate novel approaches for material performance, and enhance building procedures. In the digital age, building better, faster, and more sustainable infrastructures can be achieved by revolutionizing the construction sector by fusing human experience with state-of-the-art technologies.

# 5. Conclusion

A digital twin is a technique that exists only in the digital realm and is the virtual equivalent of a physical object. This could apply to everything from small-scale buildings and infrastructure to large-scale systems like cities, countries, or even the entire planet in the context of the construction business. A digital model must coexist with its physical counterpart throughout its existence in order to be considered a twin. This suggests that the idea of a new physical structure is inextricably related to the development of digital twin technologies. Moreover, the development of digital and physical things occurs simultaneously, mirroring the functional functions of each. It is not necessary for digital twin technology to replicate every aspect of its physical counterpart, though. Rather, the two organizations

need to have characteristics in common that support the built environment's sustainability. These characteristics could include improvements in the building sector's efficiency and project completion. The tolerance of the digital twin should be used to help building projects not just from the beginning of design to the end. It can be linked to the digital twin technology of the city from a very early the ecosystem of digital twin, the design process is maintained during the building's construction and operation. In the early stages, the building's digital twin technology is linked to the city's digital twin technology in terms of urban planning and the associated procurement processes. The scalable city digital twin technology can be integrated with the site logistics, such as the work environment and transit schedules, during the construction phase. If this happened, the place would be more like the smart manufacturing factories. Furthermore, the structure's digital twin technology may interact with the city's to manage expected health and energy usage. In addition to an abundance of newly created technologies, the digital world also encompasses a new style of doing business and a unique way of thinking. the notion of working together for the good of all people and future generations.

The results showed that DT might serve as the basis for a data-driven lifecycle that gathers ever-growing volumes of data, information and, in the end, helps make well-informed decisions. Procedures that make it possible to gather important and influential data should therefore be given top importance. The ability of DTs to cover a building's whole lifecycle makes circular construction viable. DTs are distinct from other technologies and more traditional BIM models because of their data-driven methodology.

Additionally, it can create new business models based on the capabilities of the DT platform, particularly during the O&M stage. Due to its unique benefits that may be provided to clients and customers through its digital platform and data capacity, DTs offer a compelling value proposition. The extent to which DTs can help with the shift to Construction 4.0 was also looked into in this structure.

According to the study, DT can help bring about this transformation. With reference to the SiX Keys to Success Framework, this conclusion is proved [139]. Nonetheless, the interviews revealed that this change will not happen suddenly. When it comes to the construction business, the DT concept is still in its early stages, thus it's possible that the sector will never reach its full potential. Despite this, the goal posts for the DT concept will never be achieved, even though strengthening system integration and progressively enhancing DT capabilities may be the best way to advance. For DT to realize its full potential, all of the industry's Concerned parties must support standardization of tools and procedures as well as data-sharing. As a result, there is less fragmentation in the building business since anybody can access and contribute information to a single platform. This paper elaborates on the critical role that data plays in the Digital Twin Technology (DTs) model, serving as a catalyst and an enabler in equal measure. However, data interchange appears to be a critical factor that needs more research in order to successfully implement DTs. When several Concerned parties are willing to share data, data-centric components inside DTs can never reach their full potential. At the same time, ethical issues including dangers to personal privacy need to be carefully examined because DTs involve a lot of data sharing. Furthermore, when sharing data between different projects with diverse DT models, the question of data ownership becomes even more important. Future research projects might use qualitative or quantitative

approaches in addition to case studies to measure the prevalence of data-sharing practices and gauge Concerned parties' preparedness for data exchange. This would help us better understand these complexities.

## Declarations

# Author Contribution

Dr. Pragya wrote the main manuscript text and Dr. Chandrashekhar prepared figures. Dr. Linesh Collected the data and henerated the results and Dr. Avichandra reviewed the manuscript.

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## Figures

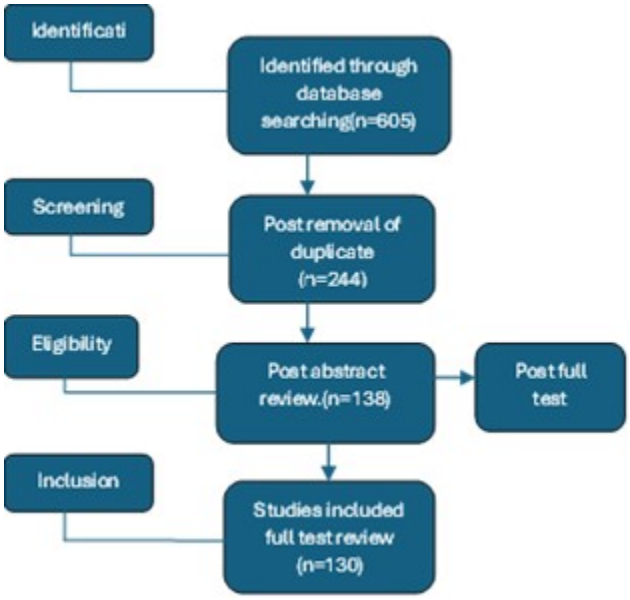


**Figure 1**

Methodology framework.

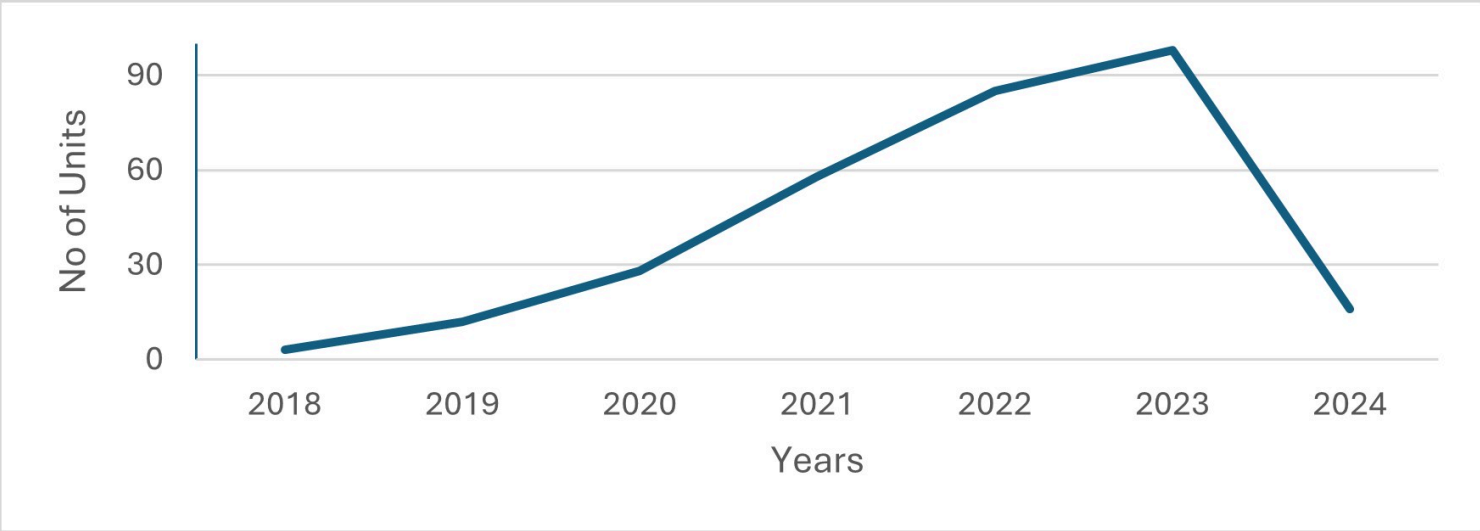



**Figure 2**

Publication by Year

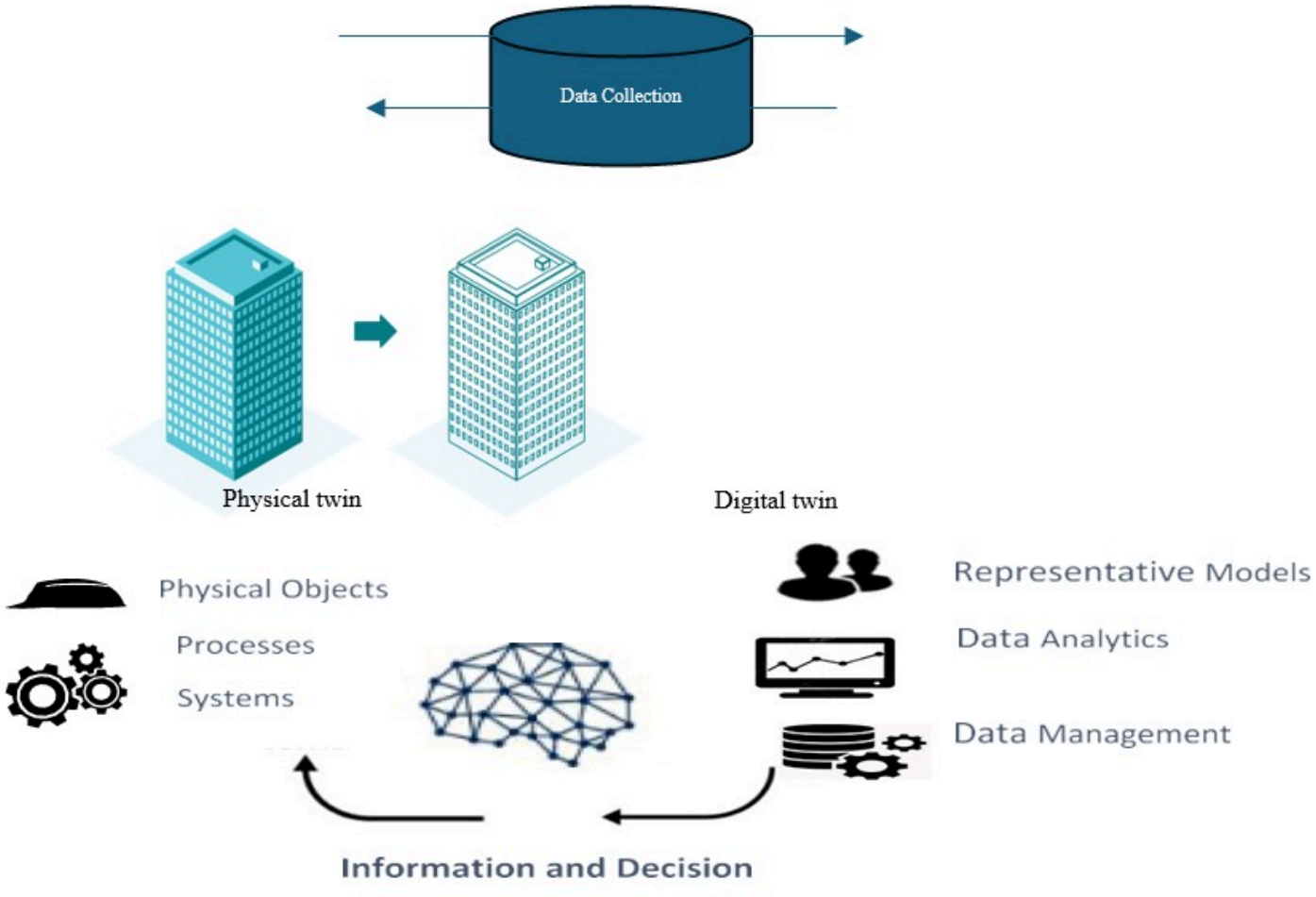



**Figure 3**

Digital twin Technology