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Towards Adopting Digital Twins for Enhancing Circular Economy in the UK Construction Industry: Benefits and Enablers

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Abstract

As a major and crucial sector, the construction sector has a global mandate to transition from a linear economy to a more sustainable circular economy (CE). Construction can overcome the limitations of the linear economy with the use of digital twinning (DT). Considering the current economic climate, promoting circularity through digital identity (twins) has become a critical topic. Moreover, a shift towards a CE has become imperative with the increasing emphasis on reusing and recycling materials and products. There is little known about the role that DT can play in improving CE practices and outcomes. Thus, this study aimed to address this gap in knowledge by investigating the benefits and enablers of adopting DT for enhancing CE in the UK construction industry. A structured questionnaire survey was used to collect data from construction sustainability professionals with UK experience in both DT and CE. The study utilised statistical data analysis techniques such as standard deviation, ranking of mean scores, and percentage calculations to examine the collected data and draw conclusions out of it. Results from the analysis indicated that the reduction of construction waste, facilitation of identifying recycling opportunities, and predictive maintenance are the major benefits of DT. An integrated data ecosystem promoting advanced data analytics, advanced modelling, simulation tools, predictive analytics, continuous monitoring, and feedback loops top the list of enablers of DT integration in CE. The findings provide insights for the development of strategies to successfully adopt digital twins, ultimately promoting a more sustainable and efficient construction industry. It is recommended that the UK Government establishes legislation and policies that could encourage construction industry stakeholders to fully embrace DT integration in improving CE.

Keywords
Construction, Circular Economy, Digital Twins, Enablers, Benefits, UK.

1. Introduction
The construction sector is considered a major driver and promoter of development and growth in any country (Awodele et al., 2023). The industry plays a significant and meaningful role in national development, infrastructure, and economic prosperity. This contribution's product offers a hazard to the ecosystem because of its negative environmental impact caused by extensive natural consumption and significant waste formation (Awodele et al., 2023; Eze et al., 2021). In the current economic climate, promoting circularity through digital identity (twins) has become a critical topic. With the increasing emphasis on reusing and recycling materials and products, a shift towards a circular economy is being witnessed. Fortunately, many items that would otherwise end up as waste are now being given a new life, as evident in the thriving second-hand market for goods like bicycles and cars, where cleaning and repair efforts are made to enhance their resale value (Pablo van den Bosch, 2018).

The construction sector has experienced a significant impact from digital twinning, particularly with the rise of automation. This technology has led to improvements in efficiency, quality, and reduced error margins. A digital twin (DT) replicates the real-time state of its physical counterpart and vice versa, representing a revolutionary notion. Real-time data exchange connects a digital twin (DT) to its physical object, creating a virtual replica (Singh et. al., 2021). Digital twin (DT) is one of the most promising enabling technologies for realising Industry 4.0, and the concept of DTs was initially introduced in 2003 and has since gained popularity (Grieves, 2014). While digital twins of materials, products, buildings, and portfolios exist, the concept is still in its early stages (Khallaf et al., 2022).

Despite being in its infancy, digital twins offer substantial added value to the construction sector. They enable economic trade by providing comprehensive information, allowing for planned reuse even before physical availability becomes a reality. As a result, the construction industry has already witnessed numerous benefits, including smarter designs and construction, improved planning, and higher-quality outcomes. Integrating digital twins throughout the life cycle of buildings opens even more possibilities for improvement and optimization, such as proactive maintenance and management, proposals for upgrading materials or products, preventing double inventories, and quicker risk identification (Pablo van den Bosch, 2018).

Looking ahead, digitization in various segments of the construction sector is expected to intensify further. Digital twinning will become a driving force behind industry developments, providing a significant boost to the circular economy. While certain physical barriers like deconstruction, reinstallation, quality testing, storage, and transportation still need to be addressed, digital twins make managing and planning these aspects considerably easier. This, in turn, enables producers, owners, and service providers to expand their activities using circular business models (Omrany et al., 2023). Digital twinning is a novel concept that holds immense potential for development. It can create a new ecosystem of services, suppliers, regulations, and fields of work. By initiating a transition within the economic system, digital twinning opens new opportunities for the construction sector and the circular economy as a whole (Pablo van den Bosch, 2018).

A review of the literature found significant research gaps in the use of digital twins in the construction industry, especially in relation to its application to the circular economy (Opoku et al; 2023; Preut et al., 2021; Rasheed et al., 2020; Escorsa, 2018). The findings of several studies indicate a general lack of understanding of how digital twins are used in circular economy practices in the construction industry(Preut et al., 2021; Ziyue and Lizhen, 2020). Moreover, there is limited empirical evidence demonstrating the actual impact of digital twins on improving sustainability and circularity in construction (Sultan et al, 2022; Preut et al;2021). Despite the growing popularity of DT research, there have been limited attempts to investigate DT applications for supporting the circular economy in construction. This study, therefore, aims to address these gaps in knowledge by deploying a questionnaire survey with industry specialists to identify the benefits and enablers of adopting DT for enhancing CE in the UK construction industry. An in-depth comprehension of the advantages and motivators for integrating digital twin technology in the circular economy can help project stakeholders in the construction sector promote the implementation of sustainable practices in digital twin and circular economy. This study will be beneficial for industry professionals, construction sustainability specialists, policymakers, and other stakeholders, as it offers information on sustainability practices that can support the adoption of digital twinning.

2. Literature Review

2.1 The benefits of adopting Digital Twins for Enhancing the Circular Economy

Contemporary research suggests that the advantages of integrating a digital twin to enhance the circular economy in any project are significant (see for example, Han et al., 2023; Chen and Huang, 2020). Digital twins are utilised to boost production and increase profits in several endeavours. Several scholars have expressed their opinions on the necessity of digital twins. Dilmegani (2020) supported the claim that using digital twins can significantly improve organisations' data-driven decision-making processes. Digital twins are linked to physical assets and businesses use this technology to understand the current condition of their assets, respond quickly to changes, improve operations, and enhance the value of their systems. Marr (2017) asserted that Digital twins are becoming a potent tool for fostering innovation and enhancing performance across many industries. These computerised duplicates have sophisticated monitoring, analytical, and predictive capacities, resembling highly competent product technicians. Over the next five years, billions of physical things are projected to be replicated as digital twins, enhancing collaboration between product specialists and data scientists (Han et al., 2023)

Companies can utilise digital twin technology to obtain insights into clients' needs and preferences, improve their current products and services, and potentially stimulate the creation of new business opportunities (Chen and Huang, 2020). For instance, General Electric's "digital wind farm" optimises wind turbine efficiency by evaluating data from each turbine and transferring it to its virtual counterpart in the cloud (Øydegard, 2017).Ganesh Bell, the chief digital officer and general manager of Software & Analytics at GE Power & Water, stated that this method has allowed the corporation to generate a digital replica of all physical assets worldwide, which constantly improves by incorporating operational data (Øydegard, 2017).

Chen and Huang (2020) evaluated the process of construction waste remanufacturing and the utilisation of Digital Twin technology in construction and remanufacturing. The study showed that Digital Twin offers a chance to address the issues related to building waste remanufacturing. Integrating Design Thinking in Civil Engineering helps reduce construction waste by monitoring and reusing waste materials. Han et al. (2023) states that current research has shown that digital twin technologies (DTs) have a favourable impact on the shift from a linear economy model to a circular economy (CE) model. Han et al. (2023) created a conceptual framework to explore digital twins in terms of customer experience operationalization based on insights from a systematic literature review, focusing on the product lifecycle. Their paper explains how Digital Twins can help achieve Circular Economy performance goals across the three stages of the product lifecycle: product recovery or recycling, product design, and product use.

The current state of Digital Twins application to circular economy practices in the construction sector showcases promising prospects and opportunities for sustainability. From optimizing resource utilization and tracking materials to supporting circular design and construction, Digital Twins are set to transform the construction industry into a more environmentally conscious and efficient sector (Meng et al.,2023). The study by Chen and Huang (2020) delved into the role of Digital Twins in the circular economy of the construction industry, focusing on the remanufacturing of construction waste. Digital Twins offer opportunities to track, recycle, and manage construction waste efficiently. However, the research indicates that most studies have centred on Digital Twins' application in the design and maintenance stages, with limited exploration in the demolition phase. The paper advocates expanding the use of Digital Twins to construction waste remanufacturing, thereby broadening the scope of circular economy research in the construction sector and encouraging its application in other industries.

Iva *et. al.,* (2020) presented the potential of digital technologies, including Digital Twins, to support circular economy practices in the Architecture, Engineering, and Construction (AEC) industry. Key applications of digital technologies in construction include resource assessment, waste prediction and optimization, and the proposed Digital Platform for Circular Economy (DEEP). DEEP integrates stakeholders and data repositories to optimize resource utilization, foster collaboration, and generate added value throughout the building project lifecycle.

Xie *et. al.* (2021) employed scientometric analysis to review the current state of Digital Twins in the construction industry. The study reveals various applications of Digital Twins, including data collection and creation of DT frameworks, detailed planning and construction site control, asset management, fault prediction, and virtual design and construction (VDC). Although Digital Twins exhibit vast potential in construction, more research is needed to ensure accurate and reliable predictions, standardized data formats, and increased interoperability between software platforms.

2.2 Digital Twins for Enhancing Circular Economy's Enablers

In the realm of the UK construction industry, digital twins possess meaningful potential to amplify circular economy practices. These digital replicas of physical assets can furnish valuable insights and data-driven decision-making across various phases of construction projects, thereby enhancing efficiency, collaboration, and sustainability. Moreover, digital twins can assist companies in adhering to regulatory requirements and fostering skill development (Mirzad,2023; Anne et.al, 2021).The UK construction sector recognizes that the integration of digital twins can improve numerous aspects, including design and planning, construction, operation and maintenance, renovation and end-of-life, data-driven decision-making, collaboration and communication, regulatory compliance, and skills development (Frąckiewicz, 2023; Pratas, 2023).Stakeholders in the UK construction industry can pinpoint opportunities for innovation, collaboration, and growth throughout different phases of construction projects by thoroughly exploring the potential of digital twins to enhance circular economy practices.

The integration of digital twins in the construction sector of the United Kingdom has arisen as a highly promising and advantageous strategy for bolstering sustainability and circular economy practices. The establishment of an Integrated Data Ecosystem is a prerequisite for the effective integration of digital twins in the construction industry. Digital twins have emerged as a highly promising strategy for promoting sustainability and circular economy practices in the construction sector of the United Kingdom. However, their successful implementation requires the establishment of an Integrated Data Ecosystem, which collects, manages, and analyses data from various sources, such as Building Information Modelling (BIM), Geographic Information Systems (GIS), and virtual design and construction (VDC) tools. Haritonova (2023) emphasized the importance of this ecosystem, which was cited by Ammar *et al.* (2022) and Lawton (2021). Such a comprehensive system allows for seamless data exchange and interoperability, which are fundamental for the successful implementation of digital twins in the construction industry, as stated by (Haritonova, 2023).

The employment of Advanced Data Analytics serves as a crucial facilitator for the efficacious implementation of digital twins in the circular economy approach of the UK construction sector. Real-time Data Analysis, a key aspect of Advanced Data Analytics, facilitates the processing of real-time data from digital twins, thus providing valuable insights into the performance of built assets. This, in turn, enables informed decision-making for sustainable practices, as posited by
Frąckiewicz in 2023. Predictive Analytics, another vital component of Advanced Data Analytics, aids in the identification of potential issues by analysing historical data and identifying patterns, thereby optimizing resource usage and contributing to the circular economy, as suggested by (Gamota in 2022).

Frąckiewicz, (2023) posits that the integration of digital twins with IoT devices and sensors enables the continuous collection and analysis of data, which can be utilized for monitoring and optimizing resource usage, waste management, and energy efficiency. Machine Learning and AI can be combined with Advanced Data Analytics to identify opportunities for improvement and automation in construction processes, thus leading to more sustainable and circular practices, as argued by (Sander, 2022; Preut *et al.,* 2021). Furthermore, Advanced Data Analytics can enhance decision-making capabilities by providing construction professionals with actionable insights and data-driven decision-making capabilities, enabling them to implement circular economy principles more effectively, as suggested by (Hazlegreaves, 2023; Program-Ace, 2023).

The emergence of Advanced Modelling and Simulation Tools has been a significant enabler for the effective utilization of digital twins in implementing circular economy principles in the United Kingdom's construction sector. These tools have facilitated the creation of virtual replicas of physical assets, which in turn has provided valuable insights and data-driven decision-making throughout various construction project phases (Omrany *et al.,* 2023); (Opoku *et al.,* 2023), (Yu *et al.,* 2022). The utilization of advanced modelling and simulation tools in the context of digital twins can offer numerous benefits.

The utilization of digital twins in combination with predictive analytics can contribute to the reduction of carbon emissions and promote the principles of circular economy by identifying opportunities for energy efficiency and sustainable practices. Numerous applications of predictive analytics in conjunction with digital twins for the construction sector in the United Kingdom include: Virtual Design in Construction: Digital twins have the capability to simulate construction projects and pinpoint potential issues before they arise, ultimately saving time and resources by preventing costly mistakes (Omrany et al., 2023).Project Planning and Management: Digital twins can facilitate the monitoring of production systems, with the goal of attaining and sustaining peak efficiency throughout the entire manufacturing process (Opoku *et al.,* 2023). Asset Management and Maintenance: Digital twins have the potential to revamp asset management and maintenance by providing real-time data and insights on the performance of constructed assets (Attaran and Celik, 2023). Safety Management: Digital twins can be utilized to simulate safety scenarios and identify potential hazards, promoting improved safety management practices (Omrany *et al.,* 2023). Energy Efficiency and Sustainability: Digital twins can help unveil opportunities for energy efficiency and sustainable practices, which can contribute to the reduction of carbon emissions while simultaneously promoting the principles of circular economy (Attaran and Celik, 2023).

Continuous monitoring and feedback loops have become increasingly prominent in recent years as enablers for the effective utilization of digital twins in implementing circular economy practices in the UK construction sector. The use of digital twins for simulating construction projects can help identify potential problems before they occur, resulting in significant savings of time and resources by avoiding costly mistakes. (Ammar *et al.,* 2022; Callcut *et al.,* 2021). In addition, digital twins can aid in monitoring production systems to achieve and maintain peak efficiency throughout the entire manufacturing process (Callcut *et al.,*2021;Broo and Schooling,2021). In terms of asset management and maintenance, digital twins can revolutionize these areas by providing real-time data and insights on the performance of built assets (Talla *et al.,*2022; Callcut *et al.,* 2021).

In order to attain the most favorable outcomes in the realm of construction by employing digital twins, it is advised that the incorporation of monitoring feedback loops should be carried out at diverse intervals of cycle time. These intervals encompass monitoring activities aimed at ascertaining adherence to the principal project master plan milestones, as well as near instantaneous cycles of monitoring material deliveries, locations of workers and equipment, among other factors (Sacks *et al.,* 2020). The use of digital twins for simulating safety scenarios can also help identify potential hazards and improve safety management practices (Callcut *et al.,* 2021). The integration of digital twins has been recognized as a promising approach to ameliorate circular economy practices in the UK construction sector (Ammar *et al.,* 2022).

3. Research Methodology

In this study, a structured questionnaire survey was used to collect data from construction sustainability professionals with UK experience in both DT and CE. United Kingdom is where the study was conducted. These professionals include structural engineers, construction managers, architects, construction project managers, quantity surveyors, and civil engineers. For this research study, convenience sampling was employed because it allows the researcher to identify the participants with the right experience and specialist knowledge needed for the study(Emerson, 2015) – for e.g. have experience in both DT and CE. The findings of the literature review analysis were used to draft the questionnaire. The collected data from the questionnaire survey were analysed using descriptive statistics (mean item score) and standard deviation tools with the Statistical Package for Social Sciences (SPSS) software. Cronbach's alpha was used to perform a reliability test on the data collecting tool, and the results suggest that enablers of DT and CE and benefits of DT and CE had values of 0.790 and 0.815, respectively.

3.1 Respondents background information

According to research into the respondents' professional backgrounds, 28% are architects, 16% are construction contractors, 24% are structural and civil engineers, 16% are project managers for the construction industry, 13.33% are sustainability experts, and 2.67% are from other professions. The results also showed that 5.6% of respondents had a doctorate degree, 17.6% had a master's degree, and 22.0% had a diploma. Of those who responded, 54.8% have a bachelor's degree. 35% of respondents work for government organizations, while 65% work for private establishments. Additionally, results showed that 33% of respondents had experience ranging from 1 to 5 years, 36% had experience ranging from 6 to 10 years, and 21% had experience ranging from 11 to 15 years. In addition, research on the number of DT and CE projects the respondents are now working on revealed that while 55.1% of respondents are actively working on DT initiatives, 44.9% are not. Results of the respondents' participation in past DT projects showed that 85.4% had previously participated in DT projects, compared to 14.6% who had never participated in any. This led to the 14.6% of respondents who had never been part in a DT project having their responses deleted from the analysis.

4. Result Discussion and Findings

4.1 Benefits of Digital Twins in Enhancing Circular Economy Practices in UK

Table 1 shows how respondents ranked the potential benefits of digital twins in enhancing circular economy in UK. It reveals that the first rank benefit of DT was DT can help in reducing construction waste in UK has a mean value of 3.97 and 1.4411SD, the second highly ranked benefit was DT can help in facilitating the identification of opportunities for material recycling in construction has (SD=1.3776) and mean value of 3.96.

Table 1. Benefits of Digital Twins in Enhancing Circular Economy Practices in UK

S/No	Benefits Factor	Mean	STD	Rank
1	Digital twins can help in reducing construction waste in UK.	3.97	1.4411	1st
2	Digital twins can facilitate the identification of opportunities for material recycling in construction.	3.96	1.3776	2nd
3	Digital twins can improve the tracking and management for materials recycling in construction.	3.92	1.5097	3rd
4	Digital twins can enhance optimization of design and planning processes to achieve circular economy.	3.89	1.5262	4th
5	Digital twins can be used for the monitoring of construction.	3.89	1.5122	5th
6	Digital twins can enable predictive maintenance progress.	3.80	1.5819	6th
7	Digital twins support the design of more sustainable buildings.	3.60	1.6311	7th
8	Digital twins make easier to implement circular economy principles.	3.56	1.5097	8th
9	Digital twins enhance collaboration among stakeholders to achieve circularity goals.	3.46	1.7080	9th
10	Digital twins have the capacity to substantially augment the circular economy practices in the renovation and end-of life stages.	3.42	1.7735	10th
11	Digital twins have the potential to lower construction costs in the long run.	3.42	1.7735	11th
12	Digital twins enable better tracking of materials in real-time	3.41	1.4180	12th

Digital twins can improve the tracking and management for materials recycling in construction ranked third having a mean estimate of 3.92 and 1.5097SD, the fourth-ranked mean and standard deviation are 3.89 and (SD=1.5262), respectively was Digital twins can enhance optimization of design and planning processes to achieve circular economy. The mean ranking for number five benefit, Digital twins can be used for the monitoring of construction was 3.89 and SD of 1.5122. Digital twins enable better tracking of materials in real-time were ranked twelfth on a mean point of 3.42 and (SD=1.4180). At the same time, the eleventh highly rated benefit is that Digital twins have the potential to lower construction costs in the long run, with a mean item value of 3.42 and 1.7735SD.

The study's findings revealed that the potential benefits of digital twins in enhancing circular economy in UK was that DT can help in reducing construction waste in UK, DT can help in facilitating the identification of opportunities for material recycling in construction, Digital twins can improve the tracking and management for materials recycling in construction. Digital twins can improve the tracking and management for materials recycling in construction, Digital twins can enhance optimization of design and planning processes to achieve circular economy, Digital twins can be used for the monitoring of construction as supported by (Omrany *et al.,* 2023; Opoku *et al.,* 2023; Yu *et al.,* 2022;Chen and Huang, 2020).Digital twins' benefits society and the community by reducing construction waste, facilitating opportunities for identifying recycling in construction. By so doing, environmental impact of construction activities is reduced to the barest minimum and markets for Digital twins products and services are stimulated. This will also result in improved performance and success for the construction industry and can enhance circular economy practices in different phases of construction projects.

4.1 Enablers of Digital Twins in Enhancing Circular Economy Practices in UK

Table 2 shows how respondents ranked the factors influencing Digital twins in enhancing circular economy practices in UK. It reveals that Integrated data ecosystem has 4.48 as mean score with (SD=0.545) and was ranked first, Advanced data analytics occupied the second position with mean value of 4.47 and (SD=0.555), Real-time data analysis was ranked number three with (SD=0.567) and achieved a mean value of 4.46, Predictive analytics has the same ranking with number third with a mean score of 4.46 and but with (SD=0.568), number eleven in order achieved a mean item score of 4.33 and (SD=0.854) which is Continuous monitoring and feedback. Having a mean item score of 4.45 and (SD=0.678), Continuous collection and analysis of data occupied fifth position.

Table 2. Enablers of Digital Twins in Enhancing Circular EconomyPractices in UK

S/No	Enablers Factor	Mean	STD	Rank
1	Integrated data ecosystem	4.48	0.5450	1st
2	Advanced data analytics	4.47	0.5550	2nd
3	Real-time data analysis	4.46	0.5670	3rd
4	Predictive analytics	4.46	0.5680	4th
5	Continuous collection and analysis of data	4.45	0.6780	5th
6	Emergence of advanced modelling and simulation tools	4.49	0.5990	6th
7	Virtual design in construction	4.38	0.6750	7th
8	Asset management and maintenance	4.37	0.6850	8th
9	Safety management	4.35	0.7250	9th
10	Energy efficiency and sustainability	4.34	0.7540	10th
11	Continuous monitoring and feedback	4.33	0.8540	11th

The tenth number on the ranking was Energy efficiency and sustainability, with a mean item score of 4.34 and (SD=0.754), and Safety management, Virtual design in construction, and Asset management and maintenance were ranked seventh, eighth and nineth respectively, having a mean value score of 4.38 and (SD=0.675), 4.37 and (SD=0.685) and 4.35 with (SD=0.725).

These findings support the work of Haritonova (2023), Ammar *et al.* (2022), and Lawton (2021) who also foundthat an Integrated Data Ecosystem is necessary for effectively integrating digital twins in the construction industry. Digital twins are a viable technique for encouraging sustainability and circular economy principles in the building sector of the United Kingdom. Successful implementation necessitates the creation of an Integrated Data Ecosystem that gathers, organises, and analyses data from diverse sources like Building Information Modelling (BIM), Geographic Information Systems (GIS), and virtual design and construction (VDC) tools. Utilising Advanced Data Analytics is essential for effectively implementing digital twins in the circular economy strategy of the UK construction industry. Real-time Data Analysis is a crucial component of Advanced Data Analytics that enables the immediate processing of data from digital twins, offering significant insights into the performance of constructed assets. This allows for well-informed decision-making on sustainable practices, as proposed by (Frąckiewicz, 2023). Predictive Analytics, a crucial element of Advanced Data Analytics, helps detect possible problems by examining past data and seeing patterns, ultimately enhancing resource allocation and supporting the circular economy, as proposed by (Gamota, 2022).

5. Conclusion and area for further research

This research paper examined digital twin and circular economy by investigating the benefits and enablers of adopting DT for enhancing CE in the UK construction industry. The primary benefits and enablers of DT for enhancing CE were identified based on data collected in the United Kingdom. According to the study's findings, the potential benefits of digital twins in enhancing circular economy in UK are enormous. Digital twin can enhance circular economy in numerous ways, including reduction of construction waste, facilitating the identification of opportunities for material recycling in construction, improving the tracking and management for materials recycling in construction, enhancing optimization of design and planning processes to achieve circular economy, useful for monitoring of construction, enable better tracking of materials in real-time, potential for to lower construction costs in the long run, it can enhance optimization of design and planning processes to achieve circular economy, among other things. The findings of the enabling factors influencing Digital twins in enhancing circular economy practices in UK are an Integrated Data Ecosystem is necessary for effectively integrating digital twins in the construction industry. Digital twins are a viable technique for encouraging sustainability and circular economy principles in the building sector of the United Kingdom. Successful implementation necessitates the creation of an Integrated Data Ecosystem that gathers, organises, and analyses data from diverse sources. Utilising Advanced Data Analytics is essential for effectively implementing digital twins in the circular economy strategy of the UK construction industry. Real-time Data Analysis is a crucial component of Advanced Data Analytics that enables the immediate processing of data from digital twins, offering significant insights into the performance of constructed assets. Predictive Analytics, a crucial element of Advanced Data Analytics, helps detect possible problems by examining past data and seeing patterns, ultimately enhancing resource allocation and supporting the circular economy.

The findings of the study suggest that the best way to promote digital twins in enhancing circular economy in the UK construction industry is the creation of an Integrated Data Ecosystem that gathers, organises, and analyses data from diverse sources. Utilising Advanced Data Analytics, Real-time Data Analysis, Predictive Analytics, and Virtual Design in Construction are essential for effectively implementing digital twins in the circular economy strategy of the UK construction industry.As a result, it is recommended that the role of government is important in driving this digital twin incorporation in circular economy.Sufficient government support, with clear call for more robust state-backed incentives, policies, and assistance is required and government should engage with industry leaders, experts, and stakeholders to understand their needs better and formulate supportive policies.These legislation and policies can include but are not limited to: For instance, government can give financial incentives such as subsidies and tax rebates to encourage digital twining and circular practices and development. Due to time and financial constraints, the study was limited to the Lincoln, United Kingdom; however, additional research can be conducted in the other areas of United Kingdom to provide a nationwide picture of enablers and benefits of DT in enhancing CE for the construction industry.

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