ISSN No:-2456-2165

Sustainable Building Project Delivery in the Era of 4th Industrial Revolution

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Abstract:- Harnessing the fourth industrial revolution for sustainable building projects requires digitization, automation, and the increased use of Information and Communications Technology (ICT). The construction industry compared to other industries seems to lag behind in incorporating these innovative technologies. However, there are numerous challenges in implementing and engaging the use of technology in the construction industry. A review is done to identify the issues underlining the adoption of technology in the construction industry.

This study shows that the critical factor affecting the successful implementation is the lack of awareness and technical know-how. However, the study also highlights that there are numerous opportunities in the future if critical steps are taken to bridge the gap in technical knowledge for sustainable building projects whilst adopting the technology of the fourth industrial revolution.

Keywords:- *Sustainability; Industrial Revolution; Information and Communication Technology; and Construction.*

I. INTRODUCTION

Since the 1700s, when the era of industrialization began, each industrial revolution has contributed significantly to the advancement of modern development. The introduction of mechanical looms, which supplanted the agricultural industries and significantly improved the economic structure, occurred in the 1700s (Philbeck, & Davis, 2018). These looms were powered by water and steam on mechanical machinery. The introduction of electrical energy, which led to the establishment of the mass production system, sparked the Second Industrial Revolution in the 1870s (Alaloul, et al. 2020) These revolutions were dependent on how much more capable humans were. The Third Industrial Revolution, brought on by the development of electronics, took place in the 1970s. The term "Digital Revolution" describes the technological advancement from analog electronic and mechanical devices to the current state of digital technology (Alaloul, et al. 2020). The Fourth Industrial Revolution (IR 4.0) is now being constructed upon the Digital Revolution, in which people and technology are interconnected. The Fourth Industrial Revolution, also known as Industry 4.0, is a concept that describes the significant changes in technology, industries, and societal patterns and processes that will occur in the 21st century as a result of growing interconnectedness and intelligent automation. The word has been widely used in scientific literature, and World Economic Forum founder and executive chairman Klaus Schwab popularized it in 2015 (Bai, et al.2020). By obfuscating the distinctions between physical, digital, and biological entities, technological advance has discovered new ways to demonstrate their capabilities. In addition to modern procedures supporting every industry component, the revolution also promotes sustainability (Colombo, et al. 2014), of which renewable energy and energy efficiency are two key elements (Lee, et al. 2018). Although the implementation is challenging, renewable energy still accounts for 19.2% of consumption and is impacted by technological advancements in the sector (Carvalho, et al 2018). The Industrial Revolution (IR) 4.0) aims for a workable and sustainable manufacturing system and has a higher level of complexity for integrating the production and product processes, where it becomes a part of the sustainable system (Carvalho, et al 2018). When adopting Industry 4.0 to create sustainable industries, all three aspects of sustainability—social, economic, and environmental—are valued and used for long-term competitiveness (Carvalho, et al 2018). For both short- and long-term impacts on sustainability, consideration of tactical, operational, and strategic dimensions is crucial. By implementing 4IR, which increases product quality while reducing time-to-market and improving operational performance, the benefits of 4IR are evident. Despite the many advantages offered by the other industries, the building industry has been reluctant to adopt these ideas. Construction industry resistance to adopting IR 4.0 was evident even in the complicated construction environment (Alaloul et al. 2020). Whereas the entire value chain of construction involves numerous dispersed counterparts from all levels with a variety of backgrounds to cater to the unique needs of each project. Small and medium-sized businesses (SMEs) are now less able to invest in new technologies due to the phenomenon's increased complexity in implementation.

Despite the obvious advantages that IR 4.0 principles provide, the construction industry is still having trouble implementing them. There are a few difficulties in the construction sector that lead to incompatibility. Complexity, ambiguity, a disjointed supply chain, short-term thinking, and culture are among the issues, according to Oesterreich and Teuteberg (Oesterreich, &Teuteberg, 2016). The engagement of numerous stakeholders makes construction projects difficult, making them special. A project's degree of

ISSN No:-2456-2165

uncertainty is also determined by the project's unpredictable environment and its added complexities. Whereas the short-term nature of building projects is a barrier to innovation, the supply chain is fragmented and construction businesses' short-term mindset has constrained their capacities. Whereas the construction industry's culture is infamous for its slow-to-adapt methods.

II. OBJECTIVE OF THE STUDY

This study seeks to ascertain the:

- Awareness and utilization rate of technology in building in the 4th industrial revolution.
- Challenges in deploying technologies of the fourth industrial revolution in construction.

A. Scope of the Study

The construction industry's scope of work is broad and includes everything from building infrastructure to residential, commercial, and industrial projects. The industry's contribution to a nation's Gross Domestic Product is more significant (GDP). The construction industry generates over US$10 trillion in total yearly sales, US$3.6 trillion in added value, and contributes roughly 6% of the global GDP, according to the World Economic Forum (WEF) [1]. Additionally, it represents more than 8% of GDP in underdeveloped countries and roughly 5% of GDP overall in affluent nations. (Keogh, & Smallwood, 2021). This study is concentrated on investigating key elements influencing the effective adoption of 4 IR in the construction industry.

B. Significance of the Study

This study looks at the potential problems faced by construction businesses that want to use modern technologies to further their goals and remain competitive in both domestic and international markets. It provides an overview of Industry 4.0 and its primary technologies as they apply to the construction industry. Knowledge of the most recent technologies empowers businesses with excellent management vision. The second advantage of this piece is that it can assist companies in assessing the level of digitization of their processes. Kids can now understand that combining two of these technologies can be more advantageous in other ways.

III. LITERATURE REVIEW

A study by Keogh, & Smallwood reviews that, Construction still faces several difficulties, including outdated processes and practices, adhering to regulations, data collection and recording, monitoring, a lack of competent labor, and a decline in enthusiasm for working in the sector. Then, difficulties are encountered regarding performance with the project's cost, environment, health and safety, productivity, quality, and schedule limits. In light of the difficulties and the arrival of Industry 4.0, research was carried out to ascertain the difficulties encountered, project performance to the parameters, and the potential contribution of Industry 4.0 to overcome the difficulties. They concluded that there is a need for interventions to increase awareness and to integrate such technologies into built environment/construction education and training. There is also a need for improvements in performance in construction that have the potential to improve a perceived need for the implementation of Industry 4.0 (Keogh, & Smallwood, 2021).

Taher (2021) states that The adoption of IR 4.0 within the construction sector would boost performance on par with that of its competitors in the industrial and automotive sectors. Industry 4.0 must be embraced since it is the direction of the future. Even on the construction site, digitization is the only option. Construction needs to catch up. According to a study on the impact of 4IR on developing nations, Industry 4.0 may make it possible for these nations to take a larger share of the global manufacturing value chain (Hopali, &Vayvay. 2018).

An article that examines the applicability of the major Industry 4.0 technologies of a digital twin, robotics, automation, building information management, sensors, wearables, and industrial networking to the construction industry. To fully realize the benefits of Industry 4.0, it is stated that Industrial connection is a crucial component. This ensures that all technologies are integrated. In addition, the article outlines a research agenda for the adoption of Industry 4.0 technologies in the construction industry, a three-phase use of intelligent assets from the point of manufacture to after construction, and a four-stage R&D process for the application of smart wearables in a digitally enhanced construction site. Building components might be used in three stages as intelligent assets, creating a new real-time and context-aware data stream that could be used to communicate with both workers and automated industrial processes in a digital twin environment. Machines and goods should be able to connect with and learn from one another thanks to faster processing, smarter tools, smaller sensors, and lower data storage and transmission costs (Turner, et al.2020).

The conventional nature of the methodologies used in the construction industry's activities and the low use of ICT are what define these activities. The quality of the resulting infrastructure is thus in doubt, which has an impact on the general performance of the construction industry [17]. However, the use of technology to deal with these issues is growing. According to research done in the construction sector in the United Kingdom in 2019, 75% of construction businesses reported using file-sharing applications to share and access designs, up from 52% in 2018 (Keogh, & Smallwood, 2021). Only a small percentage of responders (7%) use technology to oversee the entire procedure. Furthermore, there is a significant gap between businesses that approach new technology expenditures strategically and those that do so on an ad hoc basis: 26% of businesses lack a strategy, while 36% of businesses merely invest on an as-needed basis.

The industry is moving toward digitization and including technology in the construction process. The construction industry should aggressively adopt relevant software or computer systems that can communicate and utilize information, such as BIM, where applicable. Accordingly, they should incorporate off-site fabrication,

prefabrication, pre-assembly, modularization, and demonstrative installations into their building processes (Hu, & Liu, 2016)). According to Autodesk & CIOB (Keogh, & Smallwood, 2021), successful organizations will be those whose executives pursue measures to lower adoption barriers and integrate digital technologies into their corporate strategies.

IV. EMPIRICAL REVIEW

There are numerous studies on sustainable building projects in the 4th industrial revolution. According to the World Economic Forum in conjunction with PWC (2017). They surveyed over 50 countries with descriptive statistics and analysis. Their findings were that the 4tth industrial revolution technologies can potentially aid transparency and projection in risk assessment, mitigations, and responses. Technologies like AI and IoT can be deployed to communicate and predict future shocks on the go and technologies like 3D printing can be deployed to enhance the rebuilding of urban infrastructure making it more resilient and with a lower ecological footprint.

V. METHODOLOGY AND FINDINGS

Because we utilized primary data for the research, an ex post facto research design was adopted since the data already exists and we will not carry out any further iterations on the data.For this study questionnaires were distributed to multiple construction companies, Questionnaires were distributed by E-mail and hard copies.Table 1 represents the demographic data of the respondents.

For this study, MS Excel was utilized for Average Index (AI) and Relative Importance Index (RII), SPSS was used to analyze the gathered data for validity and reliability of gathered data.

Average Index (AI) The AI method is used to evaluate the influencing factors and identify the most critical factor in IR 4.0 having a higher impact on the construction industry.

The study was conducted using the Six Sigma Quality Initiative method (Define, Measure, Analyze, Improve and Control)

The AI equation is as described below:
Average Index AI ð Þ¼ PðWnÞ N ð1Þ

where W: scale weightage from 1 to 5, given to each factor by respondents;
n: frequency of respondents,
N: total number of respondents.

The classifications of the rating scales are: 1 = Strongly Disagree (1.0 Average Index < 1.5), 2 = Disagree (1.5 Average Index < 2.5) 3 = Neutral (2.5 Average Index < 3.5), 4 = Agree (3.5 Average Index < 4.5), 5 = Strongly Agree (4.5 Average Index 5.0).

Relative Importance Index (RII)

The AI equation is as described below:
Relative Importance Index RII ð Þ¼
PW
A N ð2Þ
where
W: scale weightage from 1 to 5, given to each factor by
respondents,
A: highest weightage is given,
N: total number of respondents.

VI. RESULTS AND DISCUSSION

Descriptive Statistics

Table 1: Demographic Summary of Respondents

S. No.	Variable	Category	Frequency	Perce
1	Exposure to IR 4.0 Technology	Yes	34	34
		No	13	13
		Maybe	53	53
2	Age Group	20–29	23	23
		30–39	19	19
		40–49	26	26
		>50	32	32
3	Years of Experience	<5 years	24	24
		5–10 years	8	8
		11–15 years	15	15
		>15 years	53	53
4	Position in the Company	Project Director/Manager	32	32
		Design Engineer	9	9
		Project Site Engineer	24	24
		Quantity Surveyor	6	6
		Others	29	29
5	Company Profile	Developer	15	15
		Consultant	13	13
		Contractor	41	41

Source: Authors Survey results

ISSN No:-2456-2165

53% of respondents do not have an awareness of the use of IR 4.0 technologies in the construction industry, while 34% have some exposure due to their working experience. However, the remaining 13% of respondents are not comfortable with the technology used and are listed as the technology related to IR 4.0. The distribution of companies amongst respondents profiles 41% of respondents as contractors, 15% of respondents as developers,11% as client service managers, and 13% as consultants while the remaining 20% were service providers and Government officials.

Although the 13% of respondents who replied may be, after being shown a list of IR 4.0-related technologies as listed in the Table.2, positively affirmed that they have been exposed to these technologies. This brings up to 47% of the sample who are aware of the technologies of the fourth industrial revolution.

Table 2: Summary of IR 4.0-related technology

Cluster	Key technologies in the context of IR 4.0
Smart Factory	Cyber-Physical, systems/Embedded systems Internet of Things/Services Automation Modularization/Prefabrication Additive Manufacturing Product-Lifecycle-Management Robotics Human-Computer Interaction
Simulation and Modelling	Simulation Tools/Simulation Models Building Information Modelling Augmented Reality (AR)/Virtual Reality (VR)
Digitization and Vitualization	Cloud Computing Big Data Mobile Computing Social Media Digitization

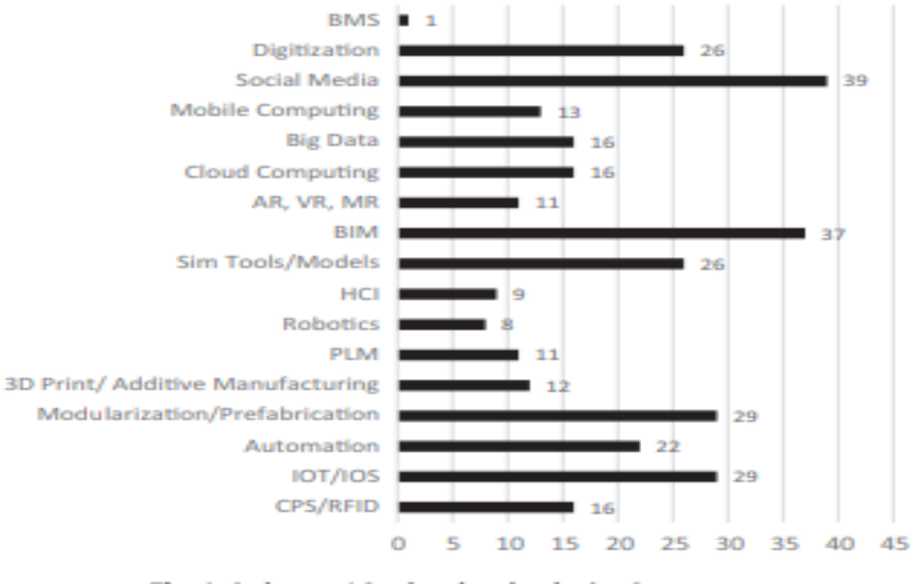

Fig. 1: Industry-related technologies and concepts

As listed in fig.1 47% of the respondents who identified as being exposed to IR 4.0-related technologies, identified Social Media and Building Information Modeling (BIM) as the most common technologies they have used. Identified in the mid-range (40– 60%) of the combined technologies were Internet of things (IoT) Modularization/Prefabrication, /Internet of Services (IoS), Digitization, and Automation.

Given the list of technologies, by verifying and identifying the IR 4.0-related technologies and concepts. the data concludes that all the Industry 4.0-related technologies have been implemented and utilized. This data proves that despite the even distribution of responses in FIG 2. It shows that these innovative technologies listed as attained some level of maturity within the construction industry.

ISSN No:-2456-2165

VII. CONCLUSION

IR 4.0 has been around for a while in the construction sector, and the technologies are at various stages of development. While other technologies like Augmented, Virtual, and Mixed Reality are still being developed and might have an impact on the industry's sustainability, some technologies like BIM, Cloud Computing, and Modularization have advanced greatly. Despite having access to these technologies, IR 4.0 adoption within the construction industry is still quite poor. The construction industry has adopted IR 4.0 methods, and the implementation of these practices has resulted in major effects across numerous platforms. However, the difficulties encountered must be resolved by all parties concerned to guarantee a successful implementation. The adoption of IR4.0 within the construction sector would boost performance on par with that of its competitors in the industrial and automotive sectors.

VIII. RECOMMENDATION

As was previously said, the lack of technical knowledge is a result of the construction industry's resistance to integrating Industry 4.0 technologies and going through the digital transformation. Since the construction sector is a complex ecosystem, more efforts from academics and industry stakeholders are needed to adopt the new concepts of the 4th Industrial revolution and push its traditional boundaries. That is, employer associations, professional associations, and statutory councils should increase public awareness of the potential application of Industry 4.0 in the construction industry; case studies should be documented and the results shared; tertiary built environment education programs should integrate Industry 4.0 into all relevant modules, and continuing professional development (CPD) should address Industry 4.0.

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