Construction 4.0

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Construction 4.0 is a variety of interdisciplinary technologies, methodologies and concepts that digitize, automate and integrate the construction process at all stages of the value chain

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1. Introduction

Construction 4.0 is a fairly new concept, but it is getting a lot of attention, therefore many researchers have attempted to define it. The literature review revealed that the definitions are vague and mostly adopt broader concepts from Industry 4.0, which is considered as a predecessor of Construction 4.0 [1]. Before even the term Construction 4.0 appeared, researchers tried to define the Industry 4.0 concept from a construction perspective. Oesterreich and Teuteberg describe it as a variety of interdisciplinary technologies that digitize, automate and integrate the construction process at all stages of the value chain [2]. One of the proposed classifications, developed to characterize the Construction 4.0 concept, is based on two pillars: the digitalization of the construction industry and the industrialization of construction processes [1][3].

There is no doubt that emerging information technology is the core driving force endorsing the smart construction system [4]. A number of articles have described the use of technology as a tool to change construction processes, but research on Building Information Modeling (BIM) as a potential catalyst for industry change has not received an adequate attention [5]. However, BIM has the potential to be the key to transforming the entire industry. Through the use of integrated tools such as collision detection, 4D planning and 5D cost estimation, business processes can be managed directly in the digital realm [5][6].

2. Impact of Industry 4.0 Platform on the Formation of Construction 4.0 Concept

There is a gap between Industry 4.0 and the construction industry, and it will continue to grow as long as there is a low adoption of technology and a lack of innovative processes in construction [7]. Modern construction urgently requires smarter resources, but smart construction is still in its infancy [4]. Going digital is a necessary solution to transform the construction industry for increasing its productivity [8]. For instance, the rate of productivity development in the manufacturing industry has long been higher than in all other sectors, especially compared to construction. However, in light of the developing idea of industrialization of construction, the construction industry can be considered as a sub-industry of the manufacturing industry [9]. As cited from [10], Hermann et al. [11] compared the interaction of Industry 4.0 and construction with a “smart factory”, where cyber–physical systems allow all stakeholders to collaborate along the entire value chain for the communication and functioning of humans and machines via the Internet of Things, as well as to control processes and make decentralized decisions through a virtual copy of the physical integrated smart factories. A cyber–physical system is the result of the integration between BIM and IoT. Cyber–physical systems can provide bi-directional information exchange used to monitor asset performance in real time and to provide notification of any problems before they occur in the physical environment or offer and share internal and inter-organizational services across the entire value chain. Therefore, the synergy of Industry 4.0 technologies with elements of the construction sector can optimize the supply chain, control physical processes by creating virtual models and decentralize decision-making [7].

Construction 4.0 is not just traditional construction upgraded with technological innovations but is also a new way of perceiving and understanding construction through the light of innovation and increased productivity [1][12]. For example, technologies that the construction industry has adopted from Industry 4.0 are Internet of Things, simulation, autonomous system, robotics, augmented reality, additive manufacturing and big data. The technology that construction has not adopted is cyber security. On the other hand, there are special applications that are specific only to construction, namely Building Information Modeling (BIM), 3D construction printing or modularization of construction components. Thus, the construction sector has also adapted, and not only adopted, the concept of Industry 4.0 within the sector [7]. Otherwise, these technologies are on different levels of maturity. Central technologies like Building Information Modeling (BIM), mobile computing, cloud computing or modularization have reached market maturity but Additive Manufacturing, Augmented, Mixed and Virtual Reality are still at the prototyping stage [2]. According to Qi et al. [13], the most adopted and funded top three technologies in the construction industry are: BIM dimensions analysis models, sensing technology and business information models [14].

BIM is one of the most widely researched smart systems [15]. Oesterreich and Teuteberg admitted that Building Information Modeling (BIM) is considered one of the most important technologies in construction and plays a central role in digitizing the building environment [2]. BIM is a key input to a more complex system, such as creating a digital twin for construction. A digital twin provides a near-real-time connection between the physical and digital world, allowing human behavior patterns and space design to be incorporated, which is only possible through integration with other Industry 4.0 pillars like IoT, and cannot be done with BIM alone [7]. BIM combined with virtual reality technology can create a virtual construction environment that can be used for site layout, construction scheduling, safety assessment, coordination of subcontractors, and safety training of workers [16]. Contractors can benefit from digital data provided by implementing BIM at a primary project stage. BIM provides time, cost and sustainability planning, decreases waste and enhances the general project performance. In the construction phase, compatible use of BIM technology and digital processing provide advanced management, well-organized project formation and precise distribution of information [9][17][18].

Despite the availability and maturity of many technologies, they are not widely adopted by construction companies [2]. According to the survey presented in [10], among the construction professionals in Malaysia, 53% of respondents are unaware of the implementation of Industry 4.0 technology in the construction industry, while 34% have met some of the technologies during their working experience. Interestingly, the remaining 13% of respondents were unsure of the connections between listed technologies and Industry 4.0. After those respondents were provided with a list of technologies related to Industry 4.0, they changed their point of view. After the change in perspective, the share of respondents familiar with Industry 4.0 technologies became 47%.

However, there are best practices that demonstrate practical ways of introducing new technologies into the construction process [2]. You and Feng proposed a framework of the cyber–physical system that integrates these technologies into a complex organizational system and verified this framework at the pilot project of the citizen service center in Xiong’an [16]. For this case study, the following applications and tools were used:

- Visual Studio—the development tool of the application software;
- SQL Azure—the database service deployed on the cloud platform;
- Autodesk Revit—the BIM tool;
- Revit Live—software for generating a VR scene through a 3D model;
- UAV with integrated functions of camera, laser scanning and orientation for real-time construction model acquisition;
- GPS helmets to capture workers’ locations in real time;
- RFID technology for tracking prefabricated components;
- Sensors for remote environmental monitoring (wind-force, wind-direction, humidity, dust, temperature and noise sensors).

The implementation of the proposed cyber–physical system in the construction project of the Xiong’an citizen service center helped complete the project according to the scheduling, contributed to the close collaboration between production, logistics and assembly processes by monitoring of the supply chain of prefabricated components, eliminated the delay of quality inspection information, and contributed to promoting sustainable construction [16].

Although Construction 4.0 is a fairly new term, it has already provoked the emergence of new concepts. For example, Calvetti et al. proposed the concept of Worker 4.0, which materializes the basic principles and behavior of workers in the Construction 4.0 scenario. Worker 4.0 is a framework for measuring craft workforce motion productivity, using embedded sensors for data collection that enable near real-time monitoring [14].

Rapid technological progress and development has also influenced technical changes in the city urban development, resulting in new models of cities, termed “smart cities”. Smart city is an important concept associated with Industry 4.0 and Construction 4.0. It is a concept that involves advanced digital technologies, new government models, sustainable management of natural resources, renewable energies and information technology knowledge [19]. The digital technologies we have analyzed support the development of Smart city concept.

3. Construction 4.0 impacts

Construction 4.0 brings new market opportunities. Competitiveness is supported by new business models [20] and innovations enable local companies to rise internationally [21] The greater competition further accelerates the development of innovations, and a growing market further facilitates the exchange of information. Furthermore, the exploding industrial revolution opens new avenues for resilient SMEs as they can adapt more quickly and flexibly to innovation solutions; this will not only be an improvement for SMEs but may even lead to a complete reorganisation of the market. In addition, centralised digital state-level strategies will further help companies' international market position[22].

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