BIM

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BIM is defined as the "construction of a model that contains the information about a building from all phases of the building life cycle" and defined by as "a digital representation of physical and functional characteristics of a facility. As such, it serves as a shared knowledge resource for information about a facility forming a reliable basis for decisions during its life cycle from inception onward".

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1. Overview

In the last decades, most industrial sectors saw a key evolution associated with product and process innovation, with digital technologies being adopted to improve their productivity and quality. However, in the Architectural, Engineering, Construction, and Operation sector (AECO), quality, productivity, and sustainability have not often kept pace, resulting in a stagnation of the sector's productivity [1]. In this case, the adoption of technologies can help enhance this sector, improving its efficiency and productivity. Several internal and external challenges are responsible for this situation, including the fragmentation of the construction projects, the lack of skilled labor, and failures in the transfer of information, either in the course of a project or from one project to another [2].

Currently, the increase of productivity, efficiency, sustainability, safety, quality levels, and the improvement of project management can be achieved only by means of digitalization, new construction techniques, and innovation. The focus on digitalization is also one of the proposed steps for construction companies to overcome the crisis caused by the COVID-19 pandemic, requiring a workforce with appropriate skills [3][4]. The construction sector, despite its importance for the European economy, has a significant negative impact on the environment, as it is responsible for 36% of carbon dioxide emissions, 40% of the energy consumption, and 55% of the electricity consumption in the European Union (EU). Accordingly, reducing energy consumption in the building sector, leading to building decarbonization and to the 2050 climate neutrality goal, is a critical and very ambitious target [5]. However, there is a current concern related to the mitigation of the climate change effects, as well as the fight against the classification of the construction sector as an unsustainable industry, owing to the severe impact of buildings on the environment, economy and society [6], which should begin in the conception phase of any project [7]. Additionally, construction management can play a crucial role in contributing to the decrease of resource consumption by means of efficient, reliable, and sustainable management processes. Thus, the development of sustainable projects, along with the recognition of the importance of Building Information Modelling (BIM) methodology, has become a priority to improve efficiency [8].

The enhancement of performance, competitiveness, productivity, and safety in the construction sector has been driven by the automation of traditional manual processes, made possible by the emergence of digital technologies (e.g., BIM, IoT—Internet of Things, mobile devices and sensors, drones) [9]. BIM permits ground-breaking ways to generate, visualize, exchange, predict, and monitor information along the life cycle of any building facility [10]. Worldwide, BIM is recognized as being one of the developments that has been contributing most significantly to the digitalization of the construction industry. It is an information technology that involves the application and maintenance of a comprehensive digital representation of all construction information for the different phases of the complex project life cycle, in the form of a data repository. This framework represents a new paradigm for designing, building, operating, and maintaining a facility, and it has become a leading practice across the AECO sector [11].

The fact that construction projects have become increasingly complex requires Industry/Construction 4.0 as a solution for a new business model [12][13]. The integration of BIM in cloud computing allows project stakeholders to collaborate in real-time from different locations, thereby improving the decision-making process and ensuring project deliverability [2]. BIM (in the design, planning, and management domain), as the center of construction digitalization, together with Industry 4.0 (production domain), can bridge the remaining digital gap and sustain the impact on future construction processes [14]. It allows for maximizing productivity [15], improving information flow during the project life cycle, optimizing energy efficiency [16], and improving safety [17][18], as well as resource planning, management, and monitoring [19].

2. BIM Concept

BIM is an object-based parametric methodology in which an element, class, or family contains a fixed or parametric geometry, a set of relations, and rules to control the parameters by which element instances can be generated. Therefore, parametric modelling relates geometry or other parameters of one object to those of other objects [20].

Therefore, BIM consists of managing and using digital information from projects [21]. Systems have also been developed to link other data sets with BIM, including spatial data generation using Geographic Information Systems (GIS), sensor data collection using IoT [19], and Facility Management (FM) software [22] to create Intelligent Facility Management (FIM) systems [23] and environmental performance data of infrastructures [24]. The growing need for many types of BIM-related data and applications, especially the urgent need to manage and operate those data in close combination with real-time, is resulting in an emerging field in the AECO referred to as Infrastructure Digital Twins (DT) [25].

3. BIM Applications

A BIM model is a computer model database of building design information which can be integrated with information about the construction, management, operations, and maintenance of the building. Thus, adding the different facility life cycle information to the 3D virtual model allows for the attainment of an nD model [26]. The 4D and 5D models can be respectively obtained by adding time (scheduling information to model construction sequences) and cost information to the 3D model. The 6D, 7D, and 8D models are obtained by adding the facility management, the sustainability, and the health and safety information to the 3D model. Those nD models allow for the visualization and simulation of the whole life cycle of a facility, supporting more accurate decision-making [27]. The application of the nD models leads to different implementations of BIM in different areas and, consequently, provides their dynamic and virtual analysis, for example in the scope of facility management [22], maintenance [28], energy analysis [29][30], sustainability and Life Cycle Assessment (LCA) [31][32][33], scheduling and budgeting [34][35], quality [36], and occupational risk prevention [18][37][38][39][40][41].

The research carried out by [42] points out BIM research papers in the scope of design and the construction phase, which highlights the need for 4D models for the virtual construction simulation, namely to analyze and visualize the variables which are constantly changing during the construction phase. It also states the importance of BIM applications based on 4D models for construction management, specifically the schedule, cost, quality, and safety control (all belonging to the construction management area). Despite the high number of applications of 4D models in the construction phase, and the wide range of different indicators and their dynamic behavior that has to be permanently analyzed during the construction phase, there is the need to automatically provide reliable, real-time, and interrelated data analysis to support the construction management in the pursuit of more efficient and sustainable management.

4. Data Management with BIM

As BIM provides an accurate parametric model of the project into which various parameters, such as the type of materials and their characteristics and construction systems, are entered in each building element, it gives the basis for better construction planning, including just-in-time procurement of people, materials, and equipment, which leads to cost savings, and a better collaboration in terms of the on-site work. Besides that, it promotes the reduction of errors, omissions, and resource consumption. Moreover, the use of collaborative forms of contracting (IPD—Integrated Project Delivery) reflects the benefit of collaborative work with integrated teams by using BIM methodology in the project and construction process management [20].

In construction management, given the amount, diversity, and complexity of the data involved, management (in any of its phases) is faced with the need for permanent data analysis and, despite the different computer tools currently at its disposal, the fast and reliable analysis of the data becomes difficult. Business Intelligence System (BIS) is a multidisciplinary analysis and decision-making system that analyses different types of data from different sources, allowing for [43]:

- the efficient analytical capacity. By means of a Business Intelligence Platform, implicit information from the data can be rapidly analyzed so that decision-makers can better understand the operation and solve problems, playing a vital role in the entire operation of an organization;

- the improved efficiency and level of decision-making, as historical information can be quickly analyzed and integrated to understand the state of the operation and support decision-making;

- the increase of the performance of an organization.

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