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Benefits and Obstacles of BIM Implementation and 4D Scheduling in Construction Projects in Egypt

Ahmed Mohamed Abdelalim[1*], Emad E Elbeltagi[2] and Hossam A Radwan[3]

[1]*Faculty of Engineering at Mataria, Helwan University, Egypt*

[2]*College of Engineering, Qassim University, Buraydah, Saudi Arabia and Faculty of Engineering- Mansoura University, Egypt*

[3]*Faculty of Engineering at Mataria, Helwan University, Egypt*

[*]Corresponding Author
Ahmed Mohammed Abdelalim, Faculty of Engineering at Mataria, Helwan University, Egypt.

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Abstract

The progress of using Building Information Modelling (BIM) in Architecture-Engineering- Construction (AEC) has been widely witnessed; many initiatives have been documented to use this technology in many countries worldwide. Despite all the research that has been published around the world, Four-dimensional (4D) scheduling applications continue to suffer from technical, regulatory, legal and financial risks. Furthermore, the research in 4D scheduling is very limited. In this research, a preliminary study identified the obstacles that prevent the use of BIM in general and 4D scheduling, particularly in the construction industry and proposed the solutions to overcome such obstacles. The results show that a lack of experience and qualified staff are the most common causes facing BIM applications. Also, the most common technical challenge for 4D scheduling is the interoperability problems. To overcome these challenges, investment in the establishment of information technology infrastructure, and training at the level of universities, companies and consulting offices is required. At the governmental level, it is necessary to develop codes, specifications describing the level of detail required. Consequently, the integrated nature of BIM raises further concerns about liability, security, ownership of data and licensing among project participants. Thus, a new form of contract is required involving all participants to account for the use of BIM.

Keywords: Methodological Review, Paradigm, Philosophy, Mixed Methods, Qualitative Designs, Qualitative Designs

1. Introduction

Construction projects are expected to be finished within budget, on time, and with the required quality. They are getting more complex and when fast project delivery is required, it may be difficult to achieve the aims and accomplish the projects on time, within the budget with traditional methods [1-14]. So, there is an increasing demand to utilize more reliable tools for planning and scheduling [15]. Currently, there is a trend towards using BIM in the construction industry [16]. The literature highlights the limitation of BIM implementation practices in Egypt, as well as the limitation of 4D scheduling [17,18]. Elyamany discussed BIM execution within the AEC in Egypt [19]. Khodeir and Nessim investigated the BIM modelling of Energy in architectural companies [20]. Gerges et al., studied the implementation of BIM in the MENA region [21]. In these researches, surveys were developed and conducted among participants to gather data; the gap recognized was the absence of interviews to get a direct viewpoint on BIM implementation in the Egyptian construction industry [22]. Gerges et al., conducted a survey among 297 participants in the MENA region [21]. Of these participants, 200 replied with a response rate of 67.34%. 19% of the respondents who use BIM were Egyptians. The research concluded that Egypt follows the UAE for infrastructural projects in using BIM.

Elyamany carried out a survey as well; 120 contracting companies and 10 consultancy offices received the questionnaire, with a response rate of 17.2%. The low rate of response could be explained by the lack of BIM application in Egyptian construction companies [18]. Participants thought that BIM would be used in the construction industry as a tool for sustainable building practices. The survey also revealed the dearth of BIM execution metrics in the public and private domains, with 79% of respondents thinking that

government engagement will improve the accreditation process and that the government is not implementing BIM. Furthermore, according to 84% of respondents, BIM objects need to be made available in order to obtain more precise data for the model's design. Additionally, 70% of participants believed that construction firms need to gain deeper knowledge of BIM. According to Khodeir and Nessim, Egypt is currently in the early phases of BIM use [20]. Also, it said that businesses adopt BIM because of its ability to coordinate, detect, and save time and money. However, the aforementioned studies guarantee that Egyptian businesses will resume using BIM in response to the expanding need for BIM in large-scale projects. Furthermore, according to the report, 62% of respondents utilize an energy modelling tool during the design phase, which is uncommon in Egyptian firms and could be related to survey. According to the study, ongoing training, research on the application of BIM for return on investment, and a lack of client demand are the main barriers to BIM adoption in Egypt. The use of BIM is significantly influenced by authorizedorganizations. As previously said, the USA, UK, and Singapore are the top BIM adopting nations; they actively work to use and improve BIM methods [16].

The primary motivator for this is the construction industry's promising strategic plans aimed at enhancing productivity, sustainability, and efficiency. The UK government was the first in the nation to require BIM in its public projects, in contrast to other natio [22]. BIM was initially recommended by public authorities in other nations like the USA, Singapore, Hong Kong, and the UAE, before being incorporated into government initiatives (a process known as middle-out diffusion) [23,24]. Other elements include the complexity of the projects and the influence of new technologies that reach out to other nations, like Qatar [4]. For the purpose of this study, a survey was developed and distributed to construction industry professionals to determine the primary barriers to using 4D BIM for streamline project scheduling and planning. The article also suggests ways to encourage the usage of 4D scheduling and BIM. Additionally, a case study was employed to illustrate the advantages of utilizing a 4D timetable.

2. Research Methodology

The research methodology consisted of three parts as shown below (Figure 1);

• The First part: An extensive literature review, online questionnaire and structured interviews to identify advantages and obstacles of using 4D BIM. What are the proposed methods that encourage the use of 4D scheduling in construction industry?
• The Second part: A case study of a complete 4D BIM model, to study the applicability of using the 4D scheduling.
• The Third part: Comparison of the results obtained from the questionnaire and interviews with the 4D model. Followed by a discussion of benefits that can be obtained from using 4D scheduling in the construction projects.

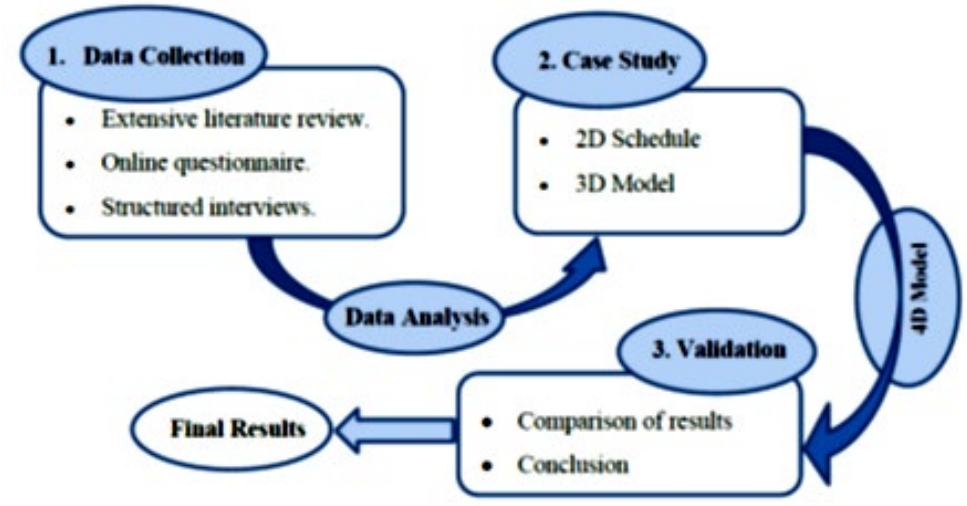

Figure 1: Research Methodology

2.1. Challenges of 4D Scheduling

To identify the challenges of 4D scheduling, the questionnaire was distributed on to 453 individuals from around the world. However, the returned responses were 150 (33.11%), 20 responses (13%) were the total responses. As a result, 130 (87%) of the sample's total replies were complete. The sample size is determined using equation1.

$$n = \frac{z^2 \cdot p \cdot q}{c^2} \qquad (1)$$

n = Sample size, z = z value, taken as 1.96 for 95% confidence level, p = Percentage picking a choice, expressed as a decimal, taken as 0.5, q = 1 – p. c = margin of error, taken as 9% = 0.09.

$$n = \frac{1.96^2 \cdot 0.5 \cdot (1-0.5)}{0.09^2} = 118.567 \approx 119$$

According to the results of the questionnaire, it was found that the lack of experience, high cost and fear of change are the obstacles with the highest percentage. The lack of experience accounts for

27.10%, the cost (training and licensing) is 25.70%, and the fear of change accounts for 20.80%, as shown in the Figure 2. This confirms what is stated in the literature mentioned by Alhumayn, et al., where they reported that a lack of training, inadequate awareness of BIM processes, lack of support on managerial level, high cost of licenses and software, lack of demand from customers and governments, lack of experience in BIM, lack of practical standards, guidance and policymakers, are all key factors hindering the use of 4D scheduling [24]. Eleven respondents reported that they did not find any significant benefits from using 4D scheduling in the project, due to the nature of the project, the duration of the project implementation, and the type of project contract, all these factors affect the use of 4D scheduling. If the contract type is "implementation only", it is not necessary to use BIM because the cost of BIM is high, in case it is not loaded on the total cost of the project.

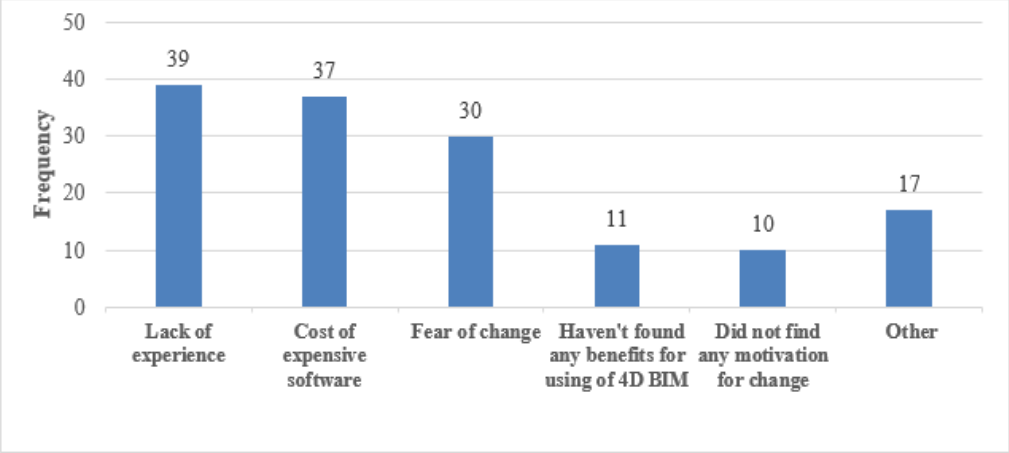

Figure 2: Challenges that Prevent the Use of 4D Scheduling

In Figure 2, seventeen respondents answered, most people don't know what 4D scheduling is and they still prefer the traditional way. Also, there is a need to change the culture of people who refuses the development.Most companies still prefer the traditional methods of planning and scheduling, if there are engineers with experience in design, planning and implementation there are no errors during execution. BIM is not a magic tool that solves all problems, it's basically a collection of programs that depend on effective coordination, and therefore, utilizing them requires enough knowledge. It also takes a lot of time in the beginning of the project to generate a comprehensive, trustworthy model. The market still needs experienced engineers in using these programs. Therefore, most of the results that can be obtained from using BIM are flawed due to lack of experience. So, it may feel like a waste of time in the absence of experience.

2.2. Time Saving

Figure 3 shows the percentage of time that could be saved in project duration in case of using BIM.

Fifty-six (46.67%) of the respondents agree that, in case of using 4D scheduling, the time (from 1% to 5%) of the total project duration can be saved and is considered the highest proportion of the respondents. While 32.5% agreed that time could be saved (from 6% to 10%). Thirteen (10.83%) of the respondents said that 4D scheduling could reduce the project implementation time (from 11% to 15%). Thus, the highest proportion of respondents agree that in case of using BIM and 4D scheduling, the project time could be reduced from 1% to 10%, this confirms with what has been mentioned in previous literature [26]. This stated that the use of BIM can be reduced from the implementation period of the project by approximately 7%.

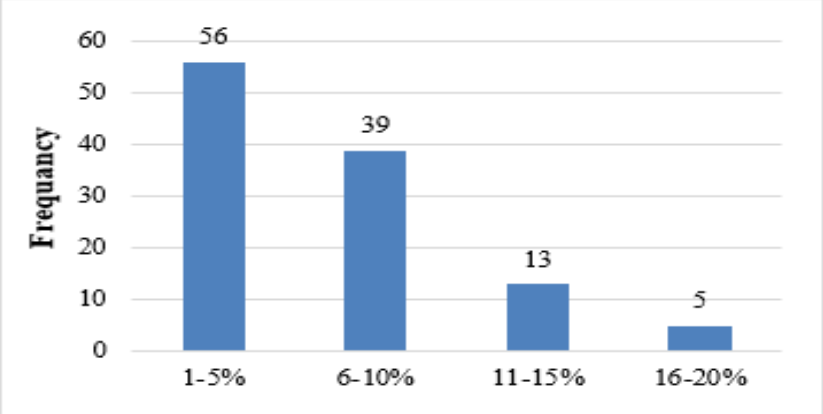

Figure 3: The Time that can be Reduced by Using 4D Scheduling

2.3. Cost Saving

The results of the questionnaire show that the use of BIM can save from 6% to10% of the total cost of the contract, which is considered the highest approved percentage, with 39.0% of total respondents agreed to this percentage. This confirms with what has been mentioned in previous literature which stated that the use of BIM savings up to 10% of contract value through clash detection [26]. As shown in Figure 4. Forty of the respondents (32.52%) agreed that the use of BIM can save from 11% to 15% of the contract value, which is considered the second highest approved percentage. The use of the traditional method may lead to errors during implementation because of a lack of clear understanding of the project, which increases the cost of the project and causes the project delay. This costs the project more than 15% of the value of the contract, while BIM may solve these problems easily. Seven (5.69%) of the respondents answered, in order to save on the cost of the project better, the project team must be fully aware of using BIM.

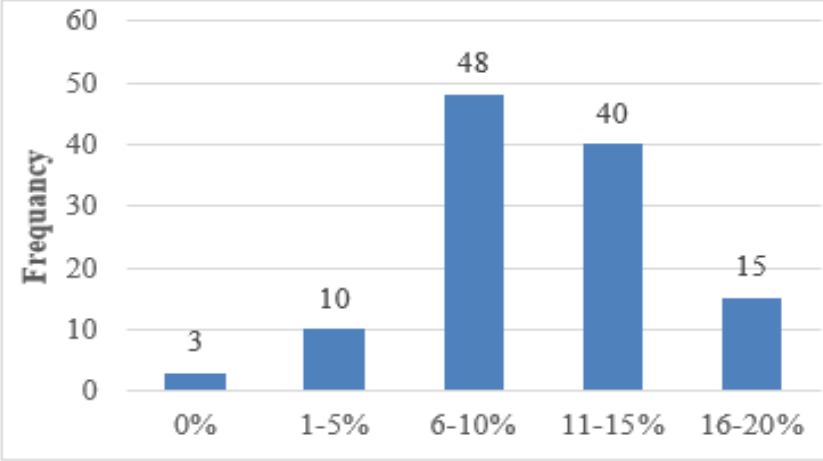

Figure 4: Cost Savings from the Total Project Cost in the Case of Using BIM

2.4. The Possibility of Winning the Tender

Fifty-six (46.7%) of the total number of respondents chose “strongly agree”. While 32.5% of the respondents chose “agree”, with the total number of respondents who chose “strongly agree and agree” was 79.2% of the total number of respondents. This confirms what has been mentioned in previous literature,which stated that the accuracy of the cost estimate is within 3% of the conventional estimates and that the usage of BIM can save the time needed to generate the estimate up to 80%. Thus, it can be concluded that, as Figure 5 illustrates, a contractor who uses BIM has a higher chance of winning tenders because of the speed and accuracy of cost and time estimation [26].

2.5. Case Study

The case study used is a police station project located in Cairo-Egypt, within the Depot project of The Greater Cairo Metro. The selected building consisting of one floor and the total area of the building is 144 m2 and used for applying 4D scheduling.

2.6. Process of Creating 4D Model

The process flowchart used to connect the 3D BIM model with the project schedule and generate the 4D model is displayed in Figure 6.

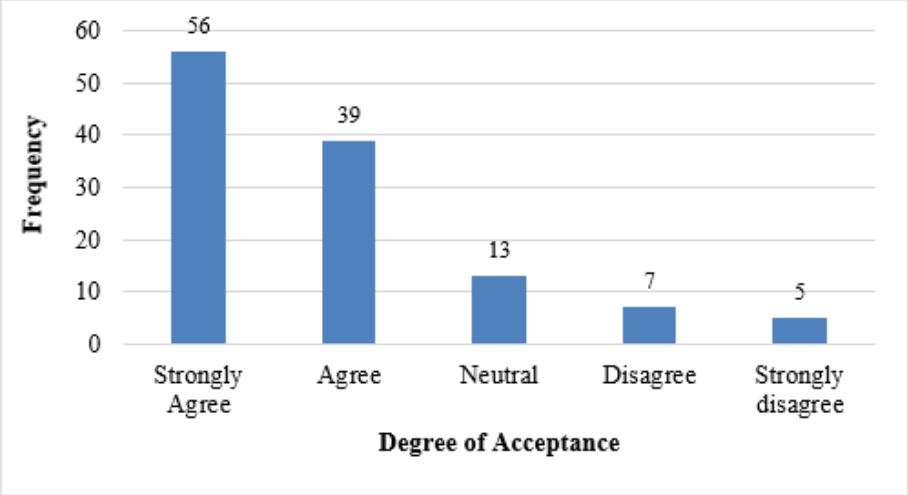

Figure 5: The Possibility of Winning the Tender in the Case of Using BIM

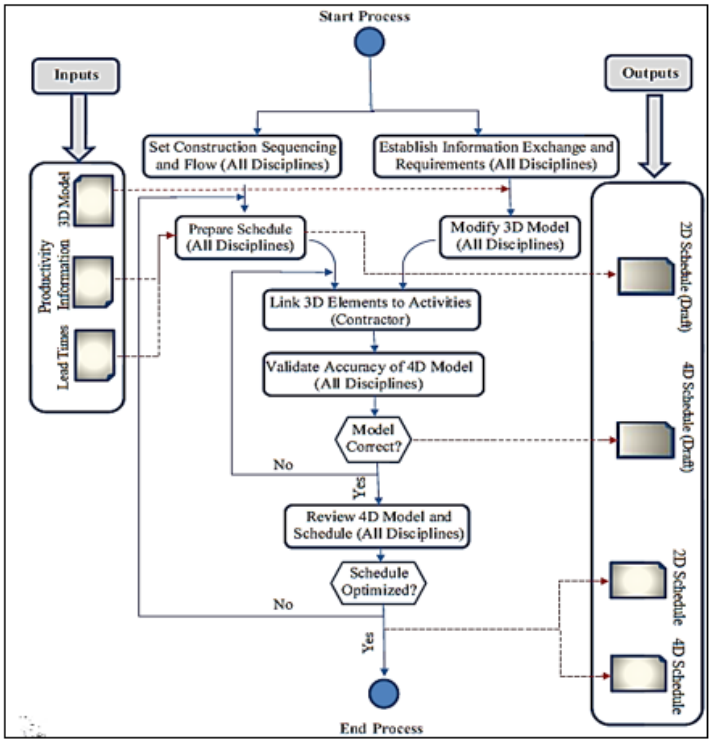

Figure 6: The Process of Creating 4D Schedule

2.7. Developing the 4D Schedule

Primavera P6 was used to develop a building schedule. The schedule included the durations of the activities as well as their relationships. A 3Dmodel from Autodesk Revit 2018 and the planned data from Primavera P6 were exported to Autodesk Navisworks separately. Next, by connecting the activities in the Schedule with the 3D object in the model, the 4D scheduling was created. The process for creating the 4D timetable was as follows, as illustrated in Figure 7.

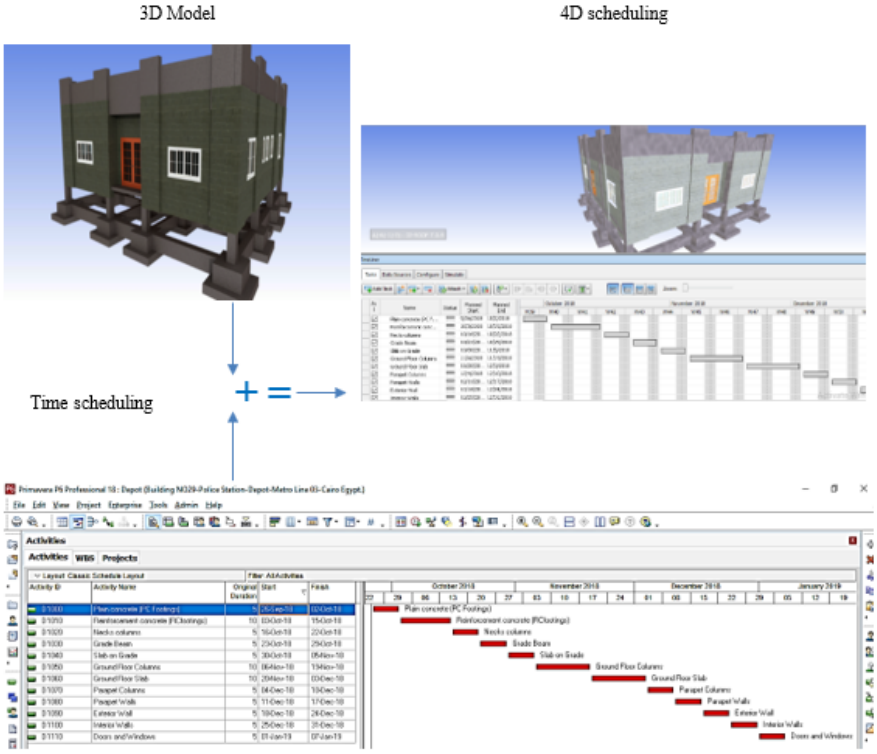

Figure 7: Steps for Establishing 4D Scheduling

3. Results Discussion

The utilization of 4D scheduling has numerous benefits that are not achievable with conventional planning techniques;

3.1. Time Saving

By creating a 4D model to better understand the project, the site engineer and technical office engineer were able to analyses which phases would function better than using a traditional method. Therefore, by minimizing delays, the adoption of 4D scheduling contributes to time savings and, ultimately, lower construction costs.

3.2. Estimate Resources

The accuracy of the resource estimate was achieved by closely monitoring the timeline and documenting each stage of the construction implementation through video before the implementation began. There are time and resource savings for the project, even though it is a fairly simple project utilized in the case study to demonstrate the benefits of 4D scheduling; this percentage can be enhanced with project size and degree of difficulty. According to studies conducted by the Construction Industry Institute (CII), the cost of rework can range from 0% to 25% of the installed cost of the building. However, the management team may, on average, cut down the amount of rework by 65% by using visual representations like 3D models [27].

3.3. Visualize and Interpret the Sequence of Construction

These are excellent visualization tools that offer a three-dimensional virtual image of a building's construction process. The utilization of distinct colour codes for 3D components during schedule simulation results in an efficient visualization. Figure 8 illustrates this, showing green colouration for ongoing activities, including the construction of neck columns. This helps the project team gain a better understanding of daily activities and construction progress.

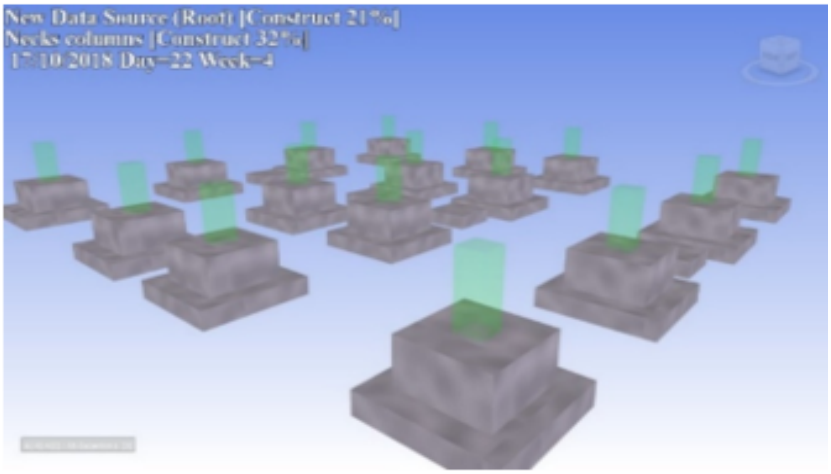

Figure 8: Comparison Between Planned and Actual (Green Colour While Activity in Progress)

By using 4D scheduling, it can be compared between planned and actual scheduling in a simple way and understandable for all stakeholders. As shown in the Figure 9, it is noted that 51% of the plain concrete was finished in the fourth week, knowing that the planned schedule had aimed to finish the reinforced concrete. Also, in the eighth week, we note that 94% of the reinforced concrete was finished, knowing that the planned schedule started in the ground floor slab. The construction progress is showed as planned, as actual, and planned against actual allow project teams to easily distinguish between the project's planned and real states.

3.4. Better Communications

Achieving construction planning success requires effective communication between project participants. Visualizing the progress is a frequent form of communication throughout building of any project, and 4D simulation interfaces are used to do this. All stakeholders had a clear understanding of the project's general direction and progress thanks to the ability to keep information up to date. The 4D timetable is a very useful tool for comprehending how work is progressing when used in a case study. The 4D timetable was crucial to the participants' ability to communicate with one another. The 4D schedule provides the client with a complete overview of the project's progress. Under the simulation tab, the contractor specified a date. The simulation interface displayed the ongoing tasks along with the percentage of completed tasks on the specified date, indicating the status of the work and facilitating smooth communication between the Laboure's, engineers, client, builder, and architect. A planned work sheet that shows the impact of a certain action makes it easier for laborers and site engineers to comprehend the task they are targeting.

4. Conclusion

Despite the limited researches measuring BIM implementation in the Egyptian AEC environment, this study demonstrates practical challenges of BIM in Construction Projects in Egypt, as agreed by Abdelalim&Elnaggar[6]. BIM and 4D scheduling applications continue to suffer from technical, regulatory, legal and financial risks. Furthermore, the study results show that lack of experience and lack of qualified staff are the most common risks at all levels of BIM implementation. These factors must be considered before applying BIM in the project. Also, the most common technical challenge for 4D scheduling according to questionnaire results is

the shortage of interoperability among software, a large number of programs and lack of standards. The interview results conducted at some construction companies in Egypt showed that, 3D BIM has been used more in the design phase in recent years and less used during construction, but 4D BIM has not been used before in the construction phase. Furthermore, smaller companies in Egypt, due to their limited involvement in BIM projects, usually suffer more from lack of BIM technology expertise.

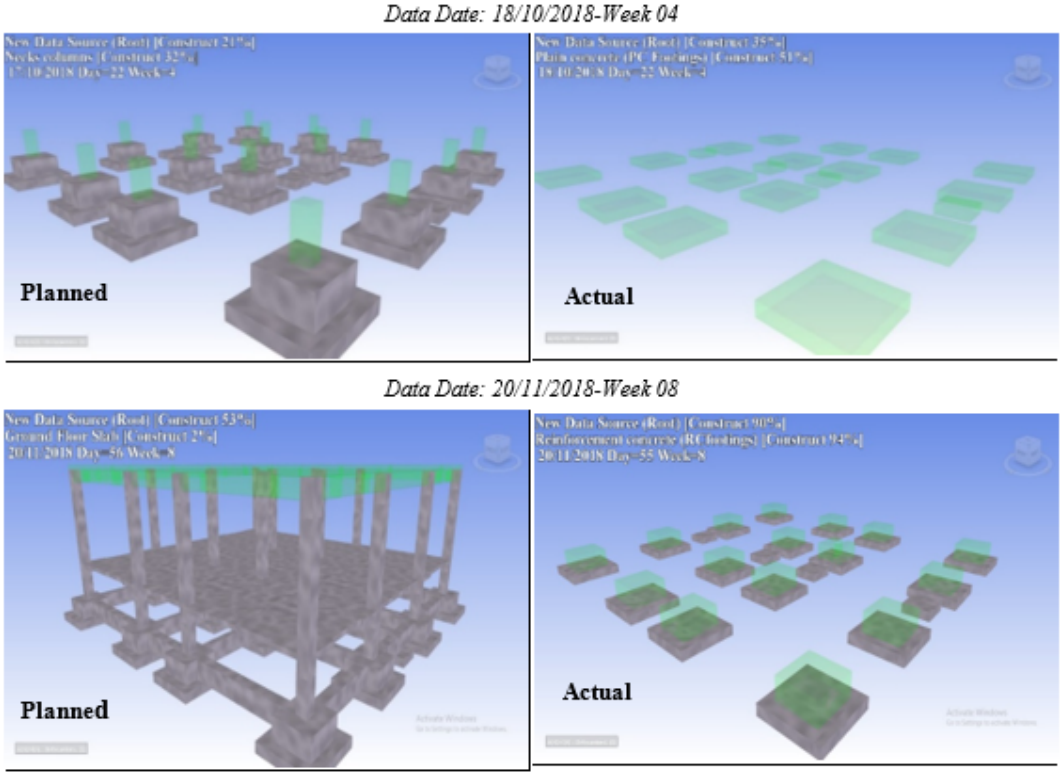

Figure 9: Planned and Actual Schedule

To overcome these challenges, especially in Egypt, it requires an investment in the establishment of information technology infrastructure, and training at the level of universities, companies, and consulting offices. At the governmental level, it is necessary to develop codes, specifications describe the level of detailing required and construction contracts that include the BIM and 4D BIM methodologies. In addition, legal and contractual issues that assist the implementation of BIM must be widely recognized. Consequently, the integrated nature of BIM raises further concerns about liability, security, ownership of data and licensing among stakeholders. Thus, a new form of contract is required that involves all stakeholders engaging with BIM or those who are part of the BIM process. It was also concluded that Strategy for Implementation BIM inside the organizational scale in Egypt is a critical step, as studied by Abdelalim, &Haras [7]. Organizations should have an external party as an expert in outlining the procedures that need to be performed and policies that should be implemented to build a BIM implementation plan within the organization. This requires further researches to investigate and explore [28-54].

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