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Reducing Subcontractor Progress Monitoring Time on Multifamily Building Finishes Using a BIM-Based Procedure

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Abstract **-** In multifamily project construction, specialty subcontracting is common, but monitoring subcontractors, especially during finishing, presents significant challenges due to manual methods that are time consuming, make it difficult to detect deviations, and result in cost overruns and delays. This research proposes an automated monitoring procedure using a BIM model that integrates tools such as Revit, Navisworks, MS Project and Trimble Connect. The methodology includes four stages: analysis of information through surveys, identification of the traditional procedure in three companies, development of the new automated approach and validation in a pilot project. The results show a 42.4% reduction in daily monitoring time for subcontractors and a 41.4% reduction for technical personnel, in addition to improved access to real-time information. This optimizes coordination, reduces errors and ensures compliance with deadlines, significantly improving resource management in multifamily projects.

Keywords**:** BIM; Construction; Monitoring time; Progress monitoring; Subcontractors.

1. Introduction

In the construction industry, effective monitoring of subcontractor (SC) progress represents a recurring challenge, especially in the finishing phase of multifamily projects, due to the complex coordination of multiple subcontractors working simultaneously. Several studies indicate that inefficiency in monitoring, due to the high time required for this activity, has caused more than 53% of projects to fall behind schedule and more than 66% have suffered cost overruns [1]. "Traditional construction progress tracking relies on labor-intensive activities, with delays, potential man-made errors, and inefficient progress management." [2]. Reliance on manual methods for monitoring the progress of subcontractors involves a high consumption of man-hours and prolongs the progress update time. This generates delays in project delivery, cost overruns and makes early detection of schedule deviations difficult, limiting the ability to make timely decisions. Various studies conducted have shown that there is much interest in using digital technologies for progress monitoring, BIM is believed to be a suitable technology for progress evaluation of construction projects [3]. 4D BIM models support progress tracking by analyzing the sequence of construction activities [4-6]. Several authors have explored the use of vision technologies for automatic tracking of construction activities, demonstrating that pattern recognition can automate real-time monitoring and significantly reduce the time needed to evaluate the progress of each task. [7-8]. Likewise, 4D BIM programming with geometric surveying using an indoor mobile mapping system (iMMS) reduces the time to monitor construction progress and avoids reliance on manual processes [9]. Finally, the use of artificial intelligence (AI) and image recognition is also beginning to be applied in progress monitoring. Recent studies have implemented neural networks to integrate visual camera data with BIM models, improving accuracy and reducing the time required for progress monitoring [10]. These studies strengthen the adoption of 4D BIM combined with collaborative platforms and image recognition systems, offering effective solutions for subcontractor management in construction. This paper proposes the development of a procedure for monitoring the progress of subcontractors in the finishing phase by integrating 4D BIM using Navisworks, MS Project and Trimble Connect. The aim is for subcontractors to be integrated through a collaborative platform for better subcontractor management.

The main contribution of the article is a procedure involving the use of a BIM model for real-time progress monitoring in multifamily building projects. Unlike previous studies that focus more on the design phase, this study focuses on the finishing phase. This solution allows for a reduction in the time required for progress monitoring and real-time access to progress information.

2. Tools and Methodology

The BIM methodology adapted to the present research project can be used to monitor the progress of subcontractors at any stage of the construction of multifamily buildings. However, this research is focused on the finishing stage. To address the problem of inefficient time management in the subcontractor progress monitoring, this research was conducted through literature review, surveys, and mapping of three construction projects. As well as the development of a monitoring procedure and its subsequent validation through the application in a multifamily project. The surveys are directed to professionals in the construction sector, selected for their experience in monitoring subcontractors and in the use of the BIM methodology. A summary of the profiles of the respondents and their distribution is presented in Table 1 below.

Table 1: Professionals surveyed.

Features	**Profile of professionals surveyed**		
	Planning Eng.	***Production Eng.***	***BIM Modeler***
Number of respondents	7	3	3
Experience in the field	More than 6 years	3 - 10 years	6 - 10 years

Three medium-sized construction companies engaged in multifamily buildings with projects under execution were selected to analyze their monitoring procedures. Key information on monitoring, data analysis and information gathering were collected. However, only Company 1 was chosen to implement the solution. Table 2 details the characteristics of the companies selected for the diagnostic.

Table 2: Selected companies.

Data	***Features***				
	Job N°	***Company size***	***Sector***	***Executed projects***	***Current projects***
Company 1	190	Median	Building construction	more than 46	14
Company 2	128	Median	Building construction	more than 14	3
Company 3	68	Median	Building construction	more than 5	3

The research utilized surveys to identify problems in monitoring the progress of subcontractors, focusing on the most critical stage of the project and assessing the level of awareness and acceptance of the use of BIM in the industry. A mapping of the monitoring procedures of the selected companies was carried out, detailing tools, roles and processes, which made it possible to design flowcharts and develop a standard procedure applicable to similar companies.

The proposed solution utilized the BIM methodology, using Revit for 3D modeling, Navisworks to simulate progress in 4D by linking with schedules in MS Project, and Trimble Connect as a collaborative platform for real-time information exchange. This integration makes it possible to automate the monitoring of project progress, optimizing the time of the personnel in charge of follow-up, reducing human errors and improving access to updated information in real time. It also facilitates collaboration among team members, ensuring a constant and efficient flow of information. Fig. 1 presents an outline of the methodology implemented in this research, highlighting its main components.

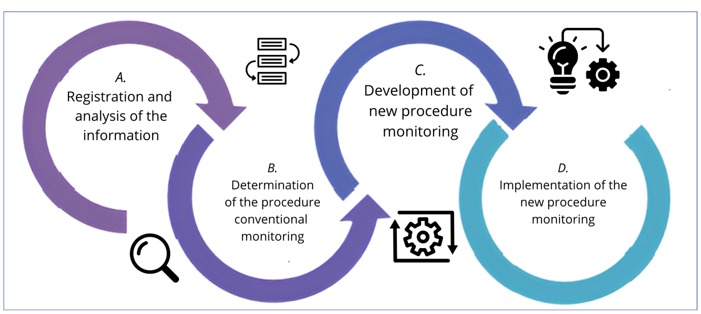

Fig. 1. Research methodology

The stage of the project with the greatest intervention of subcontractors was identified in order to implement efficient monitoring. Through questionnaires in Google Forms and interviews (face-to-face and virtual), data were collected on deficiencies and desired features in a functional system. The current monitoring procedures of three companies were analyzed and detailed flow charts were developed, comparing similarities in order to develop a standard procedure applicable to multifamily projects. This new streamlined flowchart integrates a BIM model to standardize processes, define roles and responsibilities, and foster collaboration between subcontractors and the general contractor. The procedure was implemented in a multifamily project in Metropolitan Lima, applying it to two key subcontractors in the finishing stage. The results were evaluated and compared with traditional monitoring, demonstrating improvements in the time required for monitoring and access to real-time information.

3. Results

3.1 Recording and analysis of information

In the initial phase of the research, surveys were conducted with planning engineers, production engineers and BIM modelers involved in progress monitoring. It was found that 71.4% of the respondents perform monitoring on a weekly basis. Although Primavera P6 is the most used tool, only 28% of the participants indicated that they use BIM for monitoring their projects. In addition, the architecture stage was identified as the most challenging to monitor due to the complexity of coordinating multiple teams, which is why it has been selected as the focus of the research. The results also reveal limitations in the use of advanced technologies, as most follow traditional methods, such as meetings and on-site visits, to monitor progress, as shown in Fig. 2.

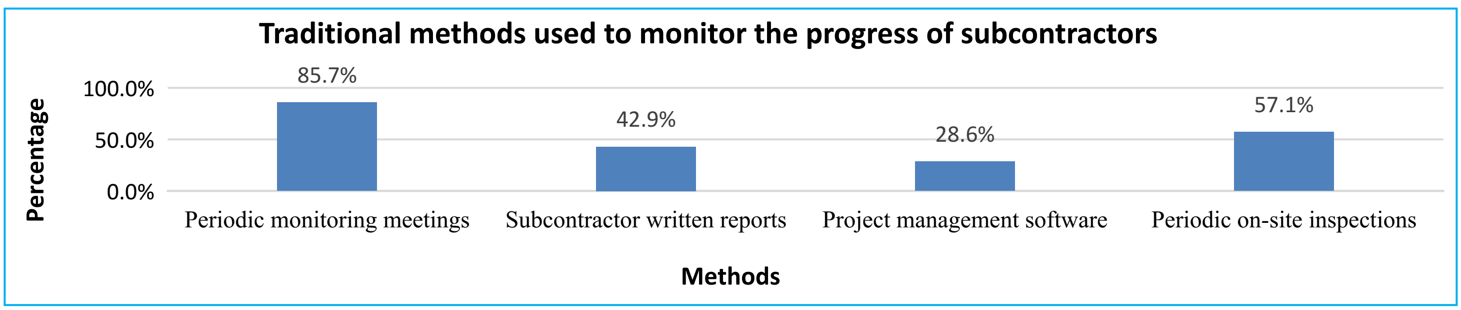

Fig. 2. Traditional methods used for monitoring subcontractor progress.

From Fig.2. The results show that periodic meetings are used by 85.7% of the respondents as the main monitoring tool, followed by periodic on-site inspections with 57.1%. Also, as part of the research, an analysis was carried out to determine three main factors that hinder effective monitoring and generate delays, cost overruns and excessive consumption of man-hours (MH) dedicated to monitoring the progress of subcontractors. Each of these factors is defined below:

- ✓ **Reliance on traditional monitoring methods**: The results show that traditional monitoring methods, such as on-site visits and manual annotations, are useful but slow, error-prone and lack real-time information, making it difficult to detect problems and make quick decisions.
- ✓ **Limited use of advanced technology**: There are deficiencies in the adoption of automated monitoring tools due to the lack of personnel trained in their use.
- ✓ **Delays in updating reports:** Reliance on manual reports from subcontractors and the lack of a collaborative work platform for real-time information exchange limit timely access to updated data, affecting efficient project management.

Despite the challenges, 100% of respondents were willing to adopt automated tools such as BIM, highlighting their ability to update data in real time and improve coordination. Revit, Navisworks and BIM viewers were identified as the most suitable, reaffirming the need to implement these technologies.

3.2 Determination of the traditional monitoring procedure

Interviews with representatives of the three projects identified the traditional procedure for monitoring the progress of subcontractors. This includes a planning phase with preparation of schedules and assignment of responsibilities, followed by an execution phase in which subcontractor managers' report progress to the Production Engineer, who reports to the Planning Engineer. Finally, progress reports are prepared and sent by e-mail. Only Company 1 uses BIM, albeit to a limited extent, while the rest rely on manual methods. The main shortcomings include lack of technological standardization, reliance on traditional methods, fragmentation of information and limited control of subcontractors, as manual supervision and periodic meetings make real-time monitoring difficult and consume many man-hours. Fig. 3 presents the traditional procedure identified.

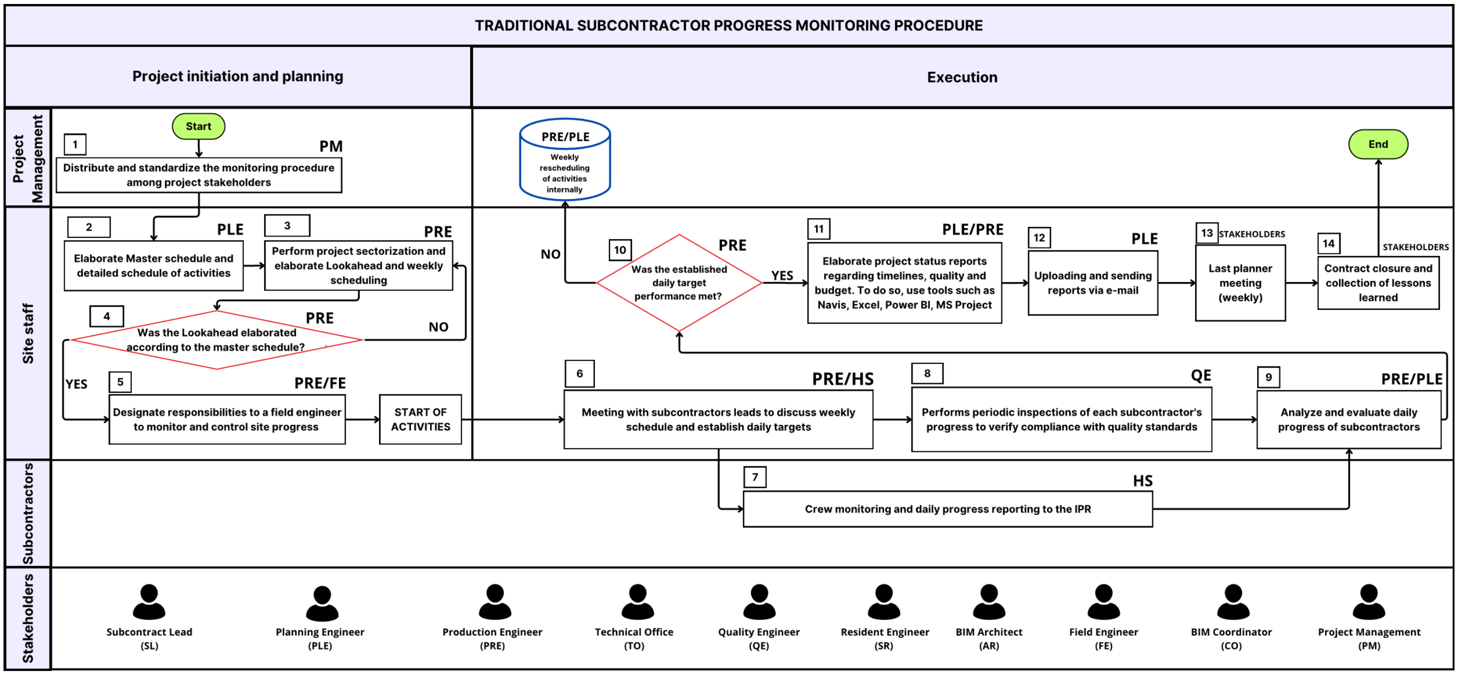

Fig. 3. Flowchart with the traditional procedure of companies for monitoring the progress of subcontractors

After defining the traditional procedure followed by the companies, project 1 was selected to measure the time in man-hours required under this approach. Taking 2 subcontractors as a sample, the total time was divided into two stages: in the first stage, the subcontractor managers spent 1.25 mh to monitor the progress of their crews and report to the production engineer; in the second stage, the project staff spent 5.82 mh to process the information received, sign documents, prepare reports and send them by mail.

3.3 Development of the new monitoring procedure

The new procedure seeks to improve the efficiency of progress control by integrating the BIM methodology, without completely replacing the current process. According to the surveys, Revit, Navisworks and MS Project, tools already used by most of the companies, were selected. For the BIM viewer, the Linear Weighting method was used, where Trimble Connect obtained the highest score (4.47), so it was selected as the collaborative platform for real-time access to information. Fig. 4 details the structure of the developed BIM model.

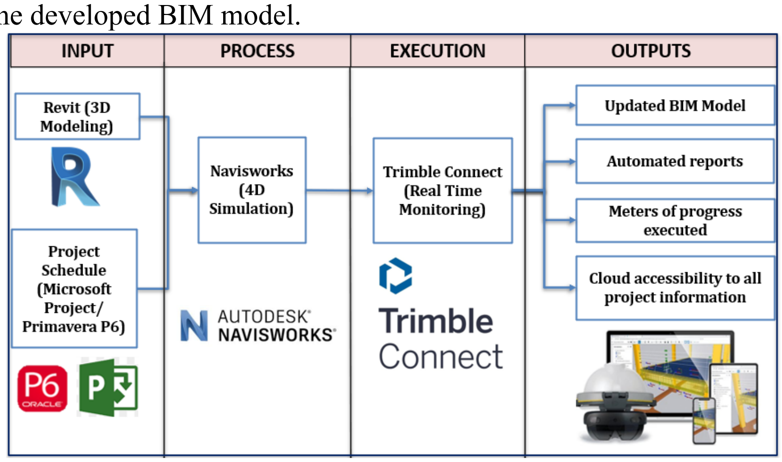

Fig. 4. Proposed structure of the BIM model

The proposal integrates BIM in the monitoring of subcontractors through Revit for 3D modeling and Navisworks for 4D integration, which allows associating each structural element to a specific time frame and facilitates progress control. Trimble Connect is also included as a collaborative platform.

The BIM model, with a LOD 3 and LOI 3, is used in all stages of monitoring. The process starts with the 3D modeling and the development of the master schedule by the Planning Engineer. The Production Engineer uses the Last Planner System to generate the weekly and daily schedule. During execution, each subcontractor reports daily progress through Trimble Connect. The Planning Engineer analyzes the data, updates the 4D model in Navisworks and compares actual to planned progress to produce progress reports. All information is centralized in Trimble Connect, with real-time access from any device. Fig. 5 presents the flow chart of the proposed procedure.

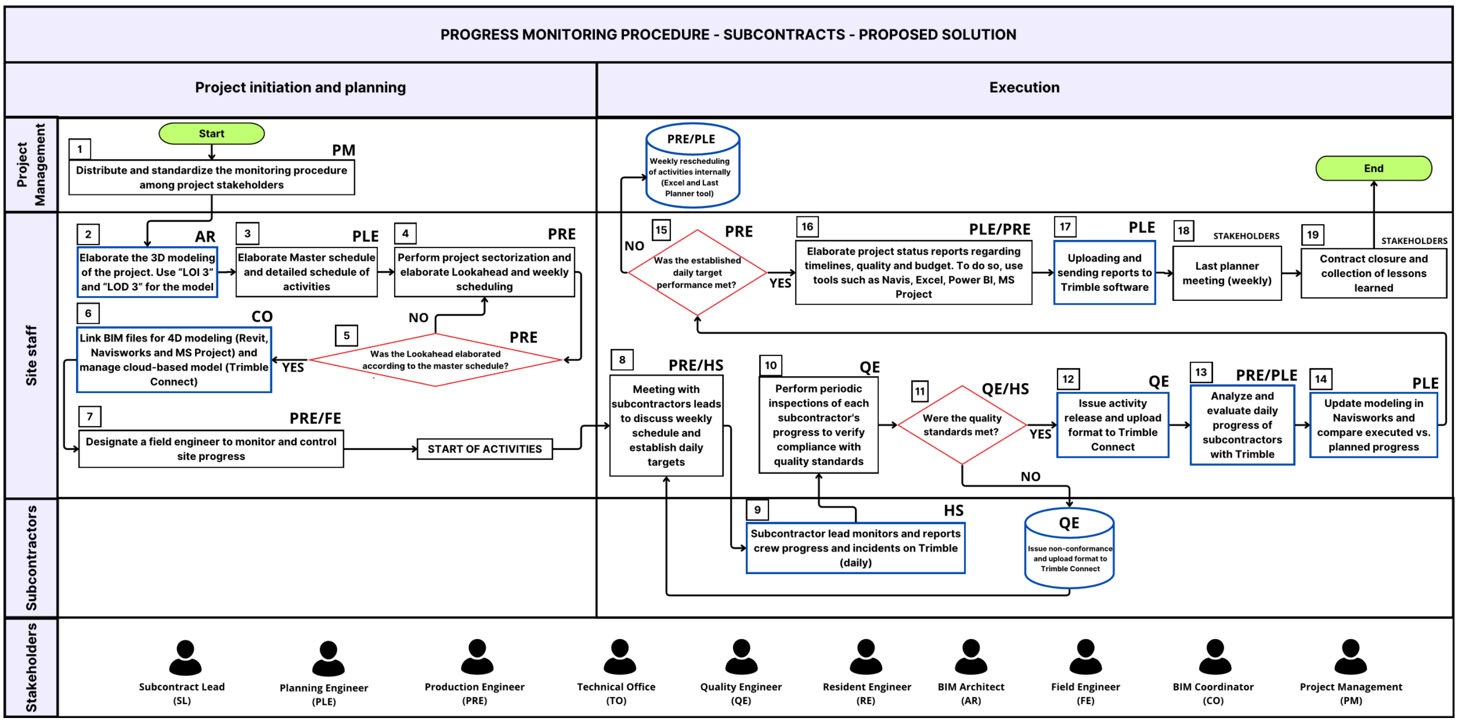

Fig. 5. Flowchart with the proposed procedure for monitoring the progress of subcontractors.

The proposed flow, illustrated in Fig. 5, introduces a centralized digital platform that automatically updates progress information and makes it available to the planning team. Project data is uploaded into a collaborative BIM environment, where progress is visualized in a 3D model in real time. This facilitates the detection of deviations in the schedule and timely decision making. The system also generates metrics and reports that the planning manager reviews to verify subcontractor compliance and approve updates. This approach seeks to optimize daily monitoring and accelerate the correction of deviations.

3.4 Implementation of the proposal

The proposal was implemented in project 1, since this company already had the 3D model of the structure and, at the time of the research, it was in the finishing phase, which facilitated its application. For the implementation, a sample of two subcontractors responsible for the flooring and veneer items was taken. The implementation of the proposed solution was carried out with the participation of the main responsible for monitoring, both from the main contractor's team and the heads of the subcontractors involved as shown in Table 3.

Table 3: Implementation stakeholders.

Stakeholders in the implementation of the proposal		
Subcontractor	Supervisor of Plastering Subcontractors	Supervisor of Tiling Subcontractors
Main contractor	Planning Eng.	Resident Eng.
	Production Eng.	Quality Eng.

The implementation was carried out through technical visits to the project, allowing the development of each step established in the flow chart of the proposed solution. The step-by-step implementation process is detailed below.

Step 1. Presentation of the proposed monitoring procedure

The first step consists of presenting the proposed solution in a meeting with those involved, where doubts are resolved, and training is provided on how to use the proposed methodology.

Step 2. Configuration of the BIM Model with Project Data

The 3D model of the project is elaborated. In this particular case, the project already had a 3D model of the structure, so the necessary modifications were made to incorporate the information required for the BIM model, according to the LOIN specified in the procedure flowchart shown in Fig. 5.

Step 3-4-5. Elaboration of activity schedule, sectorization and project Lookahead

The chronogram is elaborated considering the activities necessary for the execution of the project. The master schedule establishes the main milestones and their associated deadlines. In the selected project, the start dates of activities were adjusted according to the selected items. The sectorization is performed in Revit based on the distribution of work areas, in coordination with the production engineer. Shared parameters, worksets and phases are assigned to the model for automatic recognition in Navisworks. The planning engineer verifies that the weekly schedule matches the overall schedule.

Step 6. Linking BIM files for 4D modeling and management cloud-based model

The 3D model is linked to the timeline in Navisworks as shown in Fig. 6, and is uploaded to Trimble Connect, allowing collaborative work and real-time access to updates.

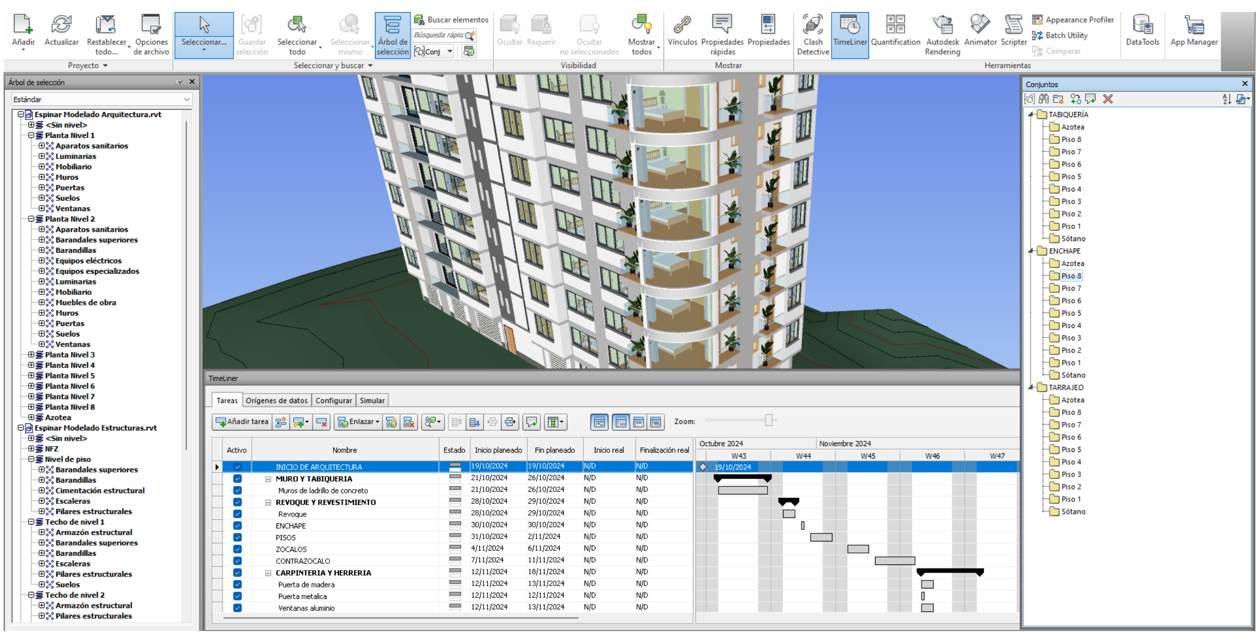

Fig. 6. Linking the 3D Model with the Navisworks Schedule.

Step 7-8. Designate a field engineer and meet with subcontractor managers

This engineer is trained in BIM to guide subcontractors on the use of Trimble Connect and validate reports in the field. Likewise, this meeting is held prior to the start of activities to designate responsibilities and daily tasks to each subcontractor, aligned with the project objectives.

Step 9. Crew monitoring and progress reporting

Each subcontractor's manager monitors and ensures that the crew's progress is aligned with plan, quantifying progress and uploading their report directly to Trimble Connect. This platform allows you to include images, text, notes and color model elements according to status: green for completed tasks, yellow for tasks in progress and red for tasks not executed. This facilitates a quick visualization of the current status of the project. Next, in Fig. 7, the report made by the two subcontractors is shown.

Fig. 7. Subcontractor Report in Trimble Connect.

Step 10 - 12. Quality Control

Quality control is performed by means of releases or identification of nonconformities. The quality engineer performs this activity on a regular basis to ensure that the established standards are met. Finally, the releases or non-conformities are uploaded to Trimble Connect and made available to those involved in the project, who use this information for reporting purposes.

Step 13. Analyze and evaluate daily progress

At this stage, the production and planning engineer evaluates the progress reported in the collaborative platform, comparing the planned progress with the reported progress. If any delay or deviation from the schedule is detected, the production engineer reschedules the affected activity and updates the weekly schedule.

Step 14 - 15. Update modeling in Navisworks

One of the highlights of the implementation was the ability to simulate progress in a 4D environment. This visualization allowed the team to accurately observe completed and pending tasks, comparing physical progress with planned progress.

Step 16-17. Automated progress report generation and reporting through Trimble Connect

The BIM model facilitated the automatic generation of progress reports, with metrics and compliance percentages by subcontractor. This automation frees up staff time for higher value activities. The validated reports are uploaded to the Trimble Connect platform, where specific tasks are also assigned to each subcontractor.

Step 18 - 19. Last Planner meeting and collection of lessons learned

A weekly meeting was planned using the Last Planner methodology with stakeholders to review reports and project status according to the 4D simulation. In addition, at the end of each contract, lessons learned are collected to help improve the use of the proposed methodology.

4. Analysis and Interpretation

Analysis of the results reveals that only 28% of respondents use BIM tools for monitoring construction projects, with traditional methods prevailing. The preference for manual tools imposes limitations on real-time tracking and updating, increasing the risk of delays and cost overruns. However, the willingness of 100% of respondents to adopt BIM tools reflects an openness towards integrated and automated solutions. In addition, the evaluation of the BIM viewers, using the Linear Weighting method, positioned Trimble Connect as the most suitable option for the proposed solution. In the traditional process, 1.25 man-hours of subcontractor managers and 5.82 man-hours of the general contractor's team are required for daily monitoring. As a solution, a new monitoring procedure was proposed (see Fig. 5) that integrates the BIM methodology, using Trimble Connect. This implementation proved to be useful by allowing real-time information exchange, reducing man-hours spent on monitoring and eliminating reliance on manual methods.

5. Validation

The validation aims to determine whether the implementation of the BIM methodology with Trimble Connect reduces the time spent for subcontractor progress monitoring in construction. The comparison between the traditional method and the proposed methodology showed reductions in the time required: subcontractor managers reduced their time from 1.25 to 0.72 man-hours (42.4% reduction), while the project team reduced from 5.82 to 3.41 man-hours (41.4% reduction). In addition, the results show that the implementation of BIM not only reduces man-hour consumption, but also improves access to real-time information and streamlines decision making compared to traditional methods. Next, in Fig. 8, the validation results are presented with a comparison of the time spent with the traditional procedure versus the proposed solution.

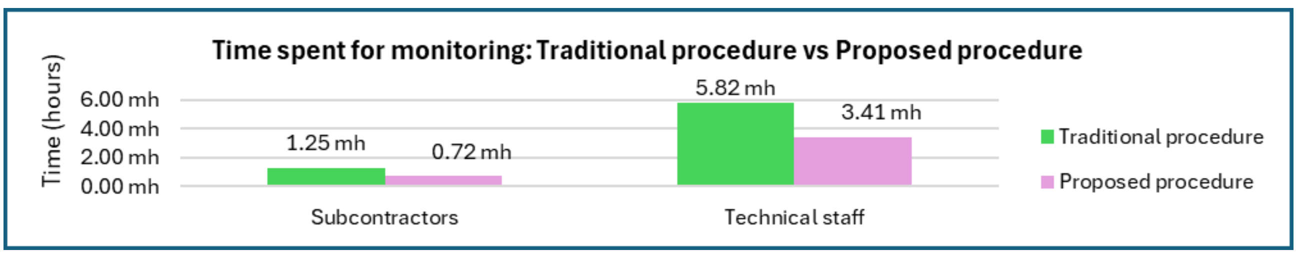

Fig. 8. Comparison of Time Spent on Monitoring Before and After Implementing the Solution

6. Conclusion

The implementation of the BIM methodology with Trimble Connect proved to be effective in improving subcontractor progress monitoring. The results of the pilot project showed reductions in daily monitoring time: 42.4% for subcontractors and 41.4% for technical personnel. The proposed methodology made it possible to centralize information in real time, improving coordination and decision making among project participants, especially in critical stages such as finishing, where there is greater interaction among subcontractors. The methodology not only reduces errors and optimizes resources to meet deadlines in multifamily projects, but also establishes a replicable model that promotes digitization and more collaborative practices in the construction sector.

References

[1] K. Han, J. Degol, M. Golparvar-Fard, Geometry- and appearance-based reasoning of construction progress monitoring, J. Construct. Eng. Manag. 144 (2018) 1–12, https://doi.org/10.1061/(ASCE)CO.1943-7862.0001428.

[2] W. Wei, Y. Lu, T. Zhong, P. Li, and B. Liu, "Integrated vision-based automated progress monitoring of indoor construction using mask region-based convolutional neural networks and BIM," *Automation in Construction*, vol. 140, Art. no. 104327, August 2022. https://doi.org/10.1016/j.autcon.2022.104327.

[3] X. Wang, BIM Handbook: A Guide to Building Information Modeling for Owners, Managers, Designers, Engineers and Contractors, John Wiley & Sons, 2012, https://doi.org/10.5130/ajceb.v12i3.2749.

[4] B.G. Hwang, X. Zhao, S.Y. Ng, Identifying the critical factors affecting schedule performance of public housing projects, Habitat Int. 38 (2013) 214–221, https://doi.org/10.1016/j.habitatint.2012.06.008.

[5] M. Kopsida, I. Brilakis, and P. A. Vela, "A Review of Automated Construction Progress Monitoring and Inspection Methods," presented at the *Lean & Computing in Construction Congress (LC3)*, Oct. 2015. https://www.researchgate.net/publication/304013510
[6] C. Kropp, C. Koch, M. König, Interior construction state recognition with 4D BIM registered image sequences, Autom. ConStruct. 86 (2018) 11–32, https://doi.org/10.1016/j.autcon.2017.10.027.
[7] F. Fakunle and A. Fashina, "Major delays in construction projects: A global overview," *PM World Journal*, vol. IX, no. V, pp. 5-15, 2020. https://pmworldlibrary.net.
[8] J. Martínez, L. González, and D. Morán, "A vision-based approach for automatic progress tracking of floor paneling in offsite construction facilities," Automation in Construction, vol. 122, pp. 103476, 2021. https://doi.org/10.1016/j.autcon.2021.103620.
[9] L. Perfetti, S. Comai, S. Mastrolembo Ventura, and A. L. C. Ciribini, "Construction progress monitoring through the integration of 4D BIM and SLAM-based mapping devices," *Buildings*, vol. 13, no. 10, p. 2488, 2023. https://doi.org/10.3390/buildings13102488.
[10] C.-C. Hsieh, H.-M. Chen, W.-Y. Chen, and T.-Y. Wu, "Integration of construction progress monitoring results using AI image recognition from multiple cameras onto a BIM," in *Proc. of the 41st Int. Symp. on Automation and Robotics in Construction (ISARC)*, 2024, pp. 691-698. https://doi.org/10.22260/ISARC2024/0090.