Implementation of BIM Methodologies in Construction Supervision

Application to the case study of the Rehabilitation of Skylights in the Civil Pavilion of Instituto Superior Técnico

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ABSTRACT

Building Information Modeling (BIM) is an increasingly used methodology in the construction industry. It is common knowledge that BIM has great advantages in the design phase, in the coordination of the different specialties and scheduling, and, in the management of buildings, facilitating the management of assets and the planning of maintenance actions. The challenge arose of verifying whether it would be advantageous to use this methodology in the supervision of works, a very important and fundamental step during the construction phase that guarantees the compliance of the project.

In this follow-up, the rehabilitation of the skylights of the Civil Pavilion of Instituto Superior Técnico (DECivil) was monitored. The inspection data was collected, which was inserted into the BIM methodology, and then the possible advantages and disadvantages of this methodology in the inspection of works were analyzed.

Keywords

Building Information Modeling (BIM); Works supervision; Navisworks; Open and public building.

1. Introduction

The concept of Building Information Modeling (BIM) has been increasingly applied in several sectors, namely in the construction industry. In the various stages of the life cycle of a building, it is mostly applied in the design phase, allowing the foresight of problems that would only be detected in the construction phase. Conflicts between different specialties such as architecture, structure, electrical network, water network, and HVAC, a method known as clash detection, saving time and money and allowing a clearer reading of the final product. Also applied in the management and maintenance of the building, it is possible through BIM to analyze the cost of the life cycle of the building and, facilitate the planning of maintenance actions.

Works supervision is a very important stage, if not one of the most important, to guarantee the conformity and quality of the construction, but it is done in a very traditional way and without resorting to great technology. It is mainly based on the control of three main pillars: quality, cost, and time, using handwritten records that are then archived. The use of BIM at this stage of construction emerges as a new approach to the inspection issue, with a possible potential to improve and innovate.

The purpose of this investigation is to evaluate how the BIM methodology can improve the supervision process compared to the traditional way. The achievement of the objective depended on the completion of the following works:

- Construction of the geometric model.
- Model export to analysis software.

- Supervision simulation in BIM.
- Collection of traditional inspection data.
- Results analysis.

The case study is the rehabilitation of skylights in the DECivil. The intervention took place in a set of 6 existing skylights, with a total of 140 panels with an area of about 750m2. This intervention is complex enough to verify whether it is possible to improve the inspection process with BIM, however, it is not complex to the point of requiring exhaustive data processing due to a large number of tasks and construction processes.

2. Literature review

2.1 Definition of BIM

BIM is a process that starts with the creation of an intelligent 3D model and allows document management, coordination and simulation during the project life cycle, it is present in the different phases (Eadie, Browne, Odeyinka, McKeown, & McNiff, 2013):

- Planning – the creation of models of the environment, both natural and urban, where the subsequent modeling of the model will be inserted, in order to create a more realistic context;
- Design – analysis of conceptual design, use of BIM information to start the pre-construction process;
- Construction – start of construction with the specifications present in the BIM model, project logistics is shared with the various stakeholders to ensure maximum efficiency;
- Operation and maintenance – BIM data allows prediction of various maintenance operations, this data can also be used for efficient reconstructions and demolitions.

2.1.1 BIM Complexity Levels

The construction of BIM models implies the choice of a set of definitions, of which the levels of detail are relevant, described through the level of geometric detail (Level of Detail), information (Level of Information), accuracy (Level of Accuracy) and development (Level of Development).

The Level Of Detail (LOD) is a classification of the detail of the graphical representation of the model, usually referring to sets of incremental levels, which can be seen in Figure 1, which includes extensive geometric information of the object as well as its connections. (Machete, et al., 2021)

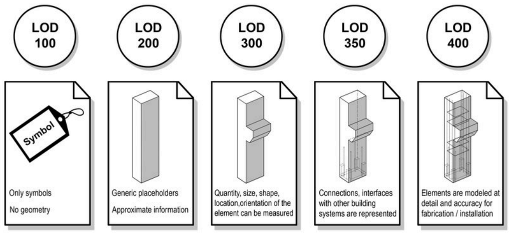

Figure 1 - Level of detail of BIM models (LOD)

The Level Of Information (LOI) is defined according to the existence of descriptive data of the objects in the model. LOI levels range from an unclassified element to a model that includes all material specifications and associated data sources. (Machete, et al., 2021)

The Level Of Accuracy (LOA), contains two characteristics, describes the accuracy of the information acquisition devices, and also describes the degree of spatial generalization in the conversion of the point cloud to an object in the model. All these levels of complexity are essential for geometric description, and graphical and non-graphical information in existing models. (Machete, et al., 2021)

Through Figure 2 and Table 1, this concept can be better understood.

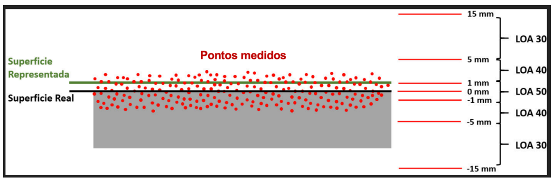

Figure 2 - Representation of the level of accuracy(LOA)

Level	Upper Range	Lower Range
LOA 10	User defined	5 cm
LOA 20	5 cm	15 mm
LOA 30	15 mm	5 mm
LOA 40	5 mm	1 mm
LOA 50	1 mm	0

Table 1 - Limit values (upper and lower range) associated with accuracy levels (LOA)

Finally, the Level Of Development (LODt) refers to the content and reliability of the model developed in the various stages during the design and construction process, this specifies the complexity and associated data contained in the model. LODt scales from simple conceptual models to highly accurate representations that include specific details such as manufacturer and installation mode. (Machete, et al., 2021)

The LODt scale is defined by:

- LODt 100 – elements are represented by symbols or other generic representations, but not with their exact location, shape, or size.
- LODt 200 – elements are graphically represented in the model as generic objects, with shapes, sizes, quantities, locations, and approximate orientations.
- LODt 300 – shapes, sizes, quantities, locations, and orientations can be measured in the BIM model, without the need to reference non-graphic information.
- LODt 350 – in addition to what is already present in the previous level, there is the possibility of modeling accessory parts, such as connection and support items, to the modeled elements.
- LODt 400 – Elements are graphically represented in full detail and accurately in the model, and include all primary and secondary supporting structures.

2.1.2 "*N*" dimensions of BIM

There are several opinions regarding the dimensions of BIM, with the common sensus defining that there are 3D, 4D, 5D, and 6D dimensions and above, shown in Figure 3. (Koutamanis, 2020)

- 3D BIM – the geometry and position of any element can be fully described based on three geometric dimensions.
- Bim 4D – construction scheduling is the main application of BIM 4D, applying different time phases to different construction phases and their elements.
- BIM 5D – cost is related to tasks and not to isolated elements. Unit prices can and should be added as primary information to the respective symbols.
- BIM 6D and above – from this point on, there is no consensus and several aspects of building performance can be considered.
- BIM 6D – according to Nical et al (2016), facility management is the sixth dimension of BIM. BIM allows quick location of building resources, easy space management, and better planning of interventions and their viability and maintenance studies. (Nical & Wodynski, 2016)
- BIM 7D – Andreani et al state that BIM points to a sustainable design, mainly because it allows the expeditious control of large amounts of data belonging to different disciplines associated with the project, facilitates the organization of functions and integrated processes, and allows the quantitative comparison of the several preliminary phase designs. (Andreani, Bertagni, Biagini, & Mallo, 2019)
- BIM 8D – the eighth dimension of BIM adds occupational safety information to the geometric model of the building, during the design and execution phase. Occupational safety at the construction site can also be improved by applying crash tests (clash detection). (Sampaio, Constantino, & Almeida, 2022)

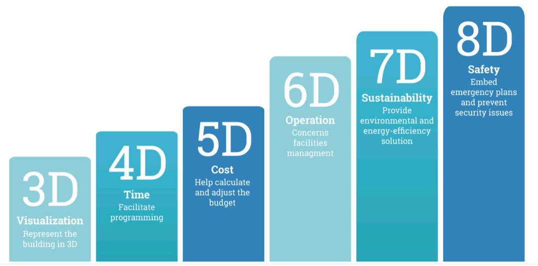

Figura 3 – BIM dimensions from 3D to 8D

2.2 BIM in supervision works

Works supervision is a topic of fundamental importance in the construction industry. The inspection director is a very influential position both on-site and outside it, he is the person who guarantees good construction practices, namely in terms of construction processes and materials, who guarantees safety, and who can lead to satisfaction or dissatisfaction. of the customer. (Rounds & Jr., 2011).

The supervisory director's job is complex and requires him to have extensive skills and knowledge of reading, interpreting, and executing construction contracts. Must be able to plan, schedule, and coordinate project work, understand construction costs, and the interaction between cost, deadlines, production, and quality, always maintaining a safe work environment.

In Portugal, BIM standardization is the responsibility of the Technical Commission (CT) 197. CT197 is coordinated by the

Sectorial Standardization Organism of Instituto Superior Técnico (ONS/IST) and its mission is to develop standardization within the scope of classification systems, modeling of information and processes throughout the life cycle of construction projects, and monitor the development of CEN/TC 442, the Technical Committee of the CEN (European Committee for Standardization) concerning BIM standardization. (Leading Change in Construction Management, 2016)

The construction of the Hong Kong Zhuhai Macao Bridge used BIM technology in the design phase, to carry out collision analysis functions and inspections for optimizations. For different construction components, it is possible to enter the respective data resulting from the inspections. In addition to being able to insert information, it is also possible to insert photos of inspections in Revit. By establishing an integrated inspection BIM model, it is possible to build a three-dimensional database of inspection data and form an inspection information management system, which greatly improves the efficiency of inspections. (Xiaojian Zhang, 2020)

BIM 4D results from the addition of the time factor to the 3D model, this dimension was included in the model through Navisworks, a software also from Autodesk, and a calendar was generated by exporting the model information present in Revit to Navisworks. (Sakdirat Kaewunruen, 2020)

According to Devi Priya Munagala (2020), a great advantage of using Navisworks is the easy import of the Revit model. Training for the use of BIM tools, and the software themselves, are accompanied by a high cost, however, the use of BIM compared to the traditional method such as MS software and Primavera, reduces time by 25%, and the total cost is reduced. (Devi Priya Munagala, 2020)

Cost control is the basic project in which the development can achieve the expected effect, so it is necessary to efficiently control costs throughout the process, BIM technology can improve the level and efficiency of cost control. The quality control of the project is carried out based on Navisworks and the 3D model created, through collision tests, these types of problems can be detected in time before the construction phase, thus avoiding problems at that stage. Through the application of BIM, it is possible to share information about all the participants involved, playing a very important role in terms of project quality management. (Ma, Wang, Bao, Dong, & Wang, 2020).

A research study carried out in Brazil aimed to verify the potential of using BIM technology in public works inspection activities. It was concluded that irregularities related to overbilling, the insufficient definition of the inspection project, and unsustainable delays in construction work could be eliminated by using a BIM approach to the inspection process. Matos and Miranda (2018) identified the proposed factors of development of the design in BIM, the association of the project documentation to the BIM model, audit of the BIM model in the design phase, where the consistency and uniformity of the specifications of the modeled elements must be verified, the integration of the maintenance plan and the analysis of the work plan through virtual simulations using BIM 4D and 5D, as the main factors in reducing the occurrence of problems. (Matos & Miranda, 2018)

According to Banihashemi et al (2021), one of the biggest challenges in project management is an accurate estimate of execution time, costs, and an acceptable level of project quality. It is considered that a project is successfully completed if it is executed in the shortest period of time, with the lowest costs while being executed with the best quality according to what is defined in the project. (Banihashemi, Khalilzadeh, Antucheviciene, & Saparauskas, 2021)

The critical path method used in the investigation by Kim et al. (2011), is based on the relationship between project execution time and project costs, with the objective being the complete execution of tasks in the shortest time interval. Kim et al. (2011) identified a third pillar that corresponds to quality, with a direct impact on the relationship between time and cost. (Kim, Kang, & Hwang, 2011).

3. Methodology

The aim of this work is to verify whether the use of the BIM approach, in the supervision stage of a rehabilitation operation, effectively brings advantages over the same process in the traditional model, regarding the three pillars of the critical path method: Time, Cost, and Quality. The methodological approach is oriented towards constructed buildings for which there is no three-dimensional model in digital format.

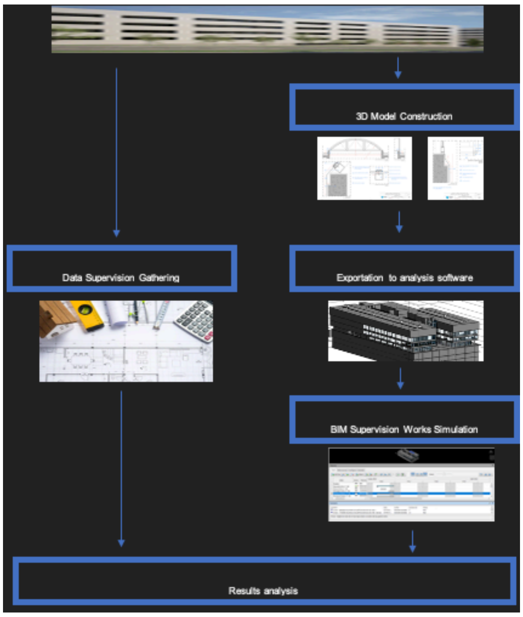

Figure 4 – Methodological representation of the workflow

The methodology, described in Figure 4, consists of five main steps: construction of the geometric model, export of the model to analysis software, inspection simulation in BIM, collection of traditional inspection data, and analysis of results.

- • Step 1 – Construction of the geometric model. Corresponds to the construction stage of the BIM model of the element to be inspected. The definition of levels of geometric detail (LOD), precision (LOA), and information (LOI) must be previously defined.
- • Step 2 – Exporting the geometric model to BIM analysis software. The BIM model was imported into software that allowed analyzing the models, for example, Navisworks. At this stage, all data related to general planning should be collected, defining the frequency of updating the general planning, scheduling of tasks, materials to be used, processes to be carried out, and all types of information that are considered relevant.
- • Step 3 – Inspection simulation in BIM. All activities and procedures must be associated with the elements modeled in BIM, in a record that must be exhaustive and continuous. This record allowed, at the end of the intervention, to know how the work went and if all the work was carried out correctly.
- • Step 4 – Collection of traditional inspection data. The inspection data must be collected, in order to understand how the traditional inspection was carried out, in order to be able to compare with the possible inspection through BIM methodology.
- • Step 5 – Comparative analysis of the inspection process. In this stage, the inspection processes associated with the traditional approach and the BIM environment were compared. The variables considered in this comparison were time, cost, and quality.

4. 4. Case study – Rehabilitation of skylights in the civil pavilion of IST

4.1 Description of the case study

The case study corresponds to the work to replace the skylights on the roof of DECivil, at Campus Alameda (Figure 5).

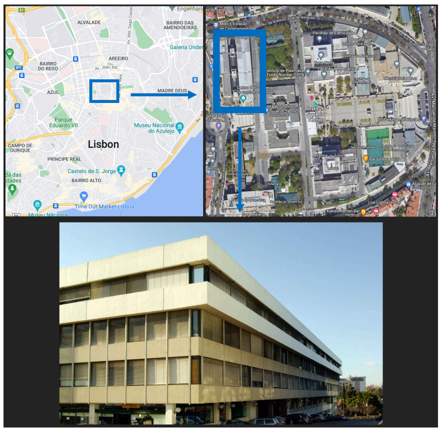

Figure 5 – Location of the Civil Engineering pavilion on the IST Alameda Campus

The skylight rehabilitation project is part of a set of works to be carried out within the scope of the technician's candidacy for the Operational Program for Sustainability and Efficiency in the Use of Resources (POSEUR) and took place in the skylights of the east and west side bodies of the DECIVIL pavilion, presented in plan in Figure 6.

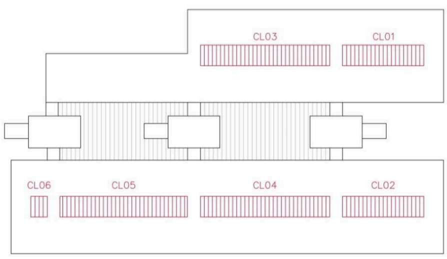

Figure 6 - Cover plan of the Civilian Pavilion with numbered skylights

4.1.1 Description of the existing situation

The skylights, illustrated in Figure 8 and Figure 9, have a semicircular section. Coated with polycarbonate sheets, using technology similar to double glazing with an air gap, and accompanying the longitudinal development of the circulation spaces on the 3rd floor of the Pavilhão de Civil. This rehabilitation work has as its biggest reason the degradation of the various elements that compose them and the poor thermal performance of the existing solution that does not meet current and desirable requirements present in the standard supported by decree-law nº 101-D/2020, and on which was placed a shading net in an attempt to minimize the thermal discomfort felt on the top floor of the building.

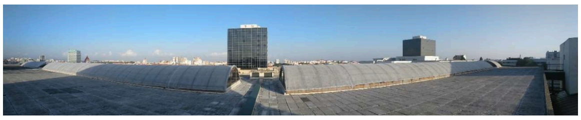

Figure 7 - Skylights of the east body

Figure 8 - Exterior of skylights with net

The choice of the applied solution resorted to a simulation using the “EnergyPlus” software, a dynamic simulation model of the Civil Building was made and integrated into the project. The software simulated the application of new exterior elements that were planned to be executed, the skylights with alveolar polycarbonate with the parameters of U=1.77 W/m2K, g=0.39, and T=0.38, which we can see in Figure 9, and frames with thermal break and double glazing with air box (to be implemented in another work).

Figure 9 - New panels to be placed

4.1.2 Rehabilitation project

The intervention took place in two major elements:

1. Complete replacement of all polycarbonate panels, all connection profiles, and seals associated with them;
2. Rehabilitation of the metal structure that supports the panels, as well as the longitudinal finishing flashings.

All the glazing and window frames at the tops of the skylights were also rehabilitated, with 2-millimeter-thick metal flashings installed on these tops.

From the point of view of safety in the use of space on the 3rd floor, in the areas covered by the skylights, it was decided by the Hygiene and Security Unit (NHS) that access to them and the corresponding offices would be prevented for 5 days, the which implied extra planning of access to spaces.

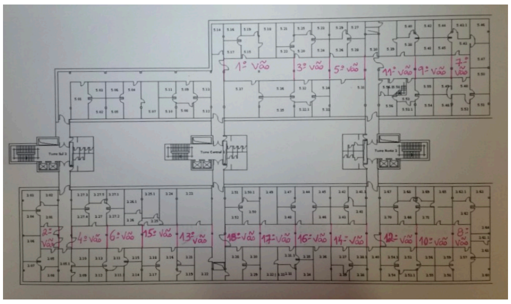

Figure 10 – Planned plan of spans to be intervened

For the intervention, the skylights were divided into spans, by the IST Works Nucleus, according to Figure 10. The detailed planning, with an expected duration of about sixty days, can be seen in Figure 11.

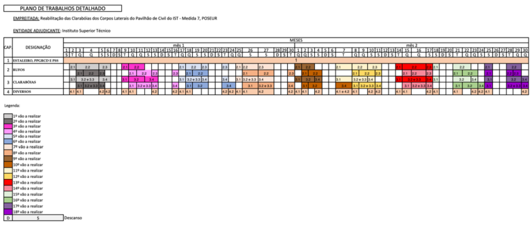

Figure 11 - Detailed work plan for the intervention to be carried out on the skylights

Regarding the characteristics of the materials, the information presented in the project specifications were:

- Flashing sheets in galvanized steel (DC01+ZE25 steel), two millimeters thick. An epoxy paint system is used (two-component, high solids content with good adhesion to galvanized steel) + polyurethane (two-component aliphatic polyurethane paint, or equivalent, in RAL 6005 color and satin finish).
- Double-sided alveolar polycarbonate sheets with UV filter, solar control by partial blocking of infrared rays, general dimensions of L900-1000 x L2770 millimeters, the thickness of 16 millimeters with 9 interior walls and configuration in X as shown in Figure 12, the maximum thermal transmission coefficient of U=1.77W/m2, K, minimum light transmission of 38% and maximum total solar transmission of 39% (according to ISO 9050 standard) and if the panel is Lexan Thermoclear LT2UVIR 169X VRD GN8B038T type or equivalent.

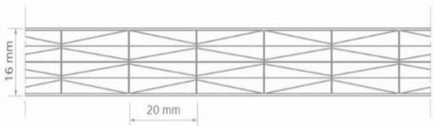

Figure 12 - Internal structure of polycarbonate sheets

4.1.3 Execution period

In the execution phase of this intervention, since it occurred on the roof, its normal course was dependent on weather conditions and, for this reason, the intervention was planned for the period between 12 July and 11 September 2021. Since it was not possible to start the intervention on the dates initially planned, the container was only placed in the shipyard space on March 5, 2022, and the work began on March 8, 2022.

Due to the adverse weather conditions that were felt, mainly in the initial phase of the intervention, with rain and strong winds, it was not possible for the work to proceed according to the initial planning. These conditions made handling the panels very difficult, both removing the old ones and installing the new ones. Due to their large surface in relation to their weight, the wind influenced their handling. In addition, the rain made all surfaces of the roof slippery and unsafe for movement. The initial division by spans was not fulfilled, first in terms of

tasks, since it was not possible to work outside, tasks such as the rehabilitation of the metallic structure had to be divided in half, by the inside and outside, when it was not possible to work outside. It was found that it was not advantageous to work on the east and west bodies simultaneously, so it was decided to finish one skylight to the end before starting another. In Figure 13 we can see the difference between the initial planning and the executed one.

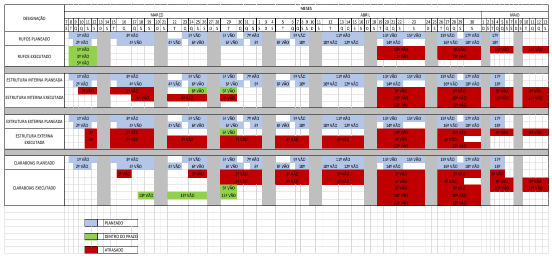

Figure 13 - Initial planning and executed planning

It was also verified that it would not be possible to take advantage of the old flashings because as the new solution applied was different, there was no way for them to fit correctly, so it was decided to acquire new metallic flashings, and the task of rehabilitation of the flashings passed to be painting the new ruffs.

4.1.4 Geometric modelling

The BIM model was developed within the framework of the master's thesis "Building Information Modeling in Facility Management: Application to the Civil Engineering Pavilion at IST" (Moreno, 2021). This model was built from 2D representations of all floors of the building

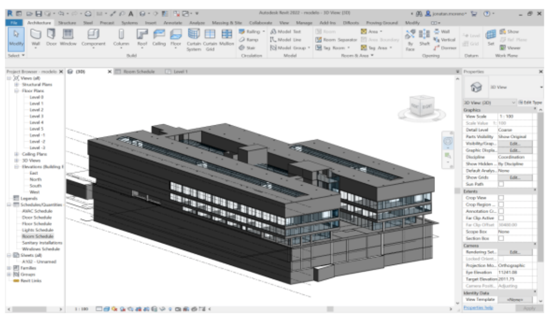

Figure 14 - Complete view of the BIM model

The CAD plans were superimposed floor by floor to be used as a basis to generate a volumetric representation of the building, shown in Figure 14.

Since the available model did not have the skylights of the case study, they modeled with a higher level of detail. This was possible through the use of 2D plans of the skylights with the respective sections and details.

Based on the information contained in these plans, and their CAD file, the various elements of the metal structure were modeled. In Figure 15, we can see the skylight Cl06

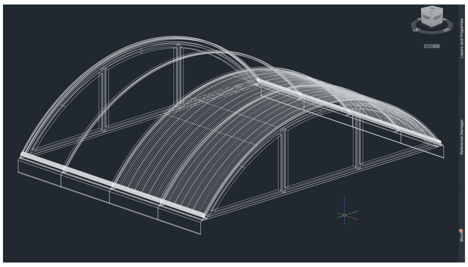

Figure 15 - CL06 altered so that it is possible to observe the modeled metallic structure

After being modeled in CAD, all skylights were imported into the Revit model and placed in their exact location. Before that, it was also necessary to model the walls that support the metallic structure, since these had not been modeled in the model provided.

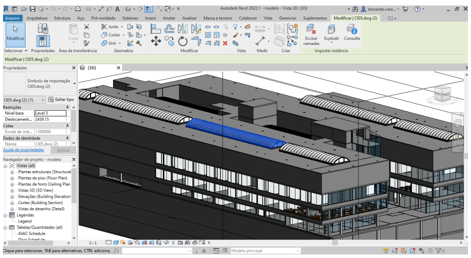

Figure 16 - Revit model with already modeled skylights

It was verified that, although in AutoCad the skylights were modeled element by element, when imported they were represented in the model as a single element, thus defining the skylight as a unit, and not the panel as intended.

The solution that was found for this problem was, firstly, to separately model the tops of the skylights and the central panels, as can be seen in Figure 17.

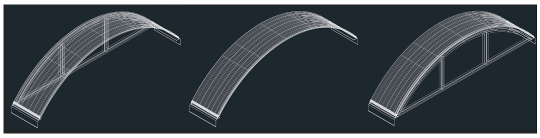

Figure 17 - Top and center panels modeled separately

These models were then imported into the 3D model one by one, the top panels were inserted into their respective places, and the central panels were repeatedly replicated and placed.

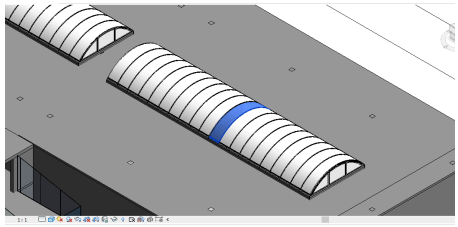

Figure 18 - Panel-by-panel 3D model of the CL01 skylight

In Figure 18, we can see that we have already managed to select each of the individual skylight panels, thus overcoming the initial problem.

4.1.5 Export to analysis software

The choice of Navisworks software to implement the works supervision process was justified by the complete interoperability with the REVIT software, used in the construction of the BIM model. After exporting the model, open the Navisworks program and select the option to open a compatible file.

The Navisworks tool used in the inspection process was the timeliner function. This tool made it possible to introduce the entire work schedule into the program, by tasks, and each task that is introduced can, and was, associated with the respective modeled 3D element. The timeliner offers several options for entering information.

First, the planned start dates for the tasks were introduced, that is, all the initial planning was put into the program. After that, more information began to be added, such as costs, always directly associated with a specific task of the construction process, which in turn is associated with the 3D element to be intervened. After exporting the model, we are left with the view shown in Figure 19.

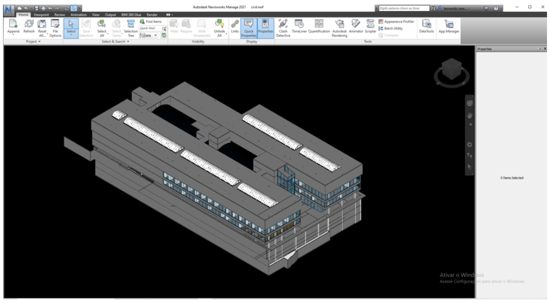

Figure 19- View of the DECIVIL model in Navisworks

4.1.6 BIM supervision works

The dates on which the tasks started to be carried out and were completed and all inspection notes were associated with the respective tasks, which allows us to have a whole other view of the intervention and more accurate control throughout the same.

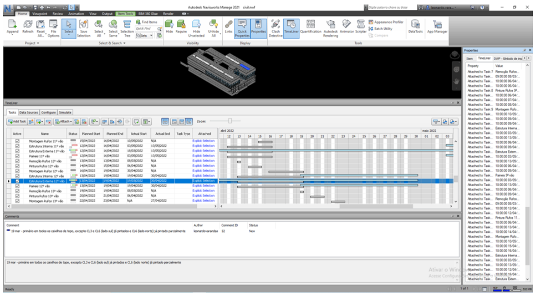

Figure 20 – Example of Navisworks with the timeliner for CI01

The result is the interface that we can see in Figure 20, the timeliner leaves various information at our disposal, allows us to select which tasks are active, and has an associated calendar that has three possible views, the initial planning, what actually happened in reality, and both simultaneously. Immediately after the task, we have the status of the task, which allows us to quickly see which tasks were comleted within the deadline (in green), those that were completed after the deadline (in red) and even those that were completed before the deadline (in blue).

For all elements in the model and after select the properties, we were able to see in the “timeliner” section of the properties, which tasks were carried out in that element and, later, opening the timeliner, see the status of those tasks, the cost, and even who made them if this information was entered. It is also possible to see if there is any kind of extra comment in relation to this task, whether it is just an update note or even a problem that has occurred in the execution of the task.

This tool allows you to export all data to an excel compatible file, and also allows you to export the planning directly to Microsoft Project.

4.1.7 Tradicional works supervision

In this case of the rehabilitation of the skylights in the civil building, inspection focused on two main aspects: control of materials and control of processes. The person responsible for supervising this work was engineer José Fonseca. The engineer was present at the work on a daily basis, when present at the work site, daily notes were made regarding the progress of the work, only not having done so between the 9th and 26th of April when he was absent.

These notes do not reflect everything that happened on the site, as many issues and problems that were detected during the daily inspection were resolved immediately. When a note mentions that a certain component has been mounted/installed or any note of a process, it assumes that this task was performed within the parameters that it is supposed to.

4.1.8 Comparative analysis according to cost, time and quality pillars.

Comparing the two methods, the traditional one, and inspection with the use of BIM (simulation), it was possible to verify that the use of the BIM-based methodology can bring several advantages in terms of the three pillars of construction: cost, time, and quality. With more emphasis on the pillar of time and quality. Time control in the case of this rehabilitation, through traditional supervision, was done through paper records, and only the tasks already performed were verified, and new weekly planning was made when the weather conditions required. In the case of simulation with BIM, it is possible to have an immediate overview as soon as the model is opened in Navisworks, it is possible to verify if any specific element has already undergone some type of intervention that it has suffered, or if it took place within the planned period or it was delayed, or on the other hand, he advanced, or if it is taking place.
When verifying that the elements have already been intervened, in the tool we can see the notes introduced in the tasks, check if there is any inconsistency verified in the process or in the material, or if everything was carried out

correctly, in case of absence of notes. This quality check in traditional inspection is not always recorded and has the disadvantage that, in the event of a future anomaly, it is very difficult to consult the inspection notes in paper format to check whether there was any constructive anomaly at the time of execution.
Cost control is carried out identically in the traditional way and with the use of BIM, a measurement of the work carried out is carried out, and depending on the measurement report, the work is paid. With the use of BIM, as there is better control of time and quality, there will indirectly be better control and possible reduction of intervention costs, which is an undeniable advantage.

5. Conclusions

5.1 Final considerations

Due to the tendency to use BIM more and more in the construction sector, the idea arose to investigate whether this methodology could bring advantages in terms of supervision of works since it was found that this methodology was not widely used in the construction phase, but mostly used in the design and management phase of buildings.

A case study was then found, in which this investigation could be applied since it should not be a very complex intervention. After analyzing the work, the BIM information that was necessary for the investigation began to be dealt with, having been a combination of existing information and new modulations.

Data were provided on the inspection carried out, including all the elements and processes that should be inspected, as well as all the daily notes of the person responsible for the inspection of this intervention. These datasets converged into a BIM model in Navisworks.

Through the inspection simulation in BIM, it was possible to verify that this methodology has several advantages, mainly related to the time factor. It allows you to know almost immediately when opening the software, if a certain element has already been executed, and also to verify if it has been executed correctly and without any type of problem, a pillar of quality. BIM allows better control of the time factor in most construction, directly implying better cost control.

However, when thinking about the entire building life cycle, it starts to become clearer that effectively, the fact that works supervision is accompanied by this methodology, will have advantages, not only in the construction phase, as expected by me at the beginning of the investigation, but it will also be useful in the building management phase.

The fact that all inspection actions are associated with the model it can save time and money in the future because, in an inspection where there is no BIM, even if there still are records in digital format, they are not visually associated with any 3D elements, if we have all inspection notes associated with the respective elements, it may be easier to identify problems.

For example, in this case, study, if an infiltration appears in a certain panel in the future, we can just go to the model, check the tasks for that element, the existing comments, and see if there was any reference to failures in the construction process or something that could cause the current problem Or in the case of verifying something relatively simple like a screw breaking, through the model it would quickly be possible to verify in which elements this type of screw is applied and suggest its replacement.

The great advantage of carrying out inspections with BIM is to allow quick access to information in a simple way, which in itself already saves money because it saves time, and which can save even more money because it can be identified immediately at the cause of the problem. This advantage exists in both the construction phase of the building's life cycle and in the building's management and maintenance phase.

We can assume as a disadvantage the cost of licenses to use BIM software, which is high. Also, the fact that this methodology requires an extensive and detailed set of data to be able to extract the full potential of BIM which, in cases of interventions in existing buildings, becomes more difficult. As a limitation of the work carried out, the fact that it was not possible to find inspection information during the periods when the engineer was absent on site can be pointed out.

5.2 Future developments

This investigation is considered an initial approach to the use of the BIM methodology in construction supervision. It would be advantageous to carry out an investigation in which a traditional inspection was compared with a BIM inspection, in real time. Even the supervisor's work could be minimized if specialized workers could upload the actions made by them, and then the supervisor would only be in a position of control in the background.

In this way, it would be possible to verify if this methodology, which has already been verified to bring numerous advantages in several phases and areas in the construction sector, can also bring even more direct advantages to the construction phase and, more specifically, to works supervision.

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