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Planning, Monitoring and Control of Mechanics Projects by the BIM

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This paper presents an analysis of the transfer of information in planning, monitoring and control phases of a structural project using building information modeling (BIM), in order to determine the essential information that should be available in each stage of the project. The results show that the integration of the BIM into the planning of project implementation results in greater control of the model, preventing the occurrence of inefficiencies during development. In addition, the BIM helps to save time and cost because the building is programmed and it is constructed virtually before being built in place. Due to this simulation process, called 4D simulation, it is possible to reduce problems in the project by 20%, and set the deadlines for a more accurate implementing, around 30%, since all project professionals (engineers, contractors, subcontractors, suppliers, etc.) can visualize how the construction advances and help to refine the 4D simulation.

Key words: BIM projects, management projects, scheduling, planning, 4D.

1. Introduction

In the material implementation of structures, there have always been problems in coordination between design and construction, due to the inefficiencies in the transfer of information from the design phase to the construction phase [1].

The BIM is a projective technology, where information has an important role throughout the project life cycle. A database where each structural element has an associated viewing and attached information is formed by the BIM model [2].

Han, Cline and Golparvar-Fard [3] carried out a study about control of projects, analyzing deviations between a point cloud generated by a laser scanning and a 4D BIM model. The authors concluded that the proposed classification mechanism increases the effectiveness of the BIM model with a lower level of development (LoD), in order to allow a visual assessment of the progress at the operational level [3].

Zhou, Ding and others [4] undertook a study of the 4D simulation adoption in the oil and gas industry. They concluded that 4D simulation improves the planning and the control in construction projects of industrial plants [4].

Moon, Dawood and Kang [5] conducted a study about visualization systems of field clash using 4D. They applied the results to the case study of a bridge project, in order to assess the practical applications and the feasibility of the developed system, concluding that the results of a project can be improved by a 4D analysis system [5].

However, none of these authors has proposed a working methodology, which would facilitate the 4D simulation by the BIM, integrating the BIM model made in the design software and the tasks defined in planning software, in order to be applied to mechanical engineering projects.

The aim of this paper is to analyze qualitatively and quantitatively the advantages of the 4D simulation used by the BIM in comparison with a conventional planning applied to mechanical engineering projects.

2. Methodology

Firstly, the parameters of the structural elements, which are part of the structure, were defined in the design software. The parameters that have to be defined were:

- Element category: defines the structural nature of the element [6].
- 4D vertical and 4D horizontal: parameters that refer to the position of the structural element in the plane, that is, they characterize the column, beam, lattice... position on the x-axis (4D horizontal) and the y-axis (4D vertical).
- Base level: this parameter defines the element position on the z-axis.

Secondly, tasks were created to define the structure implementation. To do this, the durations and interdependencies of different tasks were defined by developing a time chart, which indicates the planned execution of the structure.

Finally, a virtual simulation of the building structure was generated in the construction management software, with the help of the defined parameters in software design and a time schedule.

Figure 1 summarizes the methodology of time planning, monitoring and control followed for the structure implementation.

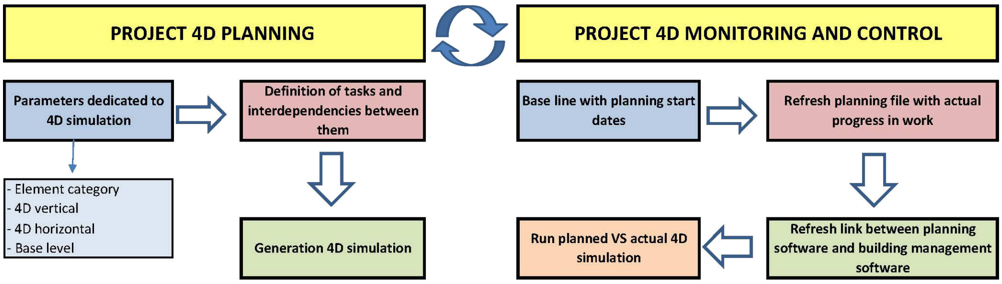

Fig. 1. Scheme of project planning (left) and project monitoring and control (right).

3. Case study

This methodology has been applied to a particular case of implementation planning of the building structure. In order to accomplish this, the structure shown in Fig. 2 was designed and modeled.

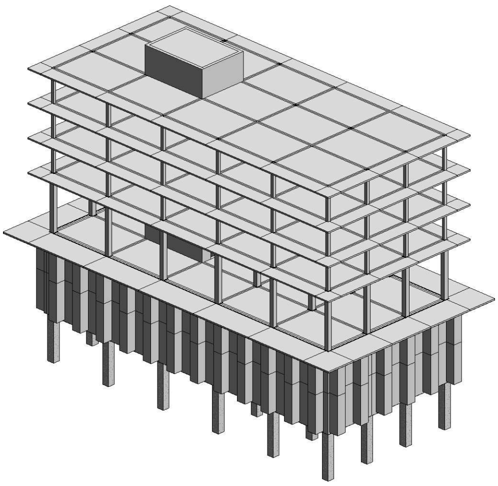

Fig. 2. 3D visualization of the project under study.

The definitions of the above mentioned parameters have been obtained in the design software. Parallel to this, a time schedule of tasks which led to the project implementation was carried out. Finally, the combination of both tasks ended up in the 4D simulation, which consists in the structure virtual progress. Figure 3 shows the temporal 4D planning and the simulation related to this 4D planning.

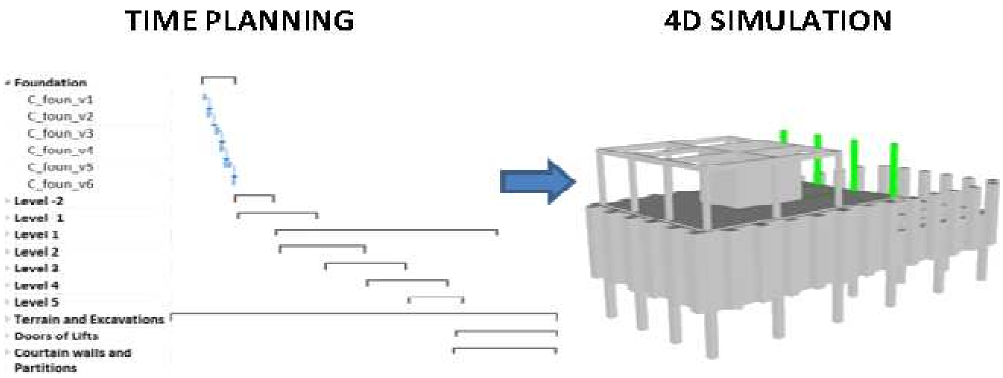

FIG. 3. Temporal planning and related 4D simulation.

After the temporal planning, the monitoring and control tasks were performed in order to compare the duration of the scheduled tasks and the actual tasks.

Figure 4 shows the actual state of the scheduled tasks (left) and 4D simulation (right) that shows a status of the scheduled tasks (transparent green) and the actual tasks (solid color).

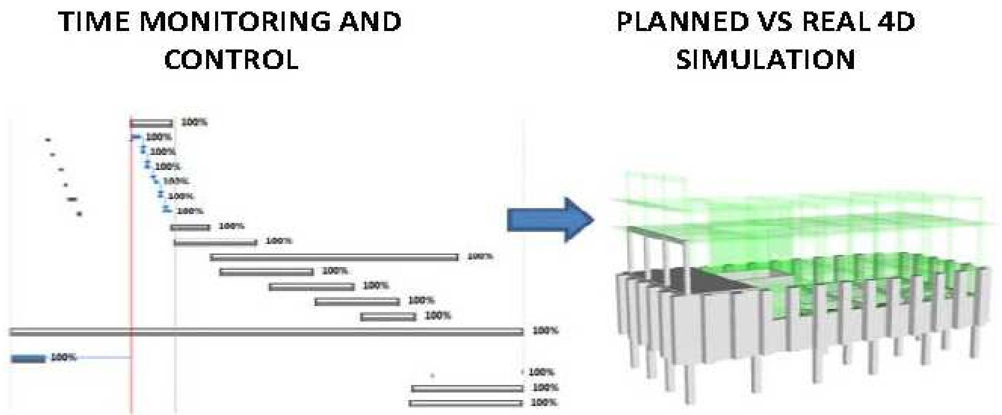

FIG. 4. Update of the status of actual tasks in time schedule (left) and planned VS actual 4D simulation (right).

Table 1 shows a comparison between the traditional planning and the 4D simulation, relating both methodologies by a titration based on variables (5 – optimal and 1 – worst). In turn, the variables are weighted by a factor which indicates the importance of each one in the field planning.

The above table shows that the traditional planning (3.25 points) is less efficient than the 4D simulation (3.9 points) in the project execution. The time

Table 1. Comparison between traditional planning and 4D simulation.

Variable	Traditional	4D	Weighting [%]	Weighted Traditional	Weighted 4D
Execution time	4	2	15	0.6	0.3
Planning difficulty	3	4	10	0.3	0.4
Information viewing	2	5	10	0.2	0.5
Documentation use ease in the office	4	4	5	0.2	0.2
Documentation use ease in the field	4	3	15	0.6	0.3
Understanding documentation	3	4	5	0.15	0.2
Information quantity and organization	3	5	15	0.45	0.75
Updating ease	3	5	25	0.75	1.25
TOTAL	26	32	100	3.25	3.9

consumption is lower when performing a traditional planning (20% lower); however, the 4D simulation allows to check the estimated time accuracy in relation to the actual performance. This means an increase of 30% in the accuracy between the planned and actual time of the field execution. Another interesting aspect is the simple data updating that allows for 4D simulation, since one of the main disadvantages of the traditional planning is the difficulty in performing data updating.

4. Conclusions

Using the 4D simulation procedure, it is possible to reduce problems in work by 20% and set deadlines for the precise execution (around 30%), as all project professionals (engineers, contractors, subcontractors, suppliers...) can visualize the construction progress and help to refine the 4D simulation with their knowledge and experience.

4D simulation has important advantages that improve the traditional planning of the work execution, as it has been shown in Table 1. The main aspects that make the 4D simulation a powerful methodology are:

- Easier planning to be performed, since this simulation is based on the association of structural elements with tasks, which makes it a more intuitive planning.
- The tracking of the virtual building progress allows construction professionals to make decisions related to planning.

- 4D simulation has much information regarding deadlines, like in traditional planning. However, the information is much more organized in 4D simulation.
- Ease to update the inserted data into the 4D simulation instead of the complex task of updating the traditional planning information.

It has been shown that the bigger the project is, the more inefficient the manual planning becomes, and this is because there is no total control of the contained information. However, the application of the BIM technology to tasks planification allows to more easily organize and manage the structure deadlines.

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