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Bulding Renovation with BIM

A Practical Guide

Timo Hartmann and Sharon Susan Verghese

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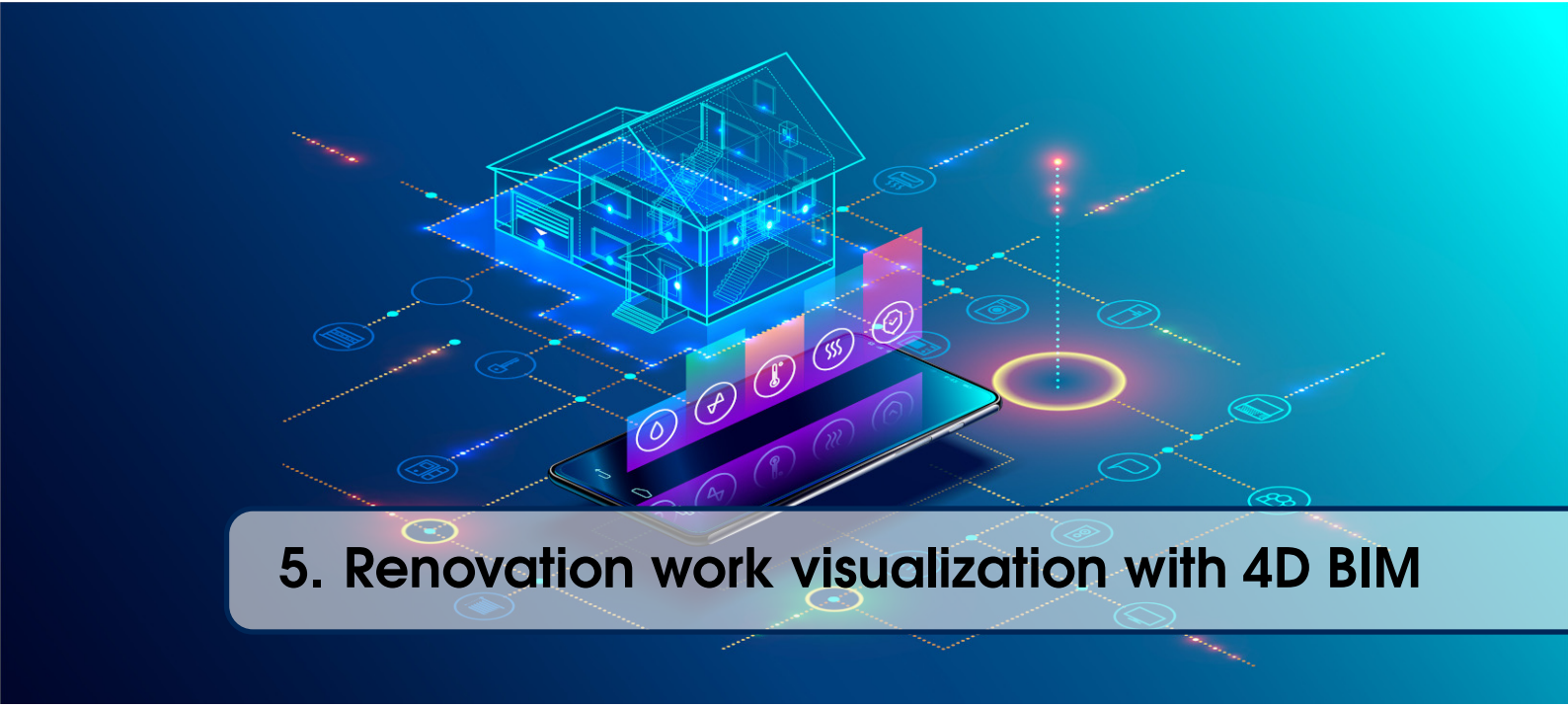


5. Renovation work visualization with 4D BIM

5.1 Introduction

Construction planning and scheduling is essential to ensure meeting of project completion dates and cost estimates. 4D BIM simulation links spatial and temporal information for enhanced construction processes visualization and decision making. Earlier processes of time scheduling in construction projects included bar chart visualization of time required for processes, as well as critical path methods to determine the most crucial tasks and sequences of construction practices to ensure efficient planning. However, such processes highly depend on the ability and experience of the planners and construction specialists to plan tasks based on experience. Furthermore, with increasing complexity and different trades involved in large scale projects, this process is highly tedious and even-more prone to errors. Project schedulers use CPM based tools to schedule construction processes along with the possibility to link resources, information and generate reports based on schedules. Some other advancements such as Monte-Carlo simulation and resource level scheduling with incorporation of uncertainty has further enhanced conventional scheduling processes. Conventional processes of time scheduling in construction projects are in illustrated in Figure 5.1.

A 4D BIM model constitutes of BIM objects being linked to the construction schedules which enables collaboration and carrying out analysis for decision making. While simple 4D models

Figure 5.1: Conventional process of time scheduling of construction processes

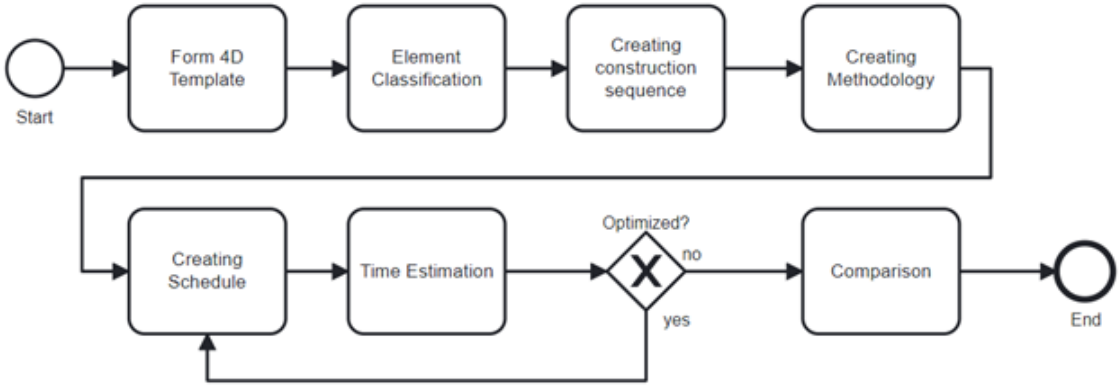
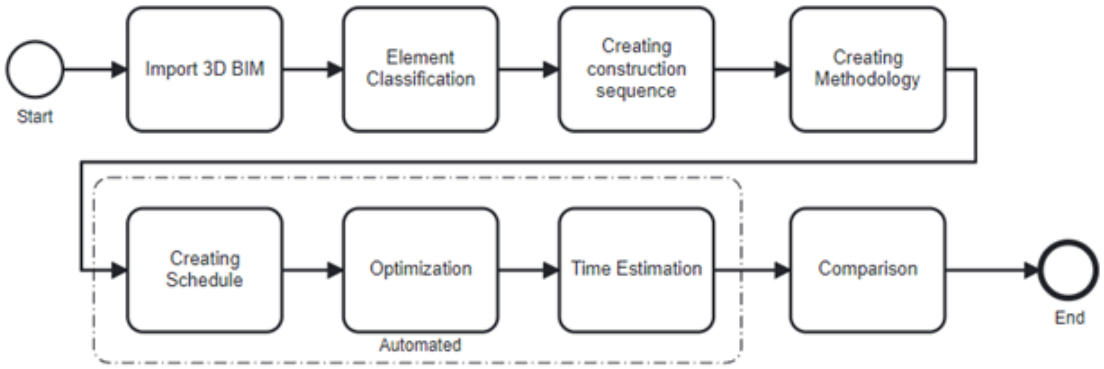


Figure 5.2: Project scheduling process



allow better visualization which aids the scheduling process and analysis of several renovation scenarios, some more complex 4D models enable optimization of activity sequencing as well as running simulations of 4D and time-based clash detection to ensure more efficient site execution planning and resource optimization.

5.2 Information and Process

BIM supported planning and scheduling requires certain pre-requisites of the model in order to ensure that time scheduling of processes can be carried out:

- Level of detail: The elements modelled in BIM should be of specific level of detail to ensure linking of separate activities. For instance, while a floor slab can be a simple model element, the definition of this element should be in detail in terms of concrete, re-inforcement, screeding, tiling etc. depending on the activities to be carried out. Furthermore, processes like concreting for 3 hours of a certain area of the model need to be independently segregated in order to ensure an activity for a particular area. However, depending on the expected analysis detail and 4D simulation based decision, the scheduler have to ensure uniformity in terms of LoD in schedule and building elements.
- Change management: 4D tools should ensure the capability to re-organize construction processes and activities flexibly in order to group model components based on phases and construction activity execution.
- Schedule parameters: Schedules are defined with parameters like early start date, duration and early finish date, latest start dates and so on, not only allow assigning pre-defined start dates, duration and end dates, but also add a duration to counteract any inaccuracies in the schedule planned but also delays in procurement of materials.

A 4D BIM analysis begins with the import of 3D BIM, followed by element classification in terms of construction process phases, which allows for creation of a construction sequence. This is followed by creation of schedules, optimized for costs and resources but also for time in order to minimize project duration. Several renovation alternatives can be studied for selection of the most optimal scenario in order to make design decisions. Furthermore, changes in design are automatically replicated and the changes in terms of duration are also automated. (Ahmadi and Arashpour, 2020)

5.3 BIM Tools with 4D capability

ll BIM platforms do not have built in functionalities for time scheduling of construction activities linked to building elements, systems and materials. 4D simulation platforms often consist of a BIM import capability to facilitate the import of geometry, spaces, hierarchy and other information required for 4D scheduling, followed by scheduling activities, re-organization and sequencing of activities, addition of temporary components as required for site execution, animation of the construction processes and analysis of time required for completion of the renovation activities and comparison of several renovation alternatives for decision on the most time effective renovation design. There are several 4D simulation tools embedded in BIM platforms and other sole 4D BIM dedicated tools. Some of them are listed out here:

- Revit (Autodesk): Revit enabled the users to segregate the model to several phases and to assess 4D enabled phase design of the model.
- Trimble: The Gantt chart interface in the platform allows linking of the model elements and enhances visualization of construction activities.
- Navisworks Manage: This tool allows automatic import and linking of schedules from several applications to the model elements in order to create 4D simulation visualization as videos. The timeliner module plays the construction activities in sequence with the execution period estimated for the project.
- BEXEL Manager : BEXEL Manager aids 4D simulation by incorporation of construction methodologies, smart automation of scheduling, and allows import of schedules from some prominent scheduling tools like Primavera and MS Project. Moreover, construction simulation can be further visualized by 4D simulation videos as well as the functionality to review 4D sequence along with color coded elements, tasks and phases of the construction process. Schedules can be optimized by identification of critical tasks and resource allocation and leveling. Furthermore, the construction progress can be monitored by comparison to the proposed schedule and updation of the schedule based on the progress on site, to carry out planned vs actual analysis and to quantify delays and variation.

5.4 Project Demonstration

4D Simulation was carried out on one of the demonstration sites in the BIMSPEED projects using BEXEL Manager to schedule activities of the renovation alternatives proposed for energy efficient renovation on a demonstration project located in Warmond, Netherlands. The Warmond democase is a complex of 4 buildings located in Warmond (the Netherlands), at van den Woudestraat. For the generation of the BEM model, one of the buildings was selected (block A). Below the aerial photo of the site with an indicative view of the urban context.

The process of 4D simulation was carried out by linking BIM model elements with a planned construction sequence, to carry out a comparison of the different renovation scenarios which were defined for energy analysis while making a decision based on other factors like the time and resources required for the execution of the renovation work.

Both renovation scenarios are only differentiated by the type of materials proposed, only one time schedule was created with the with the help of BEXEL Manager 21. In the following figures the result time schedule for the renovation works is presented. The time schedule estimates a total of 176 working hours for the finalization of installation of the renovation measures proposed for the renovation scenarios.

5.5 Benefits of BIM enabled project scheduling

Some benefits realized during the implementation of BIM based time scheduling processes include:

- Automated process of scheduling: Upon import of the 3D BIM model and creation of