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A BIM Template for Construction Site Planning

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Abstract

Building Information Modelling is gradually becoming the standard method for building design all over the world. Its rapid development is visible not only in the many researches carried on it but also in the several standards released in different countries. The spread of the method implied continuous software improvements with the aim to comply as much as possible different design needs. Nevertheless, an insufficiency of tools specifically developed for construction site planning is still detectable among BIM panorama. The principal aim of the presented research is then to develop BIM use for making more efficient construction site design. Having defined, in an early report, the structure and the contents of the postulated Construction Site Information Model, the research goes on by customizing the available tools in order to fit the needs of a construction site designer. One of these tools is a predetermined template, useful as a starting point for the design, as it is for other design disciplines. The aim is to have at disposal, since the beginning of the project, a model completed of a series of elements, parameters, visualization tools and many other issues able to satisfy the needs of construction site design in term of information contents, level of detail and model efficiency. A step-by-step procedure is also provided to assure the correct use and guarantee the completeness of the model. In particular the research steps has been the following: (i) analysis of some software to evaluate the chances of customizing templates; (ii) creation of the template according to the defined contents and aims of the Construction Site Model; (iii) test and improvement of the tool in a project simulator specifically created for the purpose; (iv) practice in real case study and evaluation about its operation. The case study permits to evaluate how this tool make more efficient site designer task in term of time spent and mistakes avoided.

Keywords: Building Information Modelling; Construction site planning; Construction Site Information Modelling; Design optimization; Project Template.

1. Introduction

It is a redundancy to say nowadays that Building Information Modelling will prevail soon on CAD applications, which are at now well established in our design trends. Software vendors dealing in the construction sector have already adopted this trend by providing a large number of software concerning with BIM design approach. This trend answer also to the numerous public administrations that, since many years, requires the use of BIM methodology as a mandatory. The need to develop in detail each part of a building project pushed BIM vendors to provide and add "discipline specific interface, objects, design rules and behaviors to the same base parametric engine" [1]. Then, each main design discipline (in particular architectural, structural and MEP) has its particular design methods according to the software used. Current research moves also to other and more specific disciplines such as energy analysis, facility management and also construction site design and management. In particular this paper shows a part of an ongoing research concerning with BIM application and implementation to enhance construction site planning in each phase of design process. The main goal is to develop an efficient way to develop site plan able to guarantee the construction site expectations in term of costs, time and workers safety needs. Efficiency means, in general, reduction of design effort and errors through a software assisted planning as well as a continuous interoperability between the site planner and other designers in order to assure the feasibility of each work.

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Academic research analyzed many different aspects of site and works planning trying to implement it in a BIM environment. Vimonsatit et al. [2] underline the possibility to enhance site planning thanks to simulations and BIM that shows available spaces throughout the construction stage. However this research focuses on a problem on a lack of serious design tools that do not leave the choices entirely to the knowledge of the users. Lot of the researches the concerns construction sites are indeed focused on construction scheduling (with the implementation of 4D models) and safety planning. In particular from many years researches on 4D scheduling have been carried out starting from 4D CAD tools [3] to 4D BIM and use of data to generate schedules [4]. The 4D tools and the resulting possibility of construction phases visualization permit a detailed design of construction works taking into particular consideration, first of all, safety aspects. However planning for safety has been considered an important task in the satisfaction of the project needs. As an example a great importance has given to the construction workspace management [5] and their interferences [6]. In general the main goal is to facilitate safety planning production [7] ensuring a detail level suitable for hazard identification before starting construction. Other researches focused also the need of a creation of parametric objects libraries of temporary structures [8] and equipment [9] with the aim of a BIM site planning optimization. However the research on the field often focuses on single aspects of construction planning (safety, scheduling, costs, etc.). The presented research aims instead to go ahead single applications and give an overview of the construction site design process by developing a method supported by different tools for the site designer.

One of these tools -specifically developed for the purpose by the task group of A.B.C. Dept.- consists in a BIM project template able to help site designer during the modelling of the construction site in all its aspects. To be more clear, a definition of what we intend as a "BIM project template" is provided since the term should have different meanings according to the used software. Then, we intend as a template a BIM model of a specific authoring software specifically prepared for a particular task. It means that this "starting" file is provided by specific settings for the users to start a project in a certain discipline. It is important to underline that some software (e.g. Revit) permit to have a specific file (e.g. *.rte) format that represents the template to be used in a model file (e.g. *rvt). Some of these software already make available some starting templates for different disciplines (e.g. architectural, structural or MEP templates) provided with the elements of that specific discipline (e.g. furniture, beams, ducts) as well as specific modelling settings. As showed in the next paragraph other software (e.g. allplan) do not have this possibility, but a customized file can be used as a template to start each project. The research carried out on these software shows that a large part of them provides, in different ways, some settings that help the modelling for the different design disciplines, but nothing specifically developed for construction site layout planning.

In our on-field experience the use of a template entails, instead, a great time saving in design. Therefore, the paper will focus on some requirements to provide in a template in order to facilitate site planning. We identify these requirements in a series of elements, parameters, visualization tools and many other issues able to satisfy the needs of construction site design in term of information contents, level of detail and model efficiency.

In order to be clear the requirement have been translated directly in a model template following these research steps.

- software analysis and evaluation of the chances of customizing templates;
- creation of the template according to the defined contents and aims of the Construction Site Model;
- test and improvement of the tool in a project simulator specifically created for the purpose;
- practice in real case study and evaluation about its operation

2. Creation of the template

2.1. *Software analysis*

Having evaluated the importance of templates availability in terms of efficiency in project production, the research moves on the analysis of some BIM authoring software in order to evaluate the possibility of implementing templates in different disciplines. The analysis takes into consideration six software (see table 1) that, obviously, do not cover the entire BIM panorama but give a general idea since they are the most diffused. The first step of software evaluation takes into consideration the general chance to start a project with a predetermined template file and to customize it according to user needs. The second step of the study goes more in detail and gives a view about how is possible to customize a template in two different ways. This step consider both the possibility to use a proper template file or to use a project file as a template. The first one concerns the possibility of having available some object and tools useful to make faster the modelling of design choices. The second one concerns, instead, the possibility of add some elements and tools in order to facilitate the production of clear deliverables such as sheets and schedules. In particular, the first step analyzes the possibility to have

available a definite layout as well as objects and materials libraries focused on a specific design discipline; while the second step analyzes the possibility of customize sheets layout or line and text styles. The whole investigation is carried on by literary and users' research as well as some tests carried on some of the analyzed software. Table 1 summarizes the results of software analysis. From this study is visible how Revit permits more flexibility in customizing templates and so it was used for the development of the template, its simulation and the case study. However the arguments faced took into account the possibilities of other software.

Table 1. Project templates characteristics for major BIM authoring software.

Template characteristics \ Software	AECOsim Building Designer	Allplan	Archicad	Revit	Tekla	Vectorworks
Templates availability	•		•	•	•	
Templates customization			•	•	•	
Elements libraries	•	•	•	•	•	
Materials libraries	•	•	•	•	•	•
Schedules and reports	•			•	•	
Styles		•	•	•		•
Drawings			•	•	•	•

2.2. *Pilot template creation*

The process of creating a template customized for construction site planning starting from the analysis of the needs of a construction site designer. An early report of research [10] focused on the contents of a postulated Construction Site information Model (CoSIM) in different design stages. It was the starting point for the creation of a template that aims to facilitate each step of the construction site design structure. The template creation consisted in the customization of graphical and informative settings of a BIM (in this case a revit template file) in order to be used to each construction site project.

Regarding *Project Contextualization* the settings consist in some graphical properties that permit to identify and evaluate the site constraints that can affect the construction site. Therefore, the template contains some parameters that identify the constraint (e.g. aerial constraint) and the graphical setting give to the element (e.g. a tree) a specific color that permits to immediately identify the constraint itself.

Regarding *Functional-Spatial* and *Technological-Plant* design the template contains a series of pre-made construction site BIM elements (e.g. equipment, temporary structures, machineries, etc.) in order to have them at disposal directly from the software without searching in computer storage. The libraries are divided into different level of detail according to design phase analyzed. For this reason, a specific template refers to a specific construction design phase. Also in this case some graphical tools are added in order to simply identify the type of element in order to directly evaluate, for example, cost classes (e.g. cost for work, cost for safety, etc.).

Concerning *Process analysis* and *Process planning* the template contains settings that permit to automate the view of some parts of the designed building according to construction phases in order to evaluate site and works layouts in each phase. For these issues the template was also set up in order to automatically extrapolate quantities of construction elements to calculate times and costs.

For what concern *Organizational modelling* and *Health & Safety coordination plan* the template contains all that issues useful for deliverable production such as sheets settings (pen styles, customized titles, position of views and information, etc.), data tables to be inserted in design documents, etc..

According to the postulated CoSIM structure [10] these are the contents of the three CoSIM pre-design phase. The creation of the templates for the CoSIM-execution design followed the same criteria with a level of detail suitable to this design phase. In order to assure the correct use of the template a step-by-step procedure, specifically written for the purpose, permits to follow the design flow in different stages. The procedure, as well as the template itself, born according to a project simulator used for the development and implementation of the presented tool.

3. Test on project simulator

In order to better understand the usefulness of a project template in construction site design this paragraph present its use in a project simulator. It consists in a specific project created with the aim to develop and refine the templates before testing it in a real case study. In particular the project simulator shows the development of the contents of CoSIM pre-design in preliminary (see fig. 1a) and developed phases (see fig. 1b) of a simulated

construction project. It is imagined as a new construction of a residential building in a city environment characterized by different constraints in order to cover a wide range of construction site planning issues.

Figure 1: Screenshots of the project simulator for preliminary (a) and developed (b) pre-design phases

The preliminary pre-design phase starts with the project contextualization that consists primarily in the identification and evaluation of the constraints of the surrounding area. As showed in figure 1a, the first identification of the constraint is a specific color that shows what type of restriction characterize an object in the model. Thanks to some settings and parameters inserted in the template is possible to select the constraint type [11] simply flagging a property of the object. It means that, once flagged, that particular object take the color and, consequently, the properties (e.g. risk evaluation) of the chosen constraint type. So the high building and streetlights are flagged as *aerial restrictions* (pink), trees and houses near the construction site are identified as *surface constraints* (blue) while a school on the left represents an *interference with other activities* (fuchsia). After the definition of the constraints and the evaluation their impact on construction site (e.g. extra time and cost for tree cutting or plants relocation), the site designer have to start with the technological *Functional-Spatial* and *Technological-Plant* design. In this preliminary phase, in which the building design is in draft phase, he starts to identify the first needs of the construction site in term of site technical elements to put in place. For this phase as well as color characterization, the template contains also a library of volumes loaded in the model in order to have at disposal each type of feature to cover the need to be satisfied during construction. As an example, figure 1a shows that the first need is a division between the construction site and the surrounding area. In this preliminary phase it's only identified with a green solid since it has the task to show a need of a physical subdivision. In the next phase it will become a fence with specific characteristics given by the particular context and project issues. In the same way a red solid appears around the draft shape of the building that shows the need of a temporary structure. Orange and yellow identify, instead, the needs in term of infrastructure in construction site area (vehicle paths and storage areas). At the end of preliminary design the output is a model (coordinated with the draft of the building model) that shows all the future needs to satisfy in term of context criticalities and site system. Figure 1b shows the evolution of the preliminary design in the developed design. In this phase the building model develops from a draft volume to a more detailed object made on technical elements. The amount of information added permits to face the needs stated in the preliminary phase. The developed phase consist primarily in the translation of these

needs in specific requirements useful for their satisfaction. So the need of a division between the street and the site is satisfied by a blind fence.

In the same way the need of a temporary structure is satisfied by the presence of a scaffold. Is visible how the template of the developed phase contains a library of proper site elements rather than simple volumes. Step by step, in the developed phase the CoSIM designer analyzes hence the single need of construction site (identified by volumes) and satisfy it by choosing the right site solution (identified by site elements).

4. Practice on a case study

In order to assess the effectiveness of the created templates, our task group tested them on a real case study. It consists of a demolition of a building located in a city centre environment and some intervention on the neighbouring structures. The choice of this intervention as a case study follows the aim to evaluate how the template can improve, in particular in terms of design time, the modelling of a proper CoSIM for an intervention. In fact, the chosen intervention was developed in another step of the research [10] without template and it is thus possible to make a comparison.

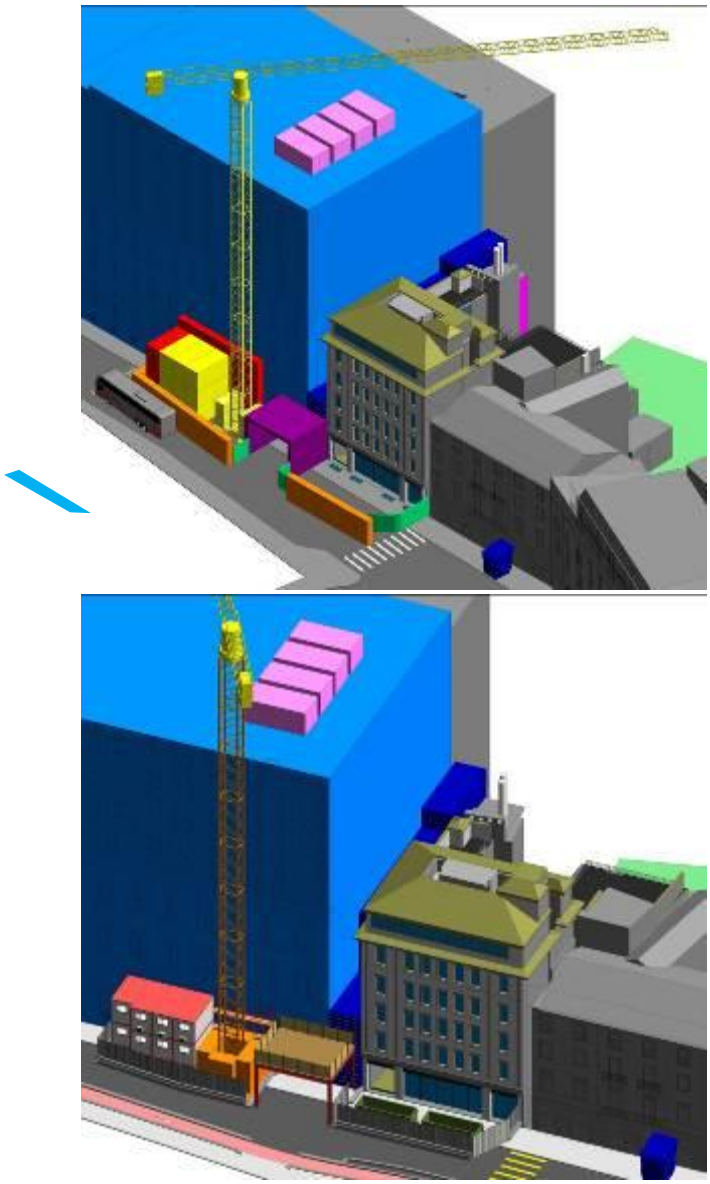

Figure 2: Screenshots of the case study for preliminary (a) and developed (b) pre-design phases

Figure 2 shows the development, from preliminary to developed phase, of the site layout for the first phase of the construction site before scaffolding mounting. The approach used is the same of the project simulator and the same design steps have been applied. First of all the context analysis underline the presence of the theatre (blue)

and its indoor loading area for trucks (dark blue). Furthermore, air-handling units (Pink) on the theatre roof represent aerial restrictions to be taken into account during the choice of the crane. As visible the construction site layout follows the need to have an area in front of the building to be demolished as working area (the pedestrian path inside the fence will be covered by scaffolding) and storage of rubbles (light blue). The other area has been designed for logistic purposes and contains the crane and offices and services sheds (yellow). These areas are connected by an elevated working platform (purple) that permits to link the construction site areas without affecting truck entrance to the loading area of the theatre. As in the simulator, the red volumes represent the temporary structures able to connect the different floor of the sheds and the logistic area with the platform. Construction site areas are obviously bordered by a physical delimitation (orange) that needs to be opened in some parts to permits the access of construction site vehicles (green). Table 2 summarize how all the underlined needs have been satisfied in developed phase.

Table 2. Needs underlined in preliminary phase and solution provided in developed phase

Need underlined in preliminary phase	Technical solution for the satisfaction of the need
Strong delimitation between site and street (orange)	New jersey and steel panel fence
Delimitation that can be opened for truck entrance (green)	Site gates and modular steel fences
Logistic area with offices and services (yellow)	Pre-fabricated sheds on three floors
Elevated working platform and portal (purple)	Metal carpentry
Temporary structures (red)	Sheds with stairs and scaffolding
Rubbles storage area (light blue)	Storage containers

5. Discussion and Conclusion

As said the choice of this particular case study permits to evaluate the difference between modelling without pre-determined settings and modelling with these settings ready in a template. Therefore, in this case study the main design choices were made before the model, so the comparison takes into account in particular modelling efficiency. Frst of all is important to take into account the efficiency of the model in terms of design issue. The use of a template permits, in fact, to have at disposal an amount of information (for example the risk analysis related to a particular constraint) otherwise to be inserted manually. This characteristic of the template permits certainly to reduce design errors and forgetfulness. Another strong point is the facility to determinate and shoe a construction site need in a preliminary phase. In fact the preliminary CoSIM template is characterized by a series of volume in which site designer can flag the need choosing from a pre-determined list. This things, permits not only to be fast in preliminary modelling but to have an efficient starting point for the developed phase. In fact the library of construction site elements is set according to the need that they have to satisfy and the choice results immediate. In fact, although the template is different, the preliminary model can be imported in the developed template in order to have the exact starting point for developed design. The assessment of the efficiency of the template use in designing and modelling construction site took into account also the time consumed in modelling with very interesting results. In fact pre-determined modelling settings made the modelling process faster than before with a great satisfaction of the users. This efficiency has been found also in deliverable production thanks to the automation in information extrapolation and pre-determined types of graphical views. Although the results of the field test are extremely satisfying, some problems occurred in the use of a template due, in particular to the changing conditions of each construction site that don't permits to always follow pre-determined settings. The next step of the research will be so the refinement of the settings in order to fit as much as possible a large number of construction site possibilities. Another future step of the research will be obviously the test of the method with other software. In fact, although the template requirements aim to fit to the use of all software we see that each of them has some particular settings that need to be studied deep in order to adapt it to the defined requirements. In particular the procedures to reach the goal are different from software to software since each one has its specific functionalities. Despite of this the filed test encourage the task group to continue in this research in order to spread as much as possible CoSIM method and realize the aim of raise construction site planning to a clear designe discipline to be faced since the first phases of each project.

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