SIMULATIONS AS PART OF THE BIM CONCEPT IN URBAN MANAGEMENT

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Abstract. *Smart city management is part of the Smart Cities concept and can be an essential element for further development in this area. The BIM concept, based on a 3D model, data and for all the beneficial cooperation, expands exponentially in the civil engineering. However, the BIM concept is so broad and there are many possibilities in his area, that the development will take many years. One of these areas may be simulations that are not so widely used so far, but which can very well specify different situations and conditions. For these conditions, buildings or cities can be prepared in advance to prevent crises or unnecessary costs. The simulations and the results obtained from them can help us in the decision making phase. They predict problems or situations that can occur during the life cycle and thus prevent them from occurring. Based on the information we receive, we can objectively decide on the design solution, the material, the internal arrangement or, for example, the location of the building in the surrounding area.*

Keywords

Simulations, BIM, building information modeling, urban management, facility management.

1. Introduction

This paper presents the possibilities of using the BIM method and 3D city model for different types of simulations. The article aims to summarize various types of simulations and possibilities of use for city management.

BIM is a concept that everyone has heard of today. Many experts deal with its parts and work with other professionals across the BIM concept. There are many companies or research institutions involved in BIM modeling, design, planning, logistics and, of course, the operation and maintenance phase of buildings, ie facility management. Another important way of BIM, if we have a realistic 3D model of building, are simulations. These can be many, such as acoustic, thermal, flood, wind, sunlight and many others.

BIM assumes digitization of the real state of building, an identical model. It can be subjected to simulations and, based on the results obtained, can modify possible designs or plan further procedures, search for crisis states or situations, and predict possible errors and costs. Simulations can also help us improve the living conditions for the citizens of the city or a smarter concept of its development. Another area where the BIM method can move is just modeling parts of a built-up area or entire cities. This is another part of the modern Smart Cities concept and digitization of cities.

Building Information modeling is based on an interactive model of a particular building, area or city. In the case of a city, the model can be named a map model. A 3D model composed of specific elements that contain important information (properties) to increase efficiency can serve as a map from which the model was partially created. The model can include underlying maps, such as cadastral maps, flood maps, etc. The map model should contain and unify all important information about city, both graphical and descriptive. Based on the model's details, we assume the relevance of the efficiency and application of the model itself in the city's operation. [5]

2. Building Information Modeling/Management

Building information modeling, or we can also say building information management, is a modern concept of construction across all disciplines. It is supposed to cooperate with each other and maximize the useful value of information to reduce costs, improve quality and save time.

Information is very important for facility management. Which is very important in the case of urban and property management. Effective use of information across municipal departments, mutual exchange, timeliness and accessibility for all, is a key element in increasing efficiency. [8]

BIM is a modern, efficient and intelligent process of creating projects that are based on a 3D model and data (informations). This approach facilitates the creation, recording and exchange of data throughout the lifecycle of buildings, from idea / design, to complex projects and operations to their disposal. Its main benefits are more efficient, faster, more economical, and more transparent creation and management of any building. [4] Of course, BIM can be applied to entire complexes or urban areas.

City Information Modelling, and even the more frequently used term City Information Management, is primarily an efficient, clear and comprehensive digital database of information, and the correct application of these data sources is certainly a continuation of this trend. 3D map models, for example Google Maps, have processed many cities that now have realistic simulations, including elevation information. In this case, however, we cannot speak of information modelling. Google Maps is based on interactive elements that can be easily edited and have not associated descriptive information stored for example in Computer Aided Facility Management (CAFM) systems.

2.1. Modeling

The model can be created in several ways. We need to recognize whether we build a model of an existing building or new project. If we create a model of an unrealized object, modeling is usually in the hands of an architect and his ideas. It creates a model in a clean environment of any of the BIM software. The second option is to create a model of already existing construction. Here, we have the built object, which we must convert to the most realistic digital form. Again, there are many ways to achieve this. The basic way is to go through the building, measure it, take a picture, and then create a model from these sources. Another option is to get quality drawing documentation and transfer to the digital form.

The most accurate alternative to creating a model is to use laser scanning using cloud of points and, for example, drones. [1] This method is ideally suited to scanning urban areas to obtain a very accurate image of large space. The model should be an authentic, true copy of reality. Only then does it make sense for subsequent use.

Level of Detail of the city model depends on the use of the BIM model. If we use the model for simulation, the level of terrain model and building shapes or trees will be decisive for us. Objects can be solid bodies that do not increase computing power. If we want to use the BIM model of the city for facility management, the level of detail will be different. It always depends on the purpose of using the model.

2.2. Level of Model Definition

The BIM is based on a model that should be identical to the realistic object in digital form. Today, we recognize two levels of model definition. Level of Detail (LoD) and Level of Information (LoI) with values of 100-500. The information has its own structure and is very important for the longest phase of the life cycle of the construction - facility management. [2] However, they can also provide a number of important information in the decision-making process of urban development. It is very important to correctly determine the degree of detail and adhere to the established value. [4]

Only an identical digital model can effectively serve its purpose. It is very important at the beginning of the modeling to determine in which detail the model will be created. The level of detail/information can be determined for the whole model or part. Too low the level of detail/information may not have sufficient value, and we may not have enough information to make decisions and work with the model. On the contrary, the too high level of detail can be unnecessary, too costly and complicated by repairs and to update the model. Such a model is very demanding on data - also known as big data.

3. Simulation on a map model

Many types of simulations can be created on the city model. Here is a list of a few basic ones that we could use in urban development and use their potential to improve the management and operation of urban property, decision-making processes and the direction of urban development.

1. Air flow through the city, wind load, cooling and impact on buildings

2. Spread of pollution from contaminated areas outside the city or directly from urban sources

3. The influence of urban greenery on the absorption of pollution

4. Temperature and overheating of urban areas depending on traffic, movement of persons, quantity of greenery, etc.

5. Load and bearing capacity of the subsoil due to undermined areas and groundwater levels, earthquake

6. Influence of building shading and regulation of heights in spatial planning

7. Expected movements of people, transport and influence on urban areas

8. Conceptual proposals for urban development

9. Fire propagation and availability of emergency services

10. Floods, prediction of crisis situations and water distribution based on hydrometeorological data

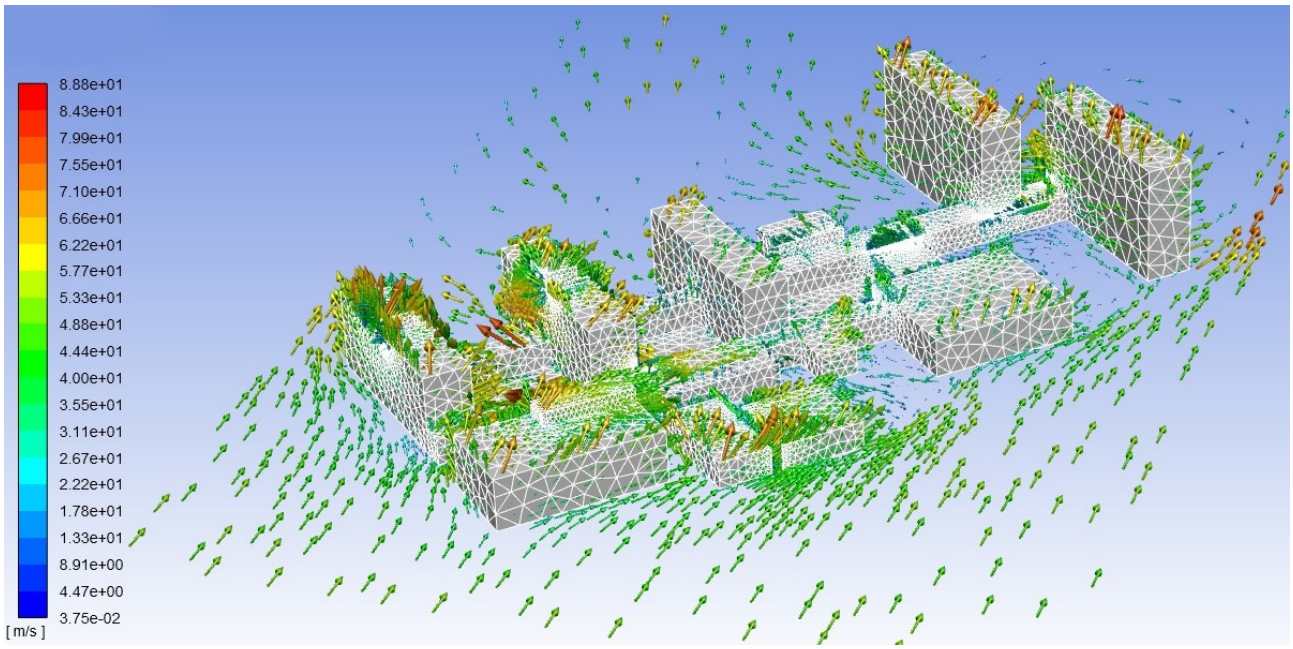

Fig. 1: Wind flow through the campus area VSB – TUO [ANSYS fluent, author].

Simulations and map model analyses are designed to facilitate decision-making on city development, improve management and operation processes, identify critical values or situations and predict potential problems and determine timely solutions. [5]

3.1. Computional Fluid Dynamics simulations

One of the open source tools for creating CFD simulations is the OpenFOAM software. If we own a model with a terrain, or at least its image created by a cloud of points, we can transfer such a model to OpenFOAM software, set the parameters of the calculation, the type of simulation we want to perform and get very accurate outputs. Other options are commercial tools like ANSYS Fluent or Comsol Multiphysics. These software are easier to use and there is no need to know the basics of programming.

This model is a demonstration of how simulations can look like. It always depends on the possibilities, boundary conditions and type of simulation. It is not a specific measurement but the possibilities of urban simulations using the BIM method.

4. Possibilities of using the information

There are many ways to exploit the results obtained by simulations. They are dependent on the type of simulation, the level of complexity and the complexity of the calculation. Many of the above-mentioned simulations are already commonly used in practice and are supported by legislative requirements. However, there are still many simulations, the value of which is underestimated and judged depending on time or financial demands. In the BIM concept these simulations have their place. [10]

The most effective simulations are CFD simulations. There are many tools that can create such simulations. In figure 1 we can see an example of airflow in the area in ANSYS fluent. Similarly, it might look like output from the spread of pollution or influence and temperature distribution. These tools are used for more complex models and simulations, such as complex buildings, landscapes, etc. However, they are able to create simulations on solitary constructions. [6]

If we want to know the behaviour of a building through its life cycle, to predict problems that may arise, to know the possible risks or all the costs associated with the construction, operation and disposal of the building, many of these simulations must be part of the BIM concept.

The concept itself, which creates a 3D BIM model, prepares very suitable conditions for creating simulations, and unlike classic 2D drawings, this model can be immediately subjected to simulations. Just transfer the model through the exchangeable formats to specialized software.

With technology development, many BIM design software will contain these simulations automatically and their results will be more accurate and shorter processing times. All this leads to a more efficient use of information linked to the BIM model.

5. Conclusion

The BIM abbreviation is not just modeling and informations. This concept expands every year and its substance, based on the life cycle of the building, absorbs all the processes. This also includes the simulations and the results obtained from them, about the future behaviour or state of the construction before it is built. The processes that BIM absorbs through the entire building life cycle and efficient to interconnect and create synergy, thereby increasing the efficiency of individual parts. Basic building information has its own utility value. But if we know other connections, the benefit can exponentially increase and on the contrary, the cost, labour or time very noticeably decrease.

Simulation of future states and building behaviour can support information management and decision-making that has so far been based on prescribed constants, experiences, and estimates, and which do not have to respond to real situations.

The most expensive part of the life cycle of buildings is maintenance. At this stage, information modeling finds its great merit, and facility management expertise, focused on the operation and maintenance of buildings, can better perform its activities with the properly implemented BIM model. Management processes are very similar to those of urban development. It is the management of specific constructions, areas, communications, technical facilities, greenery, etc.

Many types of simulations can be applied to the BIM model. However, many are very computationally demanding. Others are very demanding to get input data. These are also the reasons why the use of simulations is not so often used in practice. The financial costs of creating simulations do not want the city management to invest. Situations that can be predicted by simulations can prevent large and costly damage. In such a situation, the investment pays off. This article introduces the possibilities and ways of simulations that can be created on BIM models. It should briefly show that BIM is not just about buildings but can also be used for cities (Smart Cities). And it represents a little supported part of the BIM concept, simulation.

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Michal FALTEJSEK was born in Dolní Čermná, Czech Republic. His research interests include smart cities, facility management and BIM.