Public health component in building information modeling

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Abstract. A building information modelling (BIM) conception has established itself as an effective and practical approach to plan, design, construct, and manage buildings and infrastructure. Analysis of the governance literature has shown that the BIM-developed tools do not take fully into account the growing demands from ecology and health fields. In this connection, it is possible to offer an optimal way of adapting such tools to the necessary consideration of the sanitary and hygienic specifications of materials used in construction industry. It is proposed to do it through the introduction of assessments that meet the requirements of national sanitary standards. This approach was demonstrated in the case study of Revit® program.

1. Introduction

Nowadays civil engineers use a variety of codes and standards as well as standardized tools for design, construction, operation and demolition [1] . One of the powerful and promising design tools include Building Information Modeling (BIM) [2, 3].

According to general information modeling literature [4-8], the basis of the BIM concept are the processes and ways of working together with information about the construction object. BIM embraces all the life cycle stages of a structure: planning, preparation of technical specifications, design and analysis, issuance of working documentation, production, construction, operation and maintenance, and dismantling. Data are added to the 3D information model throughout the lifecycle of the process structure. This is necessary for business planning, design, procurement of materials, coordination of work in different sections of the project, logistics, installation and assembly, construction, and commissioning.

The BIM concept allows one to merge information already owned by the organization, with new knowledge that appears in the company during the transition to BIM. It provides data exchange between existing enterprise systems and the BIM model. The information model becomes a data provider for the procurement system, the scheduling system, the project management system, the Smart Home system, and other systems [9-11].

Authors of [12] proposed using graph theory as a language to describe building information models and pertinent security related functions. If BIM is considered as a network [13], then nodes of the

network will be participants in the project or the stage of the process, which are interconnected by information links. Changing one node on the network will lead to a dynamic change in the system itself (the project) as a whole (see Fig. 1). Among benefits of BIM, there are the following: ability to estimate the amount of materials and work, reducing the cost and timing of construction, increasing cost control and increasing the accuracy of forecasts, reducing errors and reducing design changes, which of course has a large economic effect. Also diffusion of clean technological innovations in general has been observed [14], the growing demands from ecology and health were not fully considered within BIM-supported tools (excluding few papers, accented on sustainable development such as [15,16]) .

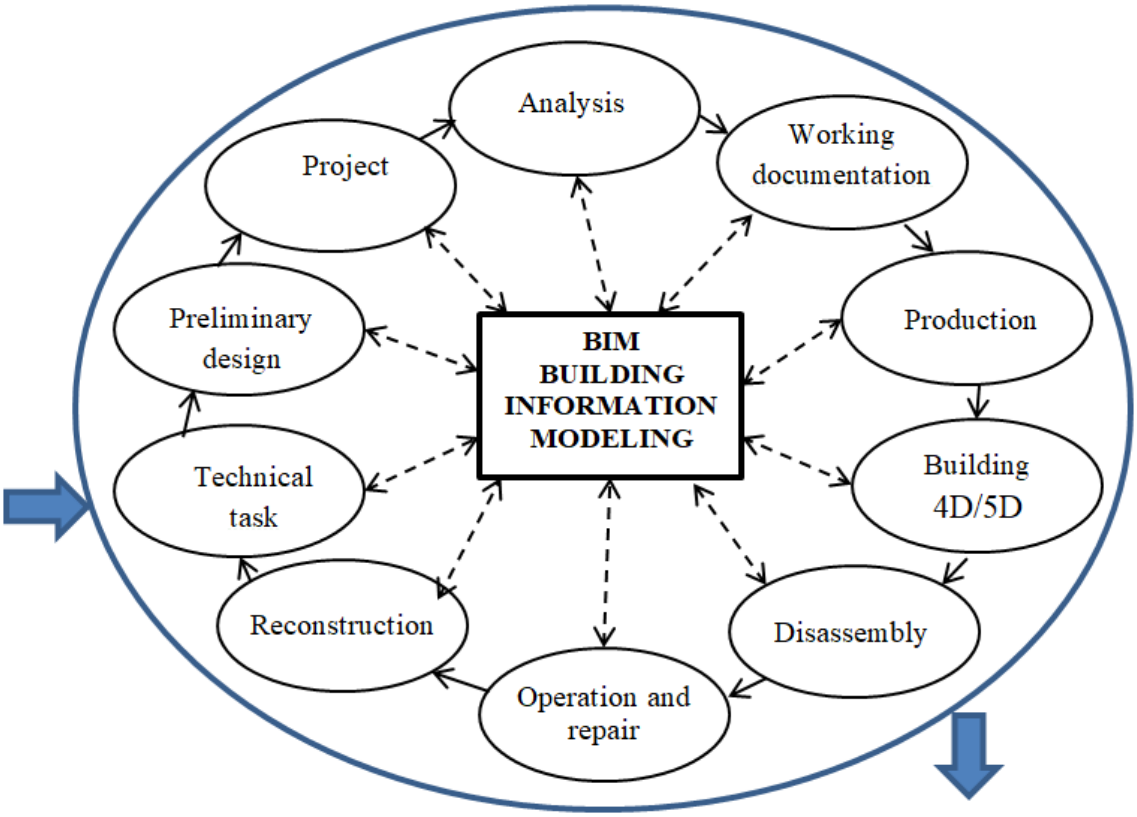

Figure 1. BIM-conception

2. Suggested solutions and methods

In this regard, it is proposed to apply and implement such component as a health one into the BIM-solutions.

Implemented BIM software products such as Autodesk Revit® as a rule offer an extended multidiscipline set of tools for designing 3D models, including the Materials Manager. This tool allows one to add a desired material to the project (see Fig. 2) [17].

The properties defining a material are systematized in a form of "sets of specifications". These are groups of properties that control some specifications or behavior of a set of specifications. To determine materials in Revit®, the following types of feature sets are used:

- graphics (only for Revit®) - these properties define the appearance of a material in non-visualized views;
- appearance - these properties determine an appearance of a material in visualized, realistic views, as well as types of "ray tracing";
- physical - these properties are used to calculate load-bearing structures;

- thermal (only for Revit®) - these properties are used to calculate energy consumption.

A material can have up to four sets of specifications, but not more than one set of specifications of each type. So, the material could not have two physical sets of specifications.

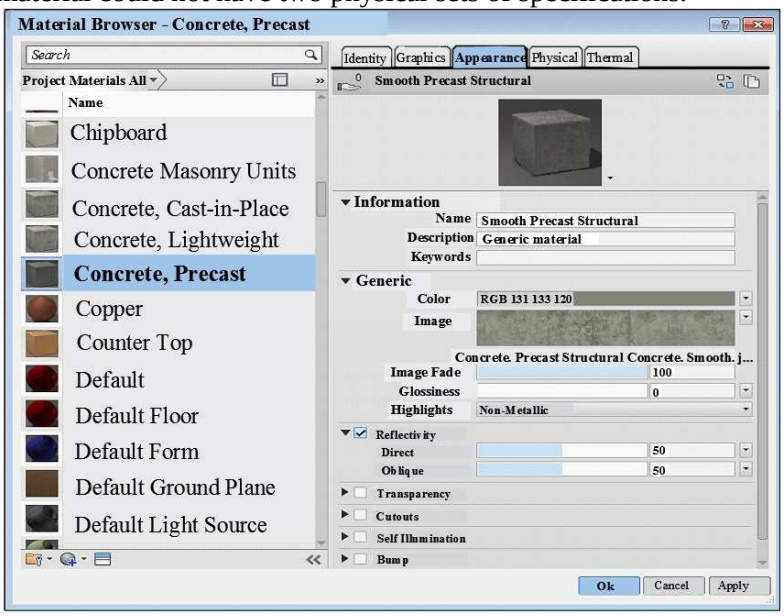

Figure 2**.** Autodesk Revit® (Material dispatcher)

The right panel of the Material Manager dialog box is used to check or edit specification sets and material properties.

It should be noted that the materials used have absolutely no specifications which, during operation, adversely affect human health, and the content of harmful substances in them can cause long-term effects - allergenic, mutagenic, embryogenic and carcinogenic effects.

3. Findings

The introduction of additional properties that have a detrimental effect on health, such as:

- toxicity,
- electrifiability (electrification),
- radioactivity,
- magnetic properties,
- the ability to disinfect,
- heat and sound insulation,
- smell,

will allow one to select a material and minimize indices, leading to negative changes in a human body [18].

Moreover, the quota -MPC (maximum permissible concentrations) of harmful substances for atmospheric air can be taken as one of the criteria, for example when monitoring the quality of premises environment. An additional requirement for building materials is not to release volatile substances in concentrations that can have a direct or indirect effect on human health and create a smell within environment [19]. So according to [20], in Russia it is customary to estimate the power of smell on a five-point scale (Table 1)

Table 1. Quantitative assessment in points

Description of smell		Quantitative assessment in points
1	0	Absent; not observed by any of the observing people
2	1	Hardly noticeable; detected by the most sensitive persons
3	2	Weak; it does not attract attention, but it is noted if the observing people are aimed at its detection
4	3	Distinct; easily felt, even if the attention of the observing people is not drawn to him
5	4	Strong; attracts attention
6	5	Unbearable; excluding the possibility of prolonged stay in the room
1	0	Absent; not observed by any of the observing people

Similarly, other six sanitary and hygienic material properties mentioned above are also reasonable to assess those on a five-point scale.

By adapting Revit® to public health objectives, assessment of these properties should be reflected in the Materials Library. For this, it is suggested to add them to the "appearance" category. The tool for adding might be similar to the following code - C #:

```
0 : [APT_String] AdvancedUIDefinition = Mats/Generic/GenericAdvancedUI.xml
1 : [APT_String] AssetLibID = AD121259-C03E-4A1D-92D8-59A22B4807AD
2 : [APT_String] assettype = materialappearance
…
50 : [APT_Integer] toxicity = 0
51 : [APT_Integer] electrifiability (electrification) = 0
52 : [APT_Integer] radioactivity = 053 : [APT_Integer] magnetic properties = 054 : [APT_Integer] disinfection = 0
55 : [APT_Integer] heat and sound insulation = 0
56 : [APT_Integer] smell = 0
57 : [APT_Integer] discharging = 0
58 : [APT_String] swatch = Swatch-Cube
59 : [APT_String] thumbnail = C:/Users/lua.ADS/AppData/Local/Temp/MaterialThumbnails_PID_1434/73c06a00Smooth Precast Structural.png
60 : [APT_String] UIDefinition = Mats/Generic/GenericUI.xml
61 : [APT_String] UIName = Smooth Precast Structural
62 : [APT_Integer] version = 2
63 : [APT_String] VersionGUID = B1E74BC9-150D-4CB2-BFF1-376BEAD5FEAE
```

In the above mentioned code, assessment of sanitary and hygienic properties of a material (the lines 50-57) corresponds to its absolute safety (Quantitative assessment in points is 0).

Thus the adapted version of the Material dispatcher focused on sanitary and hygienic specifications of the desired material within the project framework (Fig. 3).

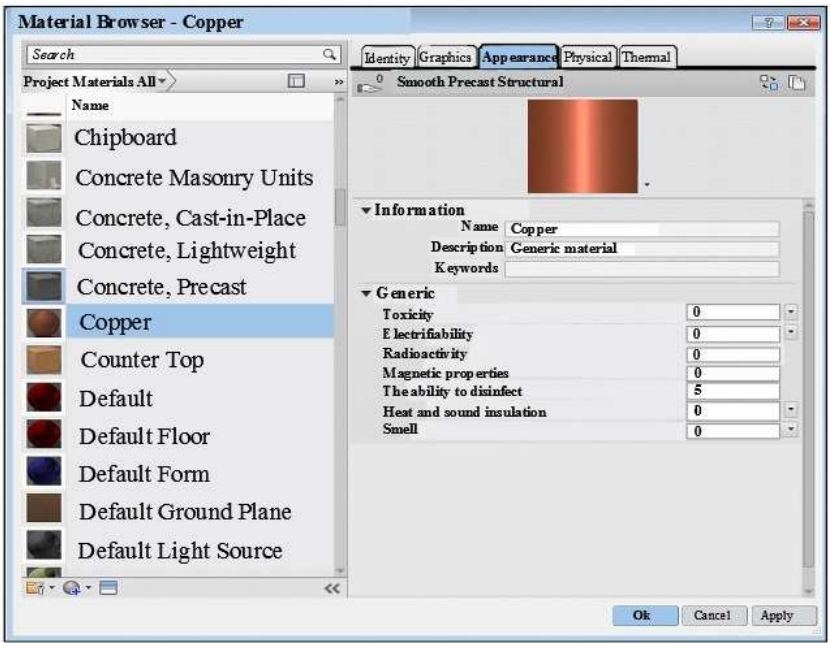

Figure 3. Adapted version of Material dispatcher

4. Conclusion

BIM-conception has established itself as an effective and practical approach to plan, design, construct, and manage buildings and infrastructure. At the same time, state-of-art of the domain reveals:

- Providing optimal quality and reliability of governance processes of large-scale construction works; this concept manifests some gaps with regard to "smart" building design [3].
- Sufficient feeble is that the BIM-developed tools do not take into account the growing demands in the field of ecology and health.
- The restrictions imposed on the total number of specification sets (graphics, appearance, physical, and thermal) in the standard Revit® package do not allow a user to augment a set of properties, to create additional properties/ to change the estimates of these properties.

The research offers an efficient way of adapting such tools to the necessary consideration of sanitary and hygienic specifications of materials used in construction industry.

The case study of the Revit® program demonstrates how expansion of the material properties library through inclusion of pertinent assessments meets the requirements of national sanitary standards.

This study will encourage developers of specialized software to create BIM-products that satisfy modern demands in ensuring human safety and health.

5. Acknowledgments

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