BIM: INTEROPERABILITY FOR SUSTAINABILITY ANALYSIS IN CONSTRUCTION

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Summary

The paper briefly presents potential benefits of BIM (Building Information Modelling) based tools for buildings sustainability analysis, reviews currently available software and explains the need for the interoperability among architectural models and sustainability analysis tools. Based on this context, there are introduced and compared two data exchange standards that allow to transfer information from architectural building modeling software to sustainability analysis tools: gbXML (green building eXtensible Markup Language) and IFC (Industry Foundation Class).

Keywords: BIM, IFC, gbXML, sustainability analysis, software interoperability

1 Introduction

Construction, as most of the industry branches, is constantly facing new challenges, as consumers expectations and legal obligations are becoming more and more sophisticated. Nowadays, buildings are expected to be consistent with the sustainable development rules, which means that they have to excel in the three essential areas: social performance, economic performance and environmental performance. Improving accessibility of the environmentally relevant data and intensifying its sharing and reuse during all the building lifecycle stages is placed among the crucial goals that have to be achieved in order to address the new challenges [1].

BIM (Building Information Modeling) is a concept that can be used to enable construction industry to meet the emerging requirements. One of its most significant advantages is the automation of data transfer and reuse, what can facilitate the process of performing detailed design analysis before the beginning of the on-site construction works.

This paper reviews current capabilities of sustainability-related decision support software tools, both BIM-based and those which are not using BIM concept, but utilizes huge amount of data, which could be potentially acquired from building models. Moreover it discusses the problem of interoperability of the sustainability support software, and briefly compares two most prevalent [2] open data exchange schemas – gbXML and IFC.

2 Decision making support

Decisions made on the design stage of building lifecycle greatly affect its overall performance in many areas, including environmental, which is one of the crucial elements of the sustainable development idea [3]. Due to that fact, it is particularly important to provide building design process participants with software tools, that would allow to

efficiently perform environmental simulations and analysis based on wide range of precise data, in order to enable them to make more informed choices.

Nowadays the most common are energy simulation software tools. This is due to the fact that the energy performance of building is one of its key features considered by customers, because of its significant impact on buildings operational cost. Some of applications implement the BIM concept (e.g. Ecotect, eQuest), so that they can automatically utilize data from the building models created in the design process. The most common open data schema used for this purpose is gbXML. On the other hand, there is a lot of energy simulation tools that do not use BIM data (e. g. EnergyPRO, TOP Energy), and require manual entry of building information. That makes them more susceptible to the data inaccuracy, and increases cost and duration of the simulation process.

Another reason why the energy analysis software applications are gaining on popularity are the law provisions concerning the energy performance of buildings, e.g. Energy Performance of Building Directive (EPBD) in the European Union, which obliges every building or building part being sold or rented to have the Energy Performance Certificate. In that case applications used have to be compliant with the given, country-specific methodology, so that there is a need to establish a software validation procedure.

There are also many LCA (lifecycle assessment) software tools available. They are supposed to calculate all environmental impacts of products, caused in their whole life cycle, and they can be applied to buildings (e.g. Gabi, SimaPro, openLCA). However, since they are not meant specifically for building analysis, they cannot import data from building models directly. On the Stanford University (USA) there was a project conducted, with the use of building model (IFC) as a data source for LCA application (i.e. SimaPro) [4]. The effort was successful, but it required a lot of additional work to transfer the data.

The efficiency of decision support tools depends significantly on their ability to interoperate with other applications . Therefore, there is a need for open data schemas, that would allow to exchange appropriate information using building models.

3 gbXML (green building XML)

gbXML [5] is an open data schema, which main purpose is to facilitate the transfer of building information from CAD applications to environmental (energy in particular) analysis software. Its first version was published in 2000, in 2012 version 5.01 was released. Currently the scope of the schema includes mainly data suitable for operational energy consumption analysis, such as the buildings geometry, information about its HVAC installations, and thermal properties of construction materials.

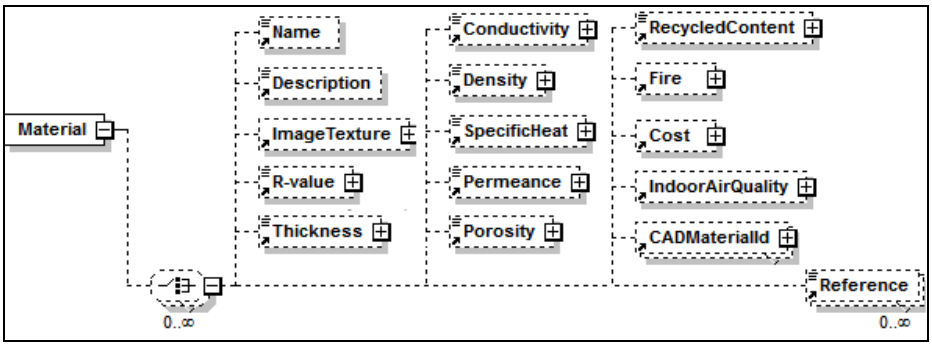

Fig. 1 *gbXML material properties schema [5]*

The main limitations of gbXML in context of environmetal analysis are:

- the lack of information about construction products included in builing model that do not influence its operational energy use,
- the lack of specific data about construction materials. List of their properties does not include e.g. many characteristics necessary to perform the building‘s life-cycle assessment(LCA) (fig. 1).

Furthermore, gbXML is not registered as official standard (e.g. ISO). This in fact has both positive and negative consequences, e.g. allows the data schema to evolve faster, but does not assure participation of various market representatives in the process of the schema development.

As gbXML is based on widely known, simple XML language, and due to its limited scope, it is considered as relatively easy to implement in software [2]. At present gbXML is widely used to transfer data from design applications to commonly used BIM-based energy simulation software, such as Ecotect, Green Building Studio or IES Virtual Environment [6].

4 IFC – Industry Foundation Class

IFC [7] is an open data schema developed with the purpose of describing all aspects of building in its whole lifecycle, within digital building model. The IFC specification is written using the EXPRESS data definition language (ISO 10303-11). IFC schema includes detailed information about building geometry, structure, materials, products, processes, actors involved etc. It is meant to be the universal mean of data sharing among all the construction-related software tools. Current release of IFC specification is version 2x3, but there is already IFC 2x4 RC4 (Release Candidate) published. Version 2x4 of IFC is to be adopted as international standard ISO 16793 (IF 2x3 was registered as ISO/PAS – Publicly Available Specification).

IFC‘s complex structure and huge variety of included types of objects makes it diffucult to implement it as a whole in the software applications. Therefore, there are udertaken initiatives to facilitate its use. One of them is based on the the MVDs – Model Viev Definitions, which are parts of the whole IFC data model, designed to include specific set of data that is required to perform particular action, e.g. Structural Analysis Viev. MVDs for thermal analysis are currently under development [8].

Due to IFC’s object oriented, hierarchical structure, it assures flexibility of object‘s property definition. Every building’s element type included in IFC inherits the attributes of the IfcObject class, hence it can be described by assigning any available property set (IfcPropertySet object) (fig. 2).

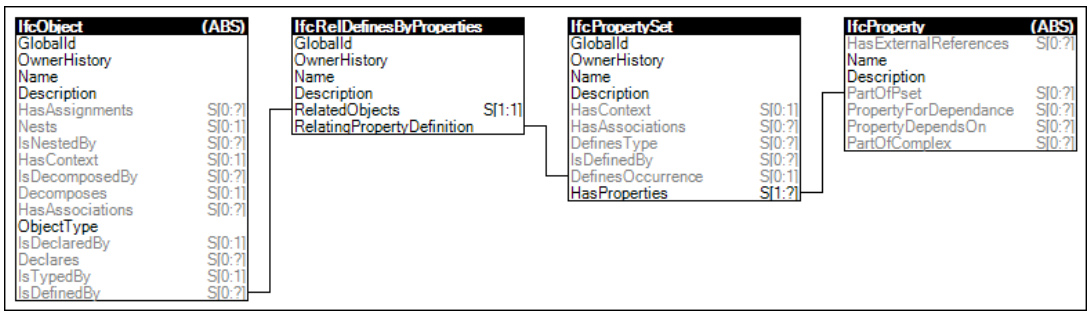

Fig. 2 *Schema of binding a property to the object in IFC [7]*

The 2x4 version of IFC specification includes property sets especially developed for environmental analysis (consistent with ISO EN 15804), namely:

- „Pset_EnvironmentalImpactIndicators“ which describes values for a given “functional unit” of the element, (e.g for window it could be „one square meter of opening elements filled by this product)”
- „Pset_EnvironmentalImpactValues“ which capture environmental impact values of element as an entity.

Currently IFC is widely supported by a wide variety BIM-based design applications, including architectural, structural, mechanical etc.

5 Conclusions

Computer aided decision support tools, especially those based on BIM concept, have a great potential to facilitate sustainable development of the construction industry. One of the crucial conditions of their proper development is assuring the interoperability among design and sustainability analysis applications. There are two data schemas available nowadays (IFC and gbXML) that can be used for this purpose. The gbXML schema is easier to implement, but does not include all building (and it’s elements) information relevant for environmental analysis, and in its current version is targeted rather towards energy simulations only. The IFC schema, more complex and including larger scope of building aspects, is not yet common in sustainability analysis software, due to the difficulty of its implementation. This can be changed by sustainability-targeted MVDs (subsets of IFC data schema), which are currently under development.

References

[1] Watson A, "Digital buildings – Challenges and opportunities" Advanced Engineering Informatics 25 (2011) 573–581.

[2] B. Dong, K.P. Lam, Y.C. Huang, G.M. Dobbs "A comparative study of the IFC and gbXML informational infrastructures for data exchange in computational design support environments" Proceedings of Build. Simulation, 3 (2007), p. 2.

[3] MoldanB., Janousková S., Hák T. "How to understand and measure environmental sustainability: Indicators and targets", Ecological Indicators 17 (2012) 4–13.

[4] Basbagill J., Fischer M. Flager F. "Multi-objective building envelope optimization for LCC and global warming potential", ECPPM, Reykjavik, Iceland, 2012.

[5] gbXML, www.gbxml.org, last reviewed: 23/01/2013.

[6] Azhar S. et al. "Building information modeling for sustainable design and LEED® rating analysis", Automation in Construction 20 (2011) 217–224.

[7] IFC 2x4 RC4 http://www.buildingsmart-tech.org/ifc/IFC2x4/rc4/html/index.htm, last reviewed: 23/01/2013.

[8] The MVD site http://www.blis-project.org/IAI-MVD/ , last reviewed: 28/01/2013.