

## **BUILDING SUSTAINABILITY AND BUILDING INFORMATION MODELLING**

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**Abstract:** The environmental protection is one of the most important socio-cultural topics. Protecting and supporting the healthy environment is an important basis for preserving human existence. The quality of the environment is influenced by the construction markedly. There is also required a considerable consumption of redundant sources and energy. In this regard, it is necessary to look for alternative ways and methods for promoting energy efficiency, production reduction, waste and emissions. During the preparation, realization and occupation of buildings, automatized processes are pushed forward. One of the new, innovative processes that increase productivity and production growth is Building Information Modelling (BIM). The paper deals with several options, how the sustainability in construction can be secured in the concepts of building information modelling. The terms as sustainability, green buildings, green components, BIM Libraries are described and the availability of selected "green components" in BIM Libraries is observed.

### **1 Introduction**

A care about the environment is an important activity about socio-economic significance. A healthy environment is the basis for the preservation of human existence, healthy development and influences the factors of the living standard of the population significantly [1,2]. Construction activity influences the quality of the environment greatly and requires enormous consumption of natural resources and energy. A huge amount of waste and pollution is generated. The negative consequences of construction work led to redundant pumping of natural sources, pollution, ecosystem disruptions, but also to negative socio-cultural impacts and changes in the environment [3]. At present's society, more emphasis is being placed on the creation of methods and procedures to objectively assess the impact of used building materials for the environment. A lot among of studies deal with green building solutions and emphasize on energy efficiency, reducing waste production, CO<sub>2</sub> emissions, etc. A suitable tool for promoting environmental behaviour is Building Information Modelling. It is considered as a system solution that allows a comprehensive analysis of the building and reviews the overall design in terms of possible environmental impacts with the aim to ensure optimal and sustainable design, construction and operation of the building [4].

### **2 Building information modelling and building sustainability**

Change of lifestyle in modern society is reflected by increased rate of flexibility, productivity and technological development. Civil engineering sector supports the process automatization. Building information modelling is important tool for raising the effectivity and productivity in civil engineering industry. There exist a lot of definitions for Building Information Modelling.

BIM is a digital representation of the physical and functional properties of the building. The process of building and building management includes many stakeholders, and it is therefore important to properly share information throughout the building's life cycle [5].

Model BIM provides graphical and non-graphical information. According to BIM principles, there exist seven established dimensions, which are:

- 3D – Geometry,
- 4D – Time,
- 5D – Cost,
- 6D – Sustainability,
- 7D – Facility management [6].

The third dimension is a more recognizable dimension because it is related to the "visible" part of the BIM model. The fourth dimension is the time schedule of the project. The dimension allows to visualize and control processes across projects. Fifth dimension is cost-related. Dimension allows for budget monitoring and cost analysis. Sixth

dimension is used for reviewing the energetic effectiveness during project and operating stage. The sixth dimension allows to measure and verify building phase data on the actual energy performance of a building. 7th dimension is a tool for collecting relevant information connected to maintenance and management of a building and its facilities during the life-cycle. Dimension offers important information about the management and maintenance of buildings [6].



Figure 1 Dimension of BIM (Source: Author's own processing)

The definition of “sustainability” is the study of how natural systems function, remain diverse and produce everything it needs for the ecology to remain in balance. Human civilization takes resources to sustain our modern way of life [7-9].

Sustainability consists of three basic pillars economic development, social development and environmental protection.

- to mitigate the effect of climate change, pollution and other environmental factors that can harm and do harm people's health, livelihoods and lives,
- increase health of the land, air and sea,
- sustainable economic growth while promoting jobs and stronger economies and other [10].

Impact of environmental aspects of civil engineering is significant in the construction industry. One of them is why and how to build buildings which should be named green buildings. Kibert defined green buildings as “healthy facilities designed and built in a resource-efficient manner, using ecologically based principles”. Green buildings, sustainable materials, green roofs and walls represent the results of green environment policy [11,12].

Green buildings get different certificates. Green building certifications can enhance reputation on the market and can bring other opportunities for example owners, developers and civil engineering (one of the most popular is LEED). To participant's construction support of green buildings brings great environmental benefits. In the practise there are more and more requirements of developers and planners on using of green attributes, which directly promote sustainability and don't burden the environment (eco-friendly). LEED was launched in 2000

and it is a voluntary, consensus-based, market-driven building rating system that evaluates environmental performance from a whole building perspective over a building's life cycle, providing a definitive standard for what constitutes a ‘green building’ [11].

### 3 BIM Libraries

BIM offers the users all the information about constructions used in the project. User has these data available from blueprint until building usage. This information is included in each elements database. Features' database, so-called BIM Library [13].

BIM Library represents central database of BIM Objects. All the library's components are created in accordance to relevant regulations and standards. User can choose and use BIM components, which contains the essential information and are compatible with all working platforms. All the information about component are saved in model file and are connected with specifications and geometrical data [14].

Libraries are exactly the critical spot of every 3D program. Each of the programs dispose of their own features' libraries, but there exist also central online portals. Most known providers of BIM libraries are [4]:

- BIM Object Cloud,
- Revit City,
- Arcat,
- BIM store,
- BIM components [13].

One of the most used libraries is the portal **BIM Object Cloud**, which spread well known accessory from Autodesk, SEEK tool. BIM Object Cloud is world-wide central internet database, which contains all object's information and BIM files and also represents searching tool, that optimize every product, that is publicized on the portal, because of using “permalinks”, what means every product gets unique URL address. Database cooperates closely with manufacturers and contains only products of real producers [15].

The company Autodesk has created popular community portal **RevitCity** for sharing BIM objects, which offers well-arranged tree structure of libraries. The main disadvantage is; that portal offers only objects intended for use only in tools made by Revit [16,17].

Portal **Arcat** offers free online database, which contain BIM objects. Database is filled and updated by the manufacturers themselves. Database are divided into 28 sections [16,18].

Database **BIM Store** offers to the users all the information about constructions used in the project. BIM Store is a collection of products that are designed for civil engineering. These models are perfect for 4D time-lining, Sequencing and planning [19].

**BIMcomponents.com** acts as a community portal, in which architects and designers can share their objects, they can discuss and rate the uploaded content. Users can also

search, download and upload objects with a single click from ArchiCAD [20].

#### 4 Green components and BIM

BIM provides multidisciplinary information that helps to share information and take action on sustainability. Many applications have been developed to address sustainability issues in the design process. During designing buildings, more emphasis is given on creating green buildings that are the main supportive tool for sustainability. Applications work with so-called green attributes - energy, emissions, solar and lighting, ventilation, material, and waste across individual project phases. Elements supporting the so-called green homes are, for example heat pumps, green roofs, mineral insulations, photovoltaics components and the others. Components that were mentioned are available in BIM Library, but only in 3D format. Single objects contain graphical characteristics and basic parameters, but don't provide information about time, cost, sustainability and facility management. Table 1 provides an overview of the availability of selected "green components" in the BIM Libraries.

Availability of heat pumps, green roofs, green walls, mineral insulation and photovoltaics components in Libraries are shown in Table 1. Heat pumps, mineral insulations and photovoltaic components are available in all BIM libraries, which is a good signal for the development of green buildings. Revit City and BIM Store After reviewing selected BIM Libraries, Revit City and BIM Store showed deficiencies in the availability of some "green components" [21,22].

Table 1 Availability of selected green components in the BIM Library

BIM Library	Component				
	Heat pumps	Green Roofs	Green Walls	Mineral insulation	Photovoltaics components
BIM Object Cloud	✓	✓	✓	✓	✓
Revit City	✓	✗	✗	✓	✓
ARCAT	✓	✓	✓	✓	✓
BIM Store	✓	✓	✗	✓	✓
BIM Components	✓	✓	✓	✓	✓

#### 5 Conclusion

Automatization is more and more used in production, management and other processes. An important part of building automatization is BIM- Building information modelling. BIM technology presents helpful tool in designing. BIM technology works with graphical information and non-graphical information. Sustainable and green buildings are object of more conferences and scientific papers. BIM's potential is notable and level of implementation of this technology is increasing more and more through the whole world. One of the important supporting tools implementing BIM are the BIM Libraries. The trend of sustainability is increasingly reflected in BIM libraries. At present, these databases are continually filled and contain more and more green elements. This article brought definitions definition of terms- building information modelling, sustainability, green building, green components and overview of the availability of selected "green components" in the BIM Libraries.

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#### References

- [1] BEZDĚK, J., SVOZIL, P.: *Stavební činnost a životní prostředí*, Vydanie 1., SNTL – Ochrana životního prostředí, pp. 167, 1987. (Original in Czech)
- [2] JOKL, M., KOČÍ, J.: *Výstavba jako faktor tvorby životního prostředí*, Vydanie 1., SNTL – Ochrana životního prostředí, pp. 187, 1986. (Original in Czech)
- [3] ZAŤKOVÁ, M.: *Stavebná činnost a životné prostredie*, POSTERUS - Portál pre odborné publikovanie, [Online], Available: <https://www.posterus.sk/?p=13466&output=pdf> [23 Feb 2019], 2012. (Original in Slovak)
- [4] FUNTÍK, T.: *BIM ako vhodný nástroj pre trvalú udržateľnosť v stavebníctve*, [Online], Available: [http://k126.fsv.cvut.cz/docs/konference/mest/2013-udrzitelnost/Přispěvky\\_v\\_pdf/FUNTIK\\_BIM\\_AKO\\_VHODNÝ\\_NÁSTROJ\\_PRE\\_TRVALÚ\\_UDRŽATELNOST\\_V\\_STAVEBNÍCTVE\\_prispevek.pdf](http://k126.fsv.cvut.cz/docs/konference/mest/2013-udrzitelnost/Přispěvky_v_pdf/FUNTIK_BIM_AKO_VHODNÝ_NÁSTROJ_PRE_TRVALÚ_UDRŽATELNOST_V_STAVEBNÍCTVE_prispevek.pdf) [23 Feb 2019], 2013. (Original in Slovak)
- [5] National Institute of building sciences, [Online], Available: <http://www.buildingsmartalliance.org/index.php/nbims/faq/> [24 Feb 2019], 2019.
- [6] AXDStudio, *From 3D to 5D: All the BIM dimensions*, [Online], Available: <http://www.axdstudio.com/portfolio/all-the-bim-dimensions/> [24 Feb 2019], 2019.

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- [7] United States Environmental Protection Agency, *Sustainability*, [Online], Available: <https://www.epa.gov/sustainability> [25. Feb. 2019], 2019.
- [8] MASON, M.: *What Is Sustainability and Why Is It Important*, [Online], Available: <https://www.environmentalscience.org/sustainability> [25 Feb 2019], 2019.
- [9] GUZANOVÁ, A., IŽARÍKOVÁ, G., BREZINOVÁ, J., ŽIVČÁK, J., DRAGANOVSKÁ, D., HUDÁK, R.: Influence of build orientation, heat treatment, and laser power on the hardness of Ti6Al4V manufactured using the DMLS process, *Metals*, Vol. 7, No. 8., pp. 1-17, 2017.
- [10] Un department of public information, General Assembly's Open Working Group proposes development goals, United Nations Conference on Sustainable Development, [Online], Available: <https://sustainabledevelopment.un.org/content/documents/4538pressowg13.pdf> [25 Feb 2019], 2014.
- [11] NALEWAIK, A.: *Costs and Benefits of Building Green*, Energy Efficient and Environmentally Compatible Civil Infrastructure Systems, Irvine, California, USA, 27.-29. Aug 2008, pp. 969-982, 2008.
- [12] PAL, S., GUBELJAK, N., HUDÁK, R., LOJEN, G., RAJŤUKOVÁ, V., PREDAN, J., KOKOL, V., DRSTVENSEK, I.: Tensile properties of selective laser melting products affected by building orientation and energy density, *Materials Science and Engineering: A, Structural Materials, Properties, Microstructure and Processing*, Vol. 743, No. January, pp. 637-647, 2019.
- [13] REYNAERS, *CAD a BIM knihovny*, [Online], Available: <https://www.reynaers.cz/cs-CZ/cad-bim-knihovny> [25 Feb 2019], 2019. (Original in Czech)
- [14] Designing buildings Wiki, *NBS National BIM Library*, [Online], Available: [https://www.designingbuildings.co.uk/wiki/NBS\\_National\\_BIM\\_Library](https://www.designingbuildings.co.uk/wiki/NBS_National_BIM_Library) [25 Feb 2019], 2016. (Original in Czech)
- [15] Bimobject, *The BIMobject Cloud*, [Online], Available: <https://info.bimobject.com/bimobject-cloud> [25 Feb 2019], 2019.
- [16] BIM SK, *Kde nájsť knižnice pre Revit*, [Online], Available: <http://bimsk.sk/?p=87> [27 Feb 2019], 2019. (Original in Slovak)
- [17] RevitCity, [Online], Available: <https://www.revitycity.com/downloads.php> [26 Feb 2019], 2019.
- [18] Arcat, *Library of free BIM objects, families, and system files*, [Online], Available: [https://www.arcat.com/bim/bim\\_objects.shtml](https://www.arcat.com/bim/bim_objects.shtml) [26 Feb 2019], 2019.
- [19] BIM store, [Online], Available: <https://www.bimstore.co/> [26 Feb 2019], 2019.
- [20] BIM components, [Online], Available: <https://bimcomponents.com/Static/About> [26 Feb 2019], 2019.
- [21] Slovenská inovačná a energetická agentúra, [Online], Available: <http://zelenadomacnostiam.sk/sk/> [26 Feb 2019], 2019. (Original in Slovak)
- [22] Autodesk, *Autodesk Ecotect Analysis*, Sustainable Building Design Software, 2012.

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