iNDiS 2012

Novi Sad

UNIVERSITY OF NOVI SAD
FACULTY OF TECHNICAL SCIENCES
DEPARTMENT OF CIVIL ENGINEERING
AND GEODESY

12 iNDiS 2012

PLANNING, DESIGN, CONSTRUCTION AND RENEWAL IN THE CIVIL ENGINEERING

International Scientific Conference

PROCEEDINGS

Novi Sad, Serbia 28 - 30 November 2012

EDITORS

V. Radonjanin, R. Folić, Đ. Lađinović

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iNDiS 2012

This year, Department of Civil Engineering and Geodesy, Faculty of Technical Sciences - Novi Sad, organizes Twelfth International Scientific Conference "iNDiS 2012".

The first conference took place in the 1976 with main topic „Industrial construction of apartments“ as current. In the following years, conference topics were extended to “Industrialization in civil engineering“, and soon, papers form all areas of construction, from urbanism planning and designing buildings to maintenance and major interventions on engineering structures. It has caused the expansion of the area covered by this conference and, beside civil engineers in various fields, urban planners, architects, engineers in other fields who work in construction, sociologists, economists and others took a part.

The present moment is characterized by, among other things, a crisis in investment sector, especially in new construction, but, as in the world, more and more resources must be directed to building management. This requires a transformation of our activities in construction and adaptation to these trends. This conference, as well as several previous ones, includes problems of planning, design, construction and renewal, which led to an adequate response of foreign and domestic participants. This wide area includes not only the aforementioned researchers, planners and designers but also the contractors, including installation and finishing works in construction, i.e. all professions whose work is connected to architecture, construction and the built environment.

It is our pleasure that a number of members of the International Scientific Committee actively participated in the preparation of the Conference and wrote papers published in this Proceeding. These, as well as other papers, contain a variety of ideas and results of experimental and theoretical research that became the basis for formulating adequate calculation models of structures and models used in other areas of civil engineering and environmental protection. It is expected that, using experience from abroad, adjustment to the legislation already adopted in Europe will be easier. In addition, it is expected to point out the main directions of the development of civil engineering in order to meet modern conditions and needs.

Two Proceedings were published for this conference, one in the Serbian and the other in the English language, which allows better communication and exchange of experiences with colleagues from foreign countries as well as establishing new and strengthening of existing professional and collegial relationship.

The editors would like to express sincere gratitude to all authors for the effort invested in writing papers and for the contribution to this event.

Novi Sad, November 2012 Editors

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BIM, MEP AND SUSTAINABILITY EVALUATION

Abstract: Sustainable design and its premise of eliminating negative environmental impact of built environment require information-rich design application with ability to iterate and analyze faster than traditionally. Software innovation targeted toward AEC practitioners known as BIM (Building Information Modeling) promises such capacity. The paper describes research in the realm of MEP design on comparing how Revit and ArchiCAD support sustainable design using inbuilt tools (Conceptual Energy Analysis tool and EcoDesigner) and in conjunction with software environments like Green Building Studio and Ecotect Analysis. The analysis of functionality is conducted both in the phase of conceptual and detailed design.

Key words: BIM, MEP design, Revit, ArchiCAD, sustainability evaluation

BIM, PROJEKTOVANJE ISTALACIJA I ODRŽIVOST

Rezime: Održivo projektovanje i njegovo geslo uklanjanja negativnih uticaja izgrađene sredine na prirodu zahteva informaciono projektno okruženje koje omogućava brže iteracije i analize od tradicionalnog. Softverska inovacija namenjena učesnicima u građevinskoj praksi poznata kao BIM (informaciono modelovanje građevine) obećava takve mogućnosti. Rad opisuje istraživanje u oblasti projektovanja instalacija na upoređivanju kako Revit i ArchiCAD podržavaju održivo projektovanje ugrađenim alatima (Conceptual Energy Analysis tool i EcoDesigner) tako i u saradnji sa softverskim okruženjima kao Green Building Studio i Ecotect Analysis. Analiza funkcionalnosti je sprovedena u izradi i idejnog i detaljnog projekta.

Ključne reči: BIM, projektovanje instalacija, Revit, ArchiCAD, ocena održivosti

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1. INTRODUCTION

Sustainable design is becoming increasingly important principle in AEC (architecture, engineering and construction) industry. Its premise of eliminating negative environmental impact of built environment require extensive performance analysis across multiple disciplines like life-cycle impacts, energy efficiency, environmental impacts, life cycle costs, occupant well-being, thermal comfort, air quality, visual comfort, acoustic comfort, safety [4] etc. This amount of labor requires information-rich design environment with ability to iterate and analyze faster than in a more traditional process. Recent software innovation targeted toward AEC practitioners known as BIM (Building Information Modeling) promises capacity to manage that amount of information, to enable interaction among professions and provides link toward building simulation applications. The paper demonstrates performance of the BIM environment from the standpoint of users that are new to the BIM methodology and identifies advantages and problems of using BIM as the technique for building sustainability evaluation.

2. BUILDING INFORMATION MODELING

Initially designed as a way to extract consistent project documentation from the central building model, BIM has evolved toward a new design paradigm encompassing lifecycle management of building information. Designed specifically for AEC industry, BIM applications does not deal with pure geometrical objects like traditional 3D modelers but instead use higher level objects like walls and windows. Each object is defined by parameters describing its geometry, materials, properties, etc. and rules that describe constraints and relations to other objects. BIM is a digital representation of the physical and functional features of a design. Since the BIM has evolved from the development of few competing commercial applications, each applying its own modeling mechanism [1], the standard model defining building objects that are used in the modeling and their behavior does not exist. Instead each application is built on the top of the intrinsic core information model and provides similar information modeling functionality with other BIM applications.

The full model of the building generated using BIM consist of multiple coordinated data files representing building from the standpoint of different professions involved in design or different phases of project development. To ensure coordination and seamless transition of information between AEC stakeholders few interoperability formats have been developed [7]. Industry Foundation Classes (IFC) is an object oriented data model developed to attain highest level of interoperability in AEC [5]. It defines classes necessary to represent all concepts related to building during its lifecycle and is intended to become international standard for data exchange in whole AEC industry. The Green Building XML schema – gbXML [2] is the format based on the Extensible markup language (XML) developed to facilitate data exchange between digital building models and the engineering analysis tools. It consists of a specific set of definitions and data requirements focusing on sustainability analysis. Its geometric requirements deal only with spatial volumes and thermal zones with simple boundary surfaces. BIM application that supports gbXML must export its complex model information in a simplified form.

At present, few BIM applications are commercially available and this paper will take into account two systems most common on Serbian market: Graphisoft ArchiCAD and Autodesk Revit. Appearing in 1987 ArchiCAD became the first BIM implementation under "Virtual Building" concept. Today, it is the full BIM environment enabling parametric modeling of

diverse building components, and equipped with MEP Modeler plug in it is able to model full range of building systems. Revit is the application specifically designed for BIM. In its core lies context-driven change management engine that updates whole building model on each modification according to inter-element relationships. It comes in three versions covering different AEC domains: architecture, construction and MEP.

3. SUSTAINABLE DESIGN

Recent estimates from international bodies show that energy use in buildings amount for 40% of total world energy consumption with 1.3% increase per year, emission of 48% of green-house gases, and 1.8 kg of construction waste per 1 square meter of constructed building [3]. All these negative environmental impacts demonstrated need for more thoughtful design and construction. Idea about sustainability has a long history. In 1987 on United Nations General Assembly sustainable development has been defined as the one that "meets the needs of the present without compromising the ability of future generations to meet their own needs" [8] and from that time onwards many human disciplines have adopted that principle. Sustainable design seeks to reduce negative impacts on the environment, and the health and comfort of building occupants by improving building performance, reducing consumption of non-renewable resources, and minimizing waste. Final goal for buildings is to have zero net annual impact on the environment from an operational standpoint. Sustainable design eliminates negative environmental impact through skillful, sensitive design [6].

Designing sustainable buildings requires an expansion of traditional methods. Recent studies of the sustainable design demonstrate that the process can be broken down into following order of operations [4]:

1. Understanding climate, culture, and place
2. Understanding the building type
3. Reducing the resource consumption need
4. Using free/local resources and natural systems
5. Using efficient man made systems
6. Applying renewable energy generation systems
7. Offsetting remaining negative impacts

These processes require large amount of information and large number of dedicated simulation applications. This situation is recognized by software developers and today increasing number of simulation software supports link with BIM applications.

4. BIM AND SUSTAINABILITY EVALUATION

Today, a large number of commercial and free simulation application are available on the market. This paper describes only those that work with Graphisoft ArchiCAD and Autodesk Revit and are available on Serbian market.

Graphisoft EcoDesigner is the plug-in that enables energy balance analysis within ArchiCAD application. It does not require any special preparations and takes all necessary data from the existing model. Before evaluation is started few additional information about project like location, activity, MEP system, energy type, and availability of green energy systems must be provided. Using provided structural and opening lists designer can re-

evaluate all parameters of the construction elements and openings, gain better understanding of the energy model and modify data if needed. The built-in U-value calculator enables user to achieve proper heat transmission coefficient values. Based on those data EcoDesigner calculates yearly energy consumption, CO2 emission and monthly energy balance. All data are given as charts or tables and can be saved as XLS or Pdf file.

From version 16 EcoDesigner is discontinued and replaced with the built-in Energy Evaluation functionality. In contrast with previous application, before any simulation is commenced all spaces in the project must be allocated to the specific zones. Upon every project modification zones must be updated. This way previous "one click" functionality is lost. Results from the simulation are similar with previous EcoDesigner application and includes yearly energy consumption by sources and targets, CO2 emission and monthly energy balance. All simulation results are represented as charts or tables that can be saved as XLS or Pdf file.

Revit Conceptual Energy Analysis Tool enables analysis of annual carbon emission, monthly heating load, monthly cooling load and annual energy use within Revit application. The tool works with massing model enabling the designer to acquire knowledge about building performances in early design phases. The evaluation mechanism is based on web service that automatically shows results as charts, and enables comparison of different alternatives.

Autodesk Ecotect Analysis is the stand alone application intended for measuring environmental design factors during conceptual design. It can read large number of file formats depicting both building geometry and building performance parameters including gbXML files. The application can be used to create analysis model from the scratch or to expand it from the imported data. Main advantage of the application is its ability to represent all analysis results in visual manner, enabling the designer to quickly understand implications of his/her decisions. The program can perform large number of specific types of thermal, solar, lighting and acoustical analysis. The application can export its results to large number of formats, enabling presentation of results in various external applications or transfer of data to other analysis tools.

The Green Building Studio is web based application intended for whole building energy analysis, forecasting how a building will consume resources and providing estimates in tabular report form. Ecotect tools measure how the environment may impact the building performance over time and provides graphical displays of information that allows architects and designers to interact with the data in real time. The application reads model data only as gbXML files. Based on provided data it can perform whole building energy analysis, calculate carbon footprint, consider design alternatives to improve energy efficiency, analyze qualification for LEED day lighting credit, estimate water use, provide ENERGY STAR scoring and summarize natural ventilation potential. The application can export its results to a number of formats, enabling transfer of data to other analysis and presentation tools.

5. APPLICATION PERFORMANCE

The advantage of Graphisoft EcoDesigner lies in its "one click" functionality. All that is necessary to start analysis is to define closed space by defining floor, walls and roof. The application will take default parameter values and will instantly give some results. The application will be of greatest value in preliminary design because for each design

modification it is possible to instantly see energy performance of the building and to see if it yields to better or worse results. So the whole process can be conducted in explorative way by trying different alternatives and instantly checking their performances.

The new Energy Evaluation functionality in ArchiCAD 16 probably gives more precise analysis results by defining zones in the building, but the process is less explorative because definition of the zones takes time, and distracts designer from making quick changes. Also, results are still given on the whole building level, so there are no visible advantages of the newly introduced mandatory definition of building zones.

The Revit built-in analysis tools provides same explorative environment that enables designer to freely investigate environmental consequences of design decisions. All that designer needs to do is to define mass of the building, than use utility to transform mass into a building model, and finally to automatically send that model to web service that will provide results.

All three applications give similar whole building evaluations without much effort to build specific energy evaluation model from the designer's side. This kind of behavior is something that everyone expects from BIM environment. On the other side, results are coarse and can be used only as a guide toward better initial designs. Also, a good understanding of results' meaning and experience with the tools is necessary for making good design decisions. Since majority of decisions that influence building sustainability are made during conceptual design these applications represent valuable addition to BIM applications.

There are many good free applications for detailed sustainability evaluation, unfortunately, they do not support either IFC or gbXML formats for data exchange, and for that reason they are omitted from this review. The paper describes results obtained with Ecotect Analysis and Green Building Studio applications since both applications support data import in gbXML format.

The ArchiCAD application dos not have native gbXML file export functionality, instead it uses third party plug in. The plug in does not support automatic collection of necessary data from the BIM model. Instead, the user must define all zones in the building in predefined manner. All internal zones must be defined as rooms, and the external perimeter of the building must be defined as external zone. This process must be repeated for each story of the building. It is also important to check if each of the zones extends to the full story height, instead a nonfunctional gbXML file will be generated. The process of manual zone creation can be replaced with the option to automatically create necessary zones. Unfortunately, the process does not produce error free results, so each generated zone must be manually checked to see if it covers correct area and if the height is accurate. The whole process is time consuming and requires person that has previous experience whit this particular plug in. This way the free flow of information between BIM application and analysis software is tampered and possibility to quickly check consequences of design decisions is disturbed. More over, inclusion of zones as necessary data for new Energy Evaluation functionality in ArchiCAD 16 interferes with the gbXML plug in. External zones required by the plug in are incompatible with Energy Evaluation functionality and must be deleted if one wants to use built in energy evaluation functionality after performing analysis with external applications.

The Revit comes with built in gbXML export capability. As in ArchiCAD the designer must define two types of zones before exporting data. The first type is the room object that should be assigned to each room in the project. The second type is the space object that should be assigned to each zone with different energy requirements or HVAC systems. The process

of defining rooms and spaces is similar, and as in ArchiCAD the height of the zone must be checked manually. The process is time consuming and laborious as in the ArchiCAD and similarly obstructs seamless integration of sustainability evaluation and BIM.

When problems with creating gbXML file are overcome data can be imported to simulation applications. Data exported from the ArchiCAD contains information about spaces and materials, but materials are defined according to the names used in ArchiCAD to define it. It means that simulation applications could not use that information unless some additional information linking ArchiCAD names and material names in simulation application is defined. Data exported from Revit contains same information as ArchiCAD exports and additionally it contains U-values for materials, information about occupancy and lighting schedules, required temperatures for heating and cooling, and information about people heat gains for each space. Both simulation applications give similar results with the imported data. The comparison of actual accuracy of each simulation with each imported data will be theme of the further research.

Part of this research was to investigate how can the designer use simulation tools to evaluate his/her MEP designs. Unfortunately, neither of gbXML export procedures have the ability to export any information regarding MEP systems. Also, neither of built-in simulation functionality takes into account that building has MEP systems. This means that all recent excitement about sustainable simulation using BIM is restricted only to the architectural design. MEP systems that have considerable effect on buildings' sustainability are left out on this stage of BIM application development.

6. CONCLUSIONS

Recent software tools that are intended to provide sustainability evaluation in synergy with BIM applications contribute mostly to the first three phases of the sustainable design process enumerated previously. The third phase of reducing the resource consumption need is covered only partially since the influence of MEP design can not be evaluated. Detailed simulations that take MEP systems into account are necessary for any meaningful support in the phases 4-7.

In some recent material that advertises simulation support for commercial applications a new term BEM (building energy model) has been introduced. Unfortunately, this idea is in direct opposition with BIM whose primary goal was to establish one information building model, that is not necessary homogenous database, but that contains all information about building during its life cycle, and in which all information is entered only once. Separation of BIM and BEM model yields to the situation where same information can be contained in both models, and even entered separately in both models.

During the research we did not find any straightforward method of returning information gained in simulations back to building model. That way cooperation between professions, which is also one of BIM principles, stays on the same level as it is today. Seamless exchange of data between BIM and sustainability simulations should be considered as the opportunity for better cooperation between professions, and increasing awareness of sustainability in AEC.

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REFERENCES

[1] Eastman, C., et al., 2011, BIM Handbook: A Guide to Building Information Modeling for Owners, Managers, Designers, Engineers and Contractors, 2nd ed., Hoboken: John Wiley & Sons, Inc.

[2] gbXML, http://www.gbxml.org/ (Retrieved on September 2012)

[3] Howe, J.C. 2010. Overview of green buildings. National Wetlands Newsletter, 33(1), 161-165

[4] Krygiel, E., Nies, B., 2008. Green BIM: Successful Sustainable Design with Building Information Modeling, Indianapolis: Wiley Publishing, Inc.

[5] Liebich, T., et al. (eds.) 2007. IFC2x Edition 3 TC1, International Alliance for Interoperability. http://www.iai-tech.org/ifc/IFC2x3/TC1/html/index.htm (Retrieved on September 2012)

[6] McLennan, J. F., 2004. The Philosophy of Sustainable Design, Kansas City: Ecotone Publishing.

[7] Svetel, I., 2007 Information technology standards and structural life in civil engineering, Integritet i vek konstrukcija, 7 (3), 167-176.

[8] United Nations General Assembly, 1987. Report of the World Commission on Environment and Development: Our Common Future. Transmitted to the General Assembly as an Annex to document A/42/427 - Development and International Co-operation: Environment. http://www.un-documents.net/wced-ocf.htm (Retrieved on September 2012)

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