The 12 th International Conference on Engineering Graphics
BALTGRAF 2013 June 5-7, 2013, Riga, Latvia

DRAWBACKS OF BIM CONCEPT ADOPTION

Modris DOBELIS[1]

ABSTRACT

Building Information Modelling (BIM) is a process of generating and managing building data during its life cycle which involves representing a design as virtual objects, which carry their geometry, relations and attributes. BIM design media allows an extraction of different views from a building model for drawing production and other uses. All the different views are automatically synchronized in the sense that the objects are all of a consistent size, location, specification – since each object instance is defined only once, just as in reality. BIM uses 3D, real-time, dynamic building modelling software to increase productivity in design and construction. BIM process co-ordinates products, project and process information throughout new product introduction, production, service and retirement among the various players, internal and external, who must collaborate to bring the concept to life. Universities have to become the initiators of the promotion of BIM ideas not only to the designers and engineers, but much wider public than at present. Universities have to seek contacts/relationships with a view of developing joint actions with industry and enterprises. Particular attention should be paid to Small and Medium sized Enterprises as they account for an enormous part of economic growth and could be the places where the innovations could be introduced easier. There is an evident role for universities to play in lifelong learning and continuing education thought them to offer possibilities of companies to increase competitiveness, productivity and efficiency, total costs estimation, and to become concurrent on the global market.

KEYWORDS: BIM, BIM Teaching, Engineering Education

HISTORY OF BIM

It is assumed that the BIM concept originates from the projects of Professor Charles Eastman at the Georgia Tech School of Architecture. Abbreviation BIM stands for Building Information Modelling (or Model) in early 1970s. The developed Building Description System (BDS) was the first software which manipulated with individual library elements from the database in the model on PDP computers. This idea was developed a long time before the victorious march of personal computers and therefore could not get wide popularity because not many architects had a chance

[1] Dep. of Computer Aided Engineering Graphics, Riga Technical University, Āzenes iela 16/20, Rīga, LV-1048, Latvia, e-mail: Modris.Dobelis@rtu.lv

to get grips on it. Later several similar systems (GDS, EdCAAD, Cedar, RUCAPS, Sonata and Reflex) were developed and tested on practical projects in United Kingdom in 1980s [1]. A wider application into practice this concept acquired only with the development of personal computers when the ArchiCAD software from Graphisoft Company appeared on the scene, which incorporated the idea of Virtual Building rather than drawing from the very first of its version Radar CH in 1984. The power of software was amplified by flexible built-in programming environment for its library components using GDL (Geometric Description Language).

The next step was when Irwin Jungreis and Leonid Raiz split from Parametric Technology Corporation (PTC) and started their own software company called Charles River Software in Cambridge, MA. They were equipped with the knowledge of working on Pro/ENGINEER software (released 1988) development for mechanical CAD that is utilizes a constraint based parametric modelling engine [1]. The two wanted to create an architectural version of the software that could handle more complex projects than ArchiCAD. A trained architect David Conan joined the project and designed the initial user interface which lasted for nine releases. By 2000 the company had developed a program called Revit, written in C++ and utilized a parametric change engine, made possible through object oriented programming.

In 2002, Autodesk purchased the company and began to heavily promote the software in competition with its own object-based software Architectural Desktop (ADT), which provided a transitional approach to BIM, as an intermediate step from CAD [2]. ADT creates its building model as a loosely coupled collection of drawings, each representing a portion of the complete BIM.

Approximately at the same time period the concept of BIM was adopted by another two software developers Bentley and Nemetschek in their further products. Bentley Systems interpreted BIM differently as an integrated project model which comprises a family of application modules that include Bentley Architecture (internationally known under Microstation Triforma name), Bentley Structures, Bentley HVAC, etc. Nemetschek provided a fourth alternative with its BIM platform approach. The AllPlan database was “wrapped” by the Nemetschek Object Interface (NOI) layer to allow third-party design and analysis applications to interface with the building objects in the model [2].

HOW BIM WORKS?

The BIM concept first of all uses parametric object-oriented 3D data in virtual models in contrary to the conventional 2D drawings, a long time used so far by engineers and designers. Instead of drawing just a filled rectangular in plan view which represents a wall of building in section, in BIM concept software the model is built virtually in 3D space, the relative location with all the neighbour elements is precisely determined and easy observable from arbitrary viewpoint for visualization purposes. The model includes not only the geometric relationships between all building elements, but these elements carry information on many real attributes associated with them, like material, paint, class of fire safety, cost, etc. The drawings – plans, elevations, and sections – are obtained automatically from the unique virtual building model, along with the bills of materials and are updated immediately after any changes are performed in the original building model. Amount of wall material in specifications (schedules) is updated as soon as real virtual building elements like windows and doors are placed in the model. This method highly eliminates the human errors while producing drawing documents, which cannot be avoided using the conventional 2D drafting technique. The synchronization between views, elevations and sections in the manually produced drawing documents is the responsibility of all parties involved, which in the case of large projects and many parties involved could be a serious problem.

The concept of BIM besides the conventional three dimensions of the model and real attributes attached to these elements includes the fourth dimension – time. The so called 4D design approach allows the coordination between parties involved not only during the building construction phase but also during exploitation, reconstruction and finally even utilization. The information is maintained and updated in the common database from the initial stage of the design through the whole lifecycle of the building.

The fifth dimension incorporated in the BIM concept is “money”. One of the most important attributes for elements and processes of the real rebuilding included in the virtual model is cost. In this case the process is described as 5D design approach. The databases may include building elements with their attributes from many vendors and the designers could easily simulate several variants of the design. Numerous design scenarios “what if” could be played to find out the most effective solution.

Besides the five more or less known dimensions the current BIM concept supports also the sixth dimension which are facility management applications like CAFM (Computer-Aided Facility Management) and the seventh dimension with procurement solutions e.g. contracts, purchasing, suppliers, and environmental standards.

In order to support all these dimensions of BIM concept in the numerous software and application, it is evident that a common standard has to be used to share the information between so many different “players on the field”. There are many problems which have to be solved before this undoubtedly effective BIM process can be widely used in practice [3].

The technology adoption lifecycle model describes the adoption or acceptance of a new product or innovation, according to the demographic and psychological characteristics of defined adopter groups. The process of adoption over time is typically illustrated as a classical normal distribution or "bell curve." The model indicates that the first group of people to use a new product is called "innovators," followed by "early adopters." Next come the early and late majority, and the last group to eventually adopt a product are called "laggards".

Since these BIM tools and techniques have become increasingly complex, architectural and civil engineering schools have been faced with a great challenge not to lie behind and not to become laggards. To train specific software requires first of all mastering itself provided there is a financing for it. In general, industry lies behind and picks up the innovations slowly. A student with knowledge of only one type of software may well be trained to design according to the biases of the programs that they are using to represent their ideas. Software performs useful tasks by breaking down a procedure into a set of actions that have been explicitly designed by a programmer. The programmer takes an idea of what is common sense and simulates a workflow using tools available to them to create an idealized goal. In the case of BIM tools, the building is represented as components including walls, roofs, floors, windows, columns, etc. These components have pre-defined rules or constraints which help them perform their respective tasks results.

PROBLEMS OF ADOPTION IN INDUSTRY

Contemporary hardware and software provides enormous potentials for the nowadays designers. How come that these potentials are not introduced in everyday practice and are not used in full scale? The two main factors that affect this are the expenses and training. The BIM's learning curve could be one of the top barriers of implementation in construction. There is an opinion that wide use of BIM concept mainly fails because of another two much more important factors – people factor and change factor [5]. BIM implementation is not really about the software, but it is about organizational change. Our experiences – and the experiences of our clients – have demonstrated that people and processes are far more important than technology.

BIM is an absolutely wonderful tool, and it has great potential to streamline costs and processes, to help different disciplines communicate effectively and to ensure little confusion on a job site. But to get to that promised land of benefits, you have to pass through the wilderness of adoption, which always seems to hinge on organizational change, not technology. This is the inconvenient truth.

People's factor has been acknowledged by many AEC/CAD/CAM analysts [5, 6]. The influence of people is significant factor in software product implementation that requires from people to re-think the way they are doing their business. Both PLM and BIM software can eliminate some roles in organizations and change business processes between organizations. It makes the process of software adoption long and complicated. This is a place where failure comes very often.

Changes are another aspect, which very often comes together with data and object and/or process oriented software like PLM and BIM. The specific character of almost every enterprise-level data and process management software is to focus on how to change organization – improve processes, re-organize business relationships, change tools, etc. It is extremely hard to people, since change is hard which consequently leads to failures [5].

BARRIERS IN BIM EDUCATION

Innovative companies nowadays require professional employees who are able to work effectively on projects undertaken with BIM. Several universities throughout the world have been running a wide range of courses to meet this demand and provide students with experience on this new paradigm. However, this learning experience is relatively new and based on a pedagogical system that has not yet been consolidated. In a recent analysis [6] an attempt was made to address the main obstacles encountered with BIM teaching, as well as to give examples of how to overcome them and introduce new strategies at introductory, intermediary and advanced levels.

The programs that are planning to introduce BIM into the curriculum face a number of obstacles that can be grouped into three types: academic circumstances, misunderstanding of the BIM concepts and difficulties in learning/using the BIM tools [7]. In an academic environment a wide range of problems occur, just to name the topics: time, motivation, resources, accreditation, and curriculum. Misunderstanding of BIM concepts is associated with individualized instruction, traditional teaching, little teamwork and week or lack at all collaboration between curricula. The weakness of BIM tools is associated with creativity, learning, teaching, and knowledge aspects.

An extensive survey on 119 building construction schools in the United States found that only 9% of them teach BIM at a degree level [8]. The main problems named by the respondents are as follows: lack of time or resources to prepare a new curriculum, lack of space in the curriculum to include new courses and a lack of suitable materials to teach BIM. Another survey involving 101 Architecture, Civil Engineering and Construction Management programs in the U.S. [9] found that, apart from these obstacles, there is a shortage of trained personnel in BIM, that the curriculum is not focused on BIM, that its implementation takes time and that the accrediting bodies for the construction programs have not drawn up clear guidelines for BIM.

The summary on BIM education activities [6] showed that only a few engineering schools have been teaching BIM since 2000, e.g. Georgia Institute of Technology, which has carried out research on BIM since the early 1990s. Several international schools have begun teaching BIM tools around 2003, but the vast majority introduced BIM between 2006 and 2009. In exceptional cases, the architecture programs were those that first showed interest in this area. Rapid advances were made and today there are a large number of BIM courses [9-11].

TEACHING APPROACHES

Through surveys the current educational programs throughout the world were reviewed and recommendations developed to assist universities with curriculum development. Based on an extensive research on BIM teaching experience in [10] three skill levels are given which define the BIM learning and teaching strategies.

These three skill levels are introductory, intermediary and advanced. At introductory level BIM usually is taught in typical engineering design graphics courses including courses like Computer Aided Design.

The main purpose in an introductory level of curricula courses is to develop the skills of geometric modelling using BIM supporting software. These courses do not require the essentials of classic 2D CAD skills like AutoCAD, which are still considered as a compulsory knowledge for architectural and civil engineering graduates. The objective is to preferably learn those BIM tools that are most commonly used in the field in order to obtain a good background of BIM concepts. The BIM tools can be taught through lectures, workshops and labs. The students do problem-solving exercises and carry out small individual tasks to practice the BIM tool. It is recommended that before the students start the modelling they make modifications to an existing model [10, 12-13]. This allows an exploration of basic concepts of geometric modelling and provides understanding how to communicate different type of information.

After this, the students create the model of a small building (or parts of it), usually with an area of or less than 600 square meters to extract quantities from it, and learn how to manipulate the model, types of basic components and their behaviour. It is recommended that a modern single family residence is used as a project. The modelling can be accompanied by analogue methods, sketches and axonometric views, which allow the students to perform suitable adjustments to the physical proportions [10, 13]. This approach is used at RTU Civil Engineering and Architectural programs.

The architecture student can make a volume/mass representation of the house, carry out an investigation of primary components (doors, windows, panels and furniture) and, based on his/her research, develop and refine a new component. The engineering student can do the following: identify a construction component of his/her choice in the Structural and/or Mechanical, Electrical and Plumbing (MEP) areas, make a list of the necessary information required for the construction of that component, categorize this information throughout the life cycle to show how it can be linked and managed from a life cycle perspective and decide how they should be shared with the other subject-areas [13-14]. In [10] it is suggested that the assessment of the students' performance can be conducted through individual exercises (components or simple models), written exams about BIM concepts and their presentation of models.

BIM could be introduced in different courses of the curriculum and the study [10] grouped them into eight categories: Digital Graphic Representation (DGR); Workshop; Design Studio; BIM Course; Building Technology; Construction Management; Thesis Project and Internship.

An introductory level of BIM at Riga Technical University is performed in several courses dealing with classical engineering design graphics. The civil engineering students have to apply the knowledge about the basics of architectural design. After four formal lectures accompanied with training exercises on modelling using ArchiCAD software, the students have to virtually build their own „dream private house" which was analysed and designed before in a separate course „Architectural Design" using the classical manual drafting technique. In this course even AutoCAD drafting technique was not allowed to use. In the final project the students have to compose all the required the basic supporting architectural documentation – plans, elevations, sections, detail drawings, room inventory, exterior and interior renderings – on a single sheet of A1 or A0 format paper. A standard or self-created zone lists for room inventory have to be used. Standard or modified door and window schedules have to be used to see the power of built-in features in the BIM supporting software. Figures 1-3 demonstrate the complexity of individual projects used in the introductory level of BIM concept study.

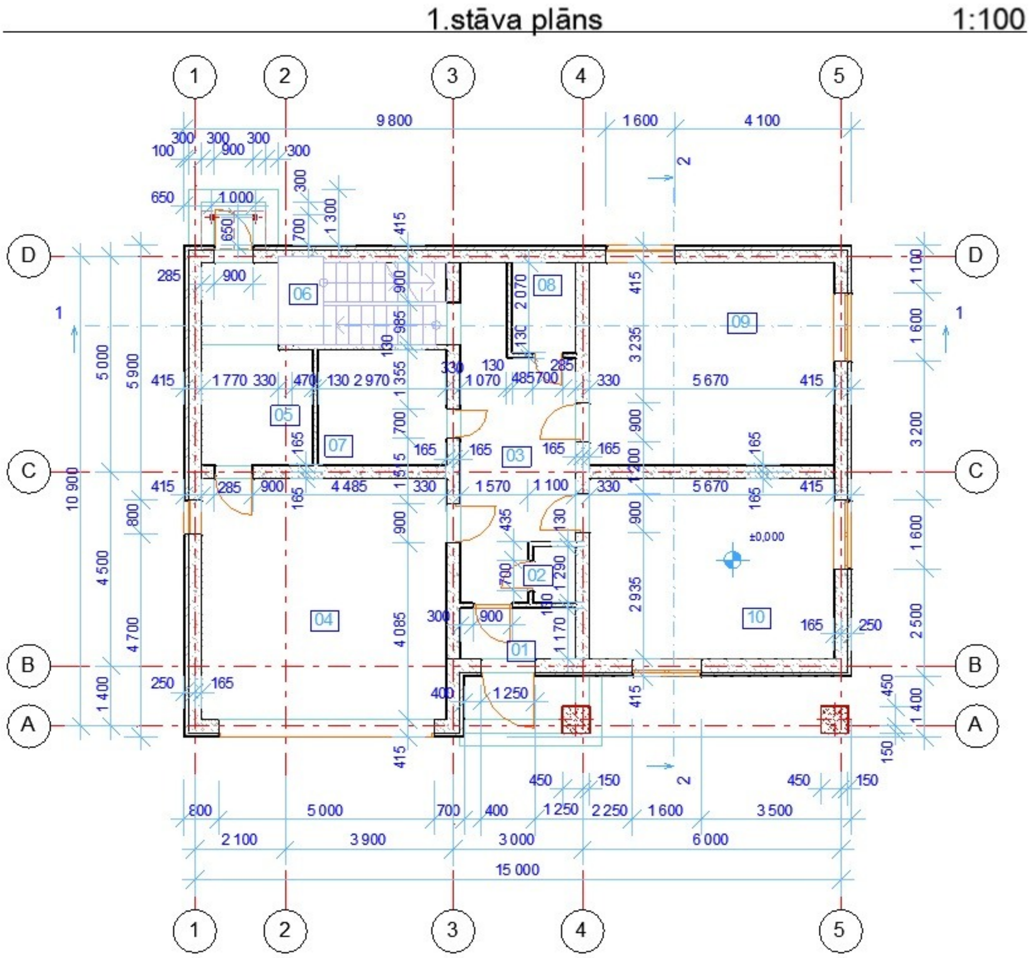

Fig. 1. A plan view of a two story building: An example showing the complexity of project in the course „Computer Aided Design" for undergraduate civil engineering students

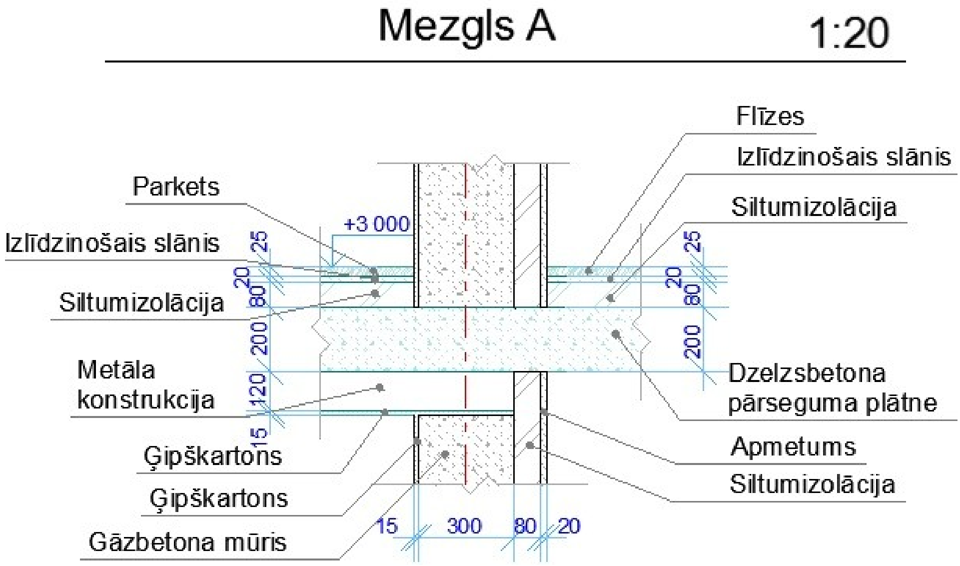

Fig. 2. Detail view: An example showing the complexity of project in the course „Computer Aided Design" for undergraduate civil engineering students

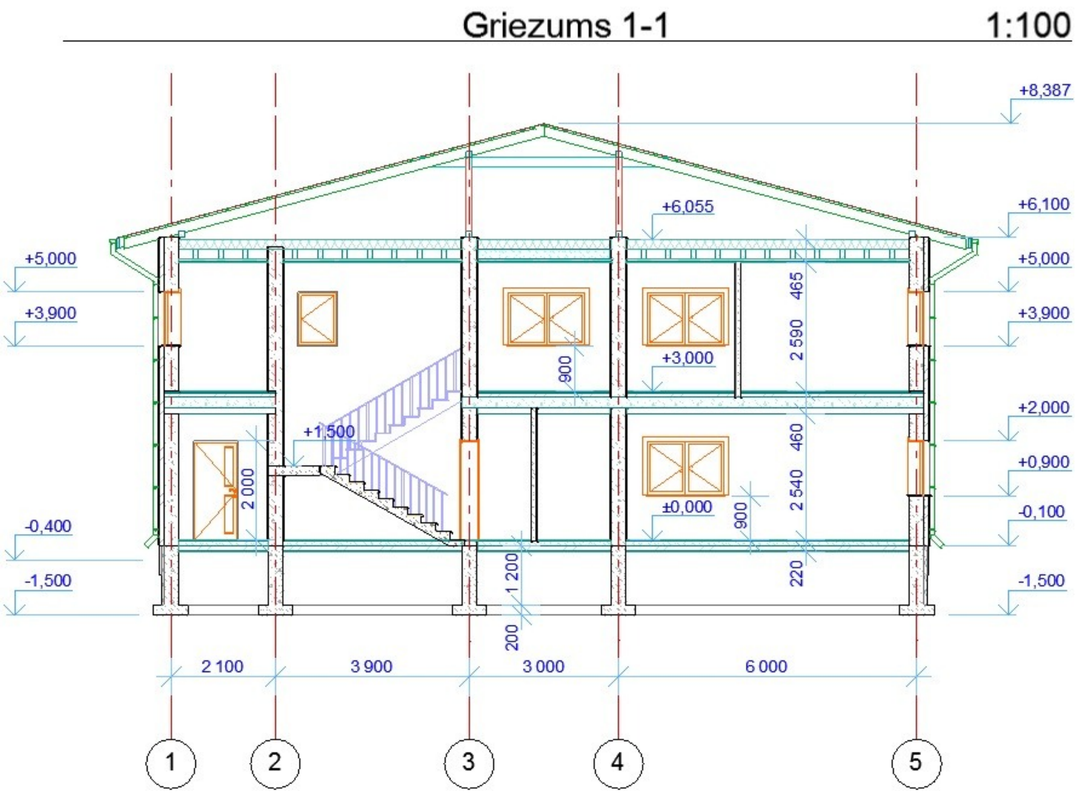

Fig. 2. Section view: An example showing the complexity of project in the course „Computer Aided Design" for undergraduate civil engineering students

At the end of the course only one informative lecture is provided on the possibility to streamline the prepared IFC compliant project for further energy analysis or structural analysis on compatible software like Axis VM, Tekla Structures, and Revit Structure which are typically used by local companies. Educators can receive well prepared presentation materials and support from some BIM software developers [15]. Unfortunately, the practice in the classroom reveals that our students are quite reserved when they are offered just the theoretical lectures about global issues. Practical training exercises during the class hours are more appreciated, but the contact hours for the last two decades for classical engineering design graphics subjects have decreased more than twice [16]. Further development of civil engineering curricula is possible through the interaction between different courses based on BIM collaboration. This would highly benefit the preparation of graduates for the next BIM challenges.

CONCLUSIONS

Instead of trying to force through changes in the curriculum, the academic world could join together with industry to promote BIM or collaborative thinking and setting up a research, teaching and consultancy projects. A closer partnership is expected between universities and industry. Unfortunately the local building industry has faced well-known global issues and seems that the current period is not yet the right time for changes. In fact, industry must be willing to provide funding for the academic world. They must devote time to visit universities and be prepared to discuss the current trends and scenarios with teachers and students, share generic models and provide current materials for students to enable them to practice the knowledge they have learned as stated in [11]. However, the biggest obstacle to the progressive changes is a human factor!

REFERENCES

1. Quirk V. A Brief History of BIM / Michael S. Bergin. *ArchDaily*, Dec 7, 2012. http://www.archdaily.com/302490. [access Mar 16, 2013].
2. Howell I., Batcheler B. Building Information Modeling Two Years Later – Huge Potential, Some Success and Several Limitations. http://www.laiserin.com/features/bim/newforma_bim.pdf. -9 pp. [access Mar 16, 2013].
3. Eastman C., Teicholz P., Sacks R., Liston K. BIM Handbook. A Guide to Building Information Modeling for Owners, Managers, Designers, Engineers, and Contractors. *John Wiley & Sons, Inc.*, 2008. -490 pp.
4. Technology Adoption Lifecycle. http://en.wikipedia.org/wiki/Technology_adoption_lifecycle. [access Mar 16, 2013].

5. Shilovitsky O. Why PLM and BIM Fail in the Same Way? *Beyond PLM,* May 4, 2012, http://beyondplm.com/2012/05/04/why-plm-and-bim-fail-in-the-same-way. [access Mar 16, 2013].
6. Barison M. B., Santos T. B. BIM Teaching: Current International Trends. *Gestão e Tecnologia de Projetos,* 2011, 6, (2), p. 67-80.
7. Kymmell W. Building Information Modeling: Planning and Managing Construction Projects with 4D CAD and Simulations. *McGraw Hill, New York, NY,* 2008. -416 pp.
8. Sabongi F. J. The Integration of BIM in the Undergraduate Curriculum: An Analysis of Undergraduate Courses. *Associated Schools of Construction. Int. Proc. of the 45th Annual Conference,* Gainesville, FL, Apr 1-4, 2009. -6 pp. http://ascpro0.ascweb.org/archives/cd/2009/paper/CEUE90002009.pdf. [access Mar 16, 2013].
9. Becerik-Gerber B., Gerber D. Ku K. The Pace of Technological Innovation in Architecture, Engineering and Construction Education: integrating recent trends into the curricula. *Electronic Journal of Information Technology in Construction*, 2011, 16, p. 411-431. http://www.itcon.org/data/works/att/2011_24.content.09244.pdf. [access Mar 16, 2013].
10. Barison M. B., Santos E. T. BIM Teaching Strategies: An Overview of Current Approaches. *Computing in Civil* and *Building Engineering. Proc. of the International Conference*. Nottingham, UK, Jun 30-Jul 2, 2010. -7 pp. http://www.engineering.nottingham.ac.uk/icccbe/proceedings/pdf/pf289.pdf. [access Mar 16, 2013].
11. Pavelko C., Chasey A. D. Building Information Modeling in Today's University Undergraduate Curriculum. *Proceedings of* the *BIM-Related Academic Workshop*. Washington, D.C., Dec 7-9, 2010. -11 pp. http://www.buildingsmartalliance.org/client/assets/files/bsa/bsa_conference_proceedings_1210.pdf. [access Mar 16, 2013].
12. Taiebat M., Ku K., McCoy A. BIM in Integrated Learning Environments for Construction: The Students' Perspectives. *Proceedings of the BIM-Related Academic Workshop*. Washington, D.C., Dec 7-9, 2010. -10 pp. http://www.buildingsmartalliance.org/client/assets/files/bsa/bsa_conference_proceedings_1210.pdf. [access Mar 16, 2013].
13. Brown N. C., Peña R. B., Folan J. Teaching BIM: Best Practices for Integrating BIM into Architectural Curriculum? Autodesk *University 2009. Learn. Connect. Explore*. Las Vegas, NV. Dec 1-4, 2009. -10 pp. http://aucache.autodesk.com/au2009/sessions/5267/AU09_TeachingBIM_ED122_1.pdf. [access Mar 16, 2013].
14. Koch D., Hazar D. Integrating BIM into Mechanical, Electrical and Plumbing (MEP) Construction Management Curriculum. *Proceedings of the BIM-Related Academic Workshop*. Washington, D.C., Dec 7-9, 2010. -6 pp.

http://www.buildingsmartalliance.org/client/assets/files/bsa/bsa_conference_proceedings_1210.pdf. [access Mar 16, 2013].

15. BIM Curriculum. A Teaching Material for Educators of BIM. http://www.graphisoft.com/education/curriculum/. [access Mar 16, 2013].
16. Dobelis M. Computer Aided Architectural Design Training. *Innovations in E-learning, Instruction Technology, Assessment and Engineering Education*, (Ed. by M. Iskander), Springer, 2007, p. 267-272.

Scientific Proceedings of the 12th International Conference on Engineering Graphics BALTGRAF 2013

Editor M. Dobelis

BALTGRAF 2013
June 5-7, Riga, Latvia

ERAF
EIROPAS REĢIONĀLĀS ATTĪSTĪBAS FONDS

IEGULDĪJUMS TAVĀ NĀKOTNĒ!

EIROPAS SAVIENĪBA

RIGA TECHNICAL UNIVERSITY

2013

ERAF
EIROPAS REĢIONĀLĀS ATTĪSTĪBAS FONDS

IEGULDĪJUMS TAVĀ NĀKOTNĒ!

EIROPAS SAVIENĪBA

Support for publishing provided by the European Community under national project “Development of international cooperation projects and capacity in science and technology Riga Technical University”.
Contract No. 2010/0190/2DP/2.1.1.2.0/10/APIA/VIAA/003

ISBN 978-9934-507-30-4
Scientific papers were peer reviewed
English (U.K.) was used for the spellchecking of all submissions
iThenticate® was used as plagiarism checker for content originality
BALTGRAF 2013 acknowledges EasyChair conference management system

Editor Modris Dobelis

CONFERENCE ORGANIZATION

Under auspices of
International Association BALTGRAF

Organizing Committee:

Modris **Dobelis** – Conference Chairman, Riga Technical University, Latvia
Juris **Smirnovs** – Conference Co-Chair, Riga Technical University, Latvia
Zoja **Veide** – Program Committee Chair, Riga Technical University, Latvia
Marika **Ubagovska** – Conference Secretary, Riga Technical University, Latvia

International Program Committee:

Harri **Annuka**	Tallinn University of Technology	Estonia
Jānis **Auzukalns**	Riga Technical University	Latvia
Aleksandr **Brailov**	Odessa State Construction and Architecture Academy	Ukraine
Anna **Błach**	Silesian University of Technology	Poland
Theodore **Branoff**	North Carolina State University	USA
Modris **Dobelis**	Riga Technical University	Latvia
Jolanta **Dźwierzyńska**	Rzeszow University of Technology	Poland
Cornelie **Leopold**	University of Kaiserslautern	Germany
Harri **Lille**	Estonian University of Life Sciences	Estonia
Daiva **Makutėnienė**	Vilnius Gediminas Technical University	Lithuania
Rein **Mägi**	Tallinn University of Technology	Estonia
Vidmantas **Nenorta**	Kaunas University of Technology	Lithuania
Imants **Nulle**	Latvian University of Agriculture	Latvia
Lidija **Pletenac**	University of Rijeka	Croatia
Monika **Sroka-Bizoń**	Silesian University of Technology	Poland
Hirotaka **Suzuki**	Kobe University	Japan
Jolanta **Tofil**	Silesian University of Technology	Poland
Antanas **Vansevičius**	Aleksandras Stulginskis University	Lithuania
Daniela **Velichova**	Slovak University of Technology in Bratislava	Slovakia
Olafs **Vronskis**	Latvia University of Agriculture	Latvia
Gunter **Weiß**	Dresden Technical University	Germany

Local Organizing Team:

Jānis **Auzukalns**
Ieva **Jurāne**
Ella **Leja**
Veronika **Stroževa**
Gaļina **Veide**

Papers were peer reviewed by

PROGRAM COMMITTEE – THE BOARD OF REVIEWERS

Scientific Proceedings of the 12th International Conference on
Engineering Graphics BALTGRAF 2013
June 5-7, 2013, Rīga, Latvia. -300 pp.