Green Technologies and Sustainable Development in Construction

Edited by
Xingkuan Wu, Jibril Danazimi Jibril,
Dodo Yakubu Aminu, Jing Wu and Hao Xie

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Green Technologies and Sustainable Development in Construction

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Introduction

The Organizing Committee of GBTM 2013 would like to extend you a very warm and friendly welcome to Kuala Lumpur, Malaysia. GBTM 2013 is an annual international forum for dissemination of original ideas and results in green building technology and materials in theoretical and practical aspects. A major goal and feature of GBTM 2013 is to bring academic scientists, engineers, industry researchers together to exchange and share their experiences and research results about most aspects of green building technology and materials, and discuss the practical challenges encountered and the solutions adopted.

GBTM 2013 received 288 technical paper submissions and committee had a very challenging task of choosing high quality submissions. Each paper was peer reviewed by independent referees and based on the recommendation of reviewers 75 papers were finally accepted to be published.

The committee members deserve many thanks for their effort in putting the technical program together. They have worked very hard to ensure that GBTM 2013 is a success. We believe that you will find GBTM 2013 to be a valuable resource in your professional, research, and educational activities whether you are a student, academic researcher, or a practicing professional.

Finally, we are very pleased to welcome you to GBTM 2013 and we hope you will find this year's event full of stimulating idea and discussions.

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CHAPTER 1:

Green Building and Energy Saving Technologies

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The Application of BIM in Green Building Energy Saving: Take Helsinki Music Center as an Example

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Keywords: BIM, Helsinki Music Center, Green building technology, Energy Simulation, Lifecycle Assessment Analysis.

Abstract. In recent years, Green BIM (building information modeling) is paid much attention and gets widespread concern in construction field, the majority of the projects using green building BIM technology also gained good results to effectively balance between sustainability and economic. This study is based on the innovation practice using BIM technology do energy simulation design in The Helsinki Music Center project. This project Build Green Building Environment through the followings: three-dimensional building information model, Energy Simulation at the Schematic Design Stage, Energy Simulation for Comparison of Design Alternatives, Lifecycle Assessment Analysis. This paper will give you a detail analysis.

Introduction

Annual energy consumption of buildings accounted for 30%~40% of global energy [1], the greenhouse gas emissions caused by buildings account for one third of total global emissions [2], as people's awareness of the performance of the building gradually enhanced, the green building concept for the purpose of effectively improving the construction resources and energy efficiency improving the impact of buildings on human health and the natural environment, has been paid extensive attention worldwide.

Meanwhile, in recent years the rising BIM (building information modeling) which creates and uses digital models for the design construction and operation management of the process in construction projects advocates a new concept using digital model technology to achieve the project life management [3]. The extensive and successful BIM uses in the United States and other developed countries make people realize the huge potential of using technology to promote the development of green building. The combination of green building and BIM forms a green BIM concept, McGraw Hill Construction defined it as: to achieve sustainability and improve building energy efficiency targets from the project level [4]. This paper will introduce Finland Helsinki Music Center project to give a specific analysis of the application of Green BIM in building energy efficiency design.

The Application of BIM in Helsinki Music Center

Project Description. The Helsinki Music Center aims to give Finland's capital city an outstanding and acoustically exceptional concert hall, along with other facilities enhancing the musical experiences for people of all ages. Helsinki Music Center is located in the city center just in front of the Houses of Parliament. The closet neighbors are Kiasma Museum of Contemporary Art and the main building of *Helsingin Sanomat*, Helsinki's major newspaper. The main users of the building will be the Sibelius Academy, the Helsinki Philharmonic, and the Finnish Radio Symphony Orchestra. It will also serve as a place to study music.

BIM Tools Used in This Project. These BIM applications include:

- First ADT, which later morphed into Autodesk Architecture-defined the 3D layout, provided project spatial coordination, and supported drawing production

- MagiCAD-performed 3D layout and sizing of piping and ductwork, based on flow requirements, and support for clash detection
- Riuska-performed energy analyses and generated flow requirements for MagiCAD
- Vico-estimated costs
- ANSYS-performed fluid flow finite element analysis
- ROOMEX-assessed the space program and identified environmental, energy, and lighting requirements of spaces
- Tekla-performed structural design
- BSLCA-performed lifecycle cost assessment tool
- Solibri-supported spatial review and rule checking

BIM for Advanced Simulations. Since the data preparation requirements for energy and lifecycle simulation are very extensive, they are usually undertaken by specialized engineers or research groups at the final stage of design, in order to validate previous decisions or to fulfill legal mandates. The use of advanced energy simulation during the design process, however, also facilitated better understanding of the design problem with respect to energy, indoor air quality, thermal comfort, visual environment, and acoustical performance. But the multiple actors and complex datasets of current practice almost prohibit their use of such analyses to provide design feedback. This case study demonstrates that advanced energy simulation can be integrated with the design process. It shows how the team used the results of these analyses to modify and influence aspects of the design.

Energy Simulation at the Schematic Design Stage. The owner established strict energy efficiency requirements and this required that the team address this aspect of design early and often in the development of the design and the acoustical aspects. A critical part of performing such analyses early is developing clear targets for performance by which the team can assess the results of energy analyses. For projects not externally restricted by energy consumption (such as a concert hall), energy simulation at the schematic design stage is helpful for the owner to set realistic energy-per-unit area targets and to estimate the operation cost. Figure 1 shows an early energy consumption simulation result and the selected annual energy usage per unit area design target. Simulation at early stages requires some assumptions based on experience or from previous similar projects. More disaggregated results from schematic design simulations can also reveal the energy consumption by each component of the building. Energy simulation was used to evaluate design alternatives; energy and cost savings were achieved while maintaining the highest quality acoustics.

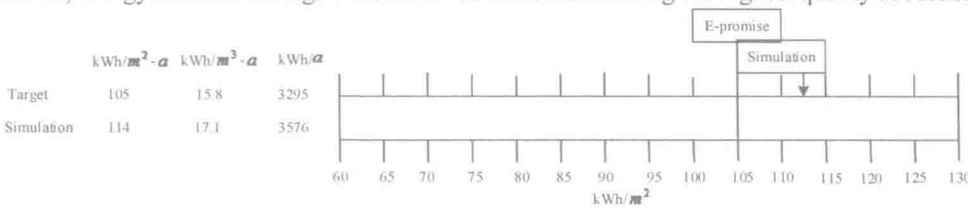

Figure 1 Schematic design energy consumption simulation results and Selected energy target for use during design development

Energy Simulation for Comparison of Design Alternatives. Energy simulation makes it possible to compare different design schemes and to direct the decision-making from the point of view of energy consumption. It can be performed for varied systems like heating energy consumption, cooling energy consumption, electricity consumption, water consumption, and the like [5]. For the Helsinki Music Center, Granlund evaluated several design alternatives and offered feedback to the architects by doing energy simulation at the early design stage. The following is an example that compares different glazing types for curtain walls.

Curtain walls are very popular for commercial building design due to their open appearance as well as daylight benefits. However, parameter selection related to solar gain is difficult to determine, especially for predominantly glass curtain walls. Whether solar gain is good or not from the point of view of energy consumption relates to multiple factors, including outdoor weather condition, internal heat gain, and these vary case by case. Therefore, energy simulation is necessary for informed decision-making. Two glazing types were compared here:

Glazing Type One:
- G-value = 28 percent (total solar energy transmittance)
- ST = 16.5 percent (direct solar energy transmittance)
- U-value = O.8W/m2 K

Glazing Type Two:
- G-value = 35 percent (total solar energy transmittance)
- ST = 32 percent (direct solar energy transmittance)
- U-value = 1 W /m2K

Riuska was the tool used for the energy simulation. It was developed by Granlund with the core of the software being the DOE 2.1 E simulation energy program. DOE 2 was the main energy analysis tool in the United States until Energy Plus was released. Riuska can directly transfer the geometry data from IFC-compliant architect software, like Autodesk's Revit and AutoCad Architecture, ArchiCAD, Nemetschek's Vectorworks, and others [6]. This project used AutoCad Architecture. Providing hourly simulation throughout the year, the results can be used for:

- Analysis of alternative indoor air quality levels
- Comparison of alternative windows and shades
- Dimensioning of air conditioning equipment
- Analysis of temperature problems in existing facilities

Simulation results for the glazing alternatives are presented in Figure 2. Heating energy consumption of glazing Type Two is about 10 percent lower, even though its U value is higher, because solar heat gain through glazing Type Two is more than that through glazing Type One. But for cooling, glazing Type Two results in 20 percent higher energy consumption due to more solar heat gain. For Helsinki, the heating season is much longer than the cooling season, so glazing Type Two still has a better performance based on total annual energy consumption. Figure 2 also shows the energy cost comparison which is equally important for the final decision-making.

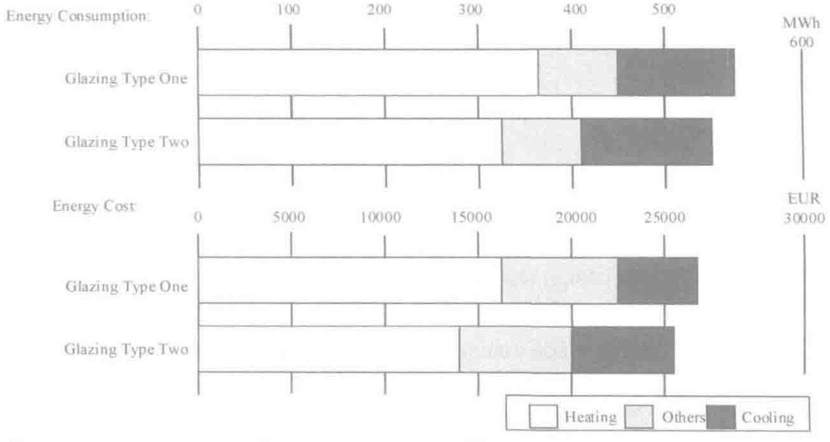

Figure 2 Energy consumption and cost comparison. "Others refers to lighting and other internal energy demands"

Lifecycle Assessment Analysis. Life recycle assessment (LCA) is a powerful method to analyze, evaluate, and compare design alternatives from a broad ecological perspective. To do so, it requires a varied set of measures over the lifecycle of the facility, for example, construction, operating and maintenance costs, energy use, water consumption, building structures, technical systems, and equipment. With a properly conceived and implemented tool, teams can make decisions applicable over all stages in the building Lifecycle, from conceptual design to construction and then to facility operation and management. Measured quantities are refined over time, similar to cost estimation. Most current approaches to LCA use 2D drawings and manual entry of material and building data. They are time consuming and often performed late in the design-construction process or after the building is complete. BIM provides designers and engineers with data that can more readily integrate with LCA tools during design. BSLCA (Building Services Life Cycle Analysis) is such a highly integrated software package (see Figure 3). It links together layout and material data from the 3D building model, system data from the building services design database, ducting and piping data from commercial HVAC-CAD tools, and energy consumption data from the building energy simulation. BSLCA relies on tools that can operate on building models at various levels of detail. These include SMOG, a space modeling package that addresses space and building use measures, the Systems Design tool that is linked to the BSLCA database structure to address the whole range of building services: HVAC, electrical, building automation, kitchen, and hospital equipment. The System Design tool is also used in the routine everyday design work by project engineers to save technical information into a building services database. That data includes the material for electrical, piping, and duct layout. This building systems database also forms the basic data for the facilities management system in the building operation phase. Riuska is used to generate heating, cooling, internal equipment, and lighting costs. The measures required for BSLCA can be generated by multiple external tools which are structured by the different packages into the LCA database, from which global assessments are made.

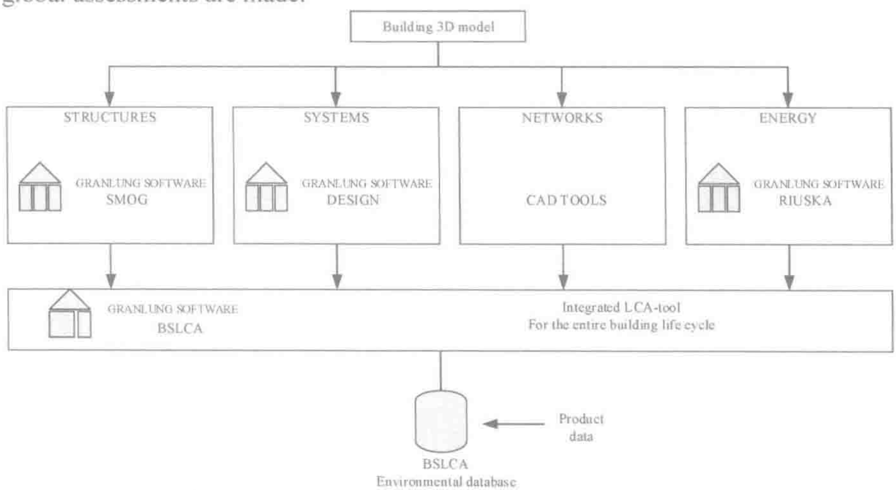

Figure 3 Structure of the BSLCA integrated LCA tool

The Helsinki Music Center design team used BSLCA to compare the design against a benchmark set up for the project:

- The benchmark design made assumptions about a typical but good project of this type and using similar methods of construction. Overall thermal energy consumption of 114 kWh/m2a; the Music Center target design was set at an overall thermal energy consumption of 105 kWh/m2a.
- Scenario two consumes less energy during operation of the building, but it requires the use of more costly, higher thermal performance materials during the construction process to achieve that target. Lifecycle analysis is an effective way to balance energy consumption between building construction and operation stage.

The 50-year lifecycle results shown in Figure 4 reveal these two design schemes have similar lifecycle energy consumption, and Scenario Two has a slightly better lifecycle environmental performance.

Conclusions

Riuska shows how energy analysis can support design. It transfers the geometry data from architectural software to a thermal simulation geometry model, providing consistency between the two models. Its use was shown in the simulation used to evaluate the energy performance of two glazing types in the curtain wall system.

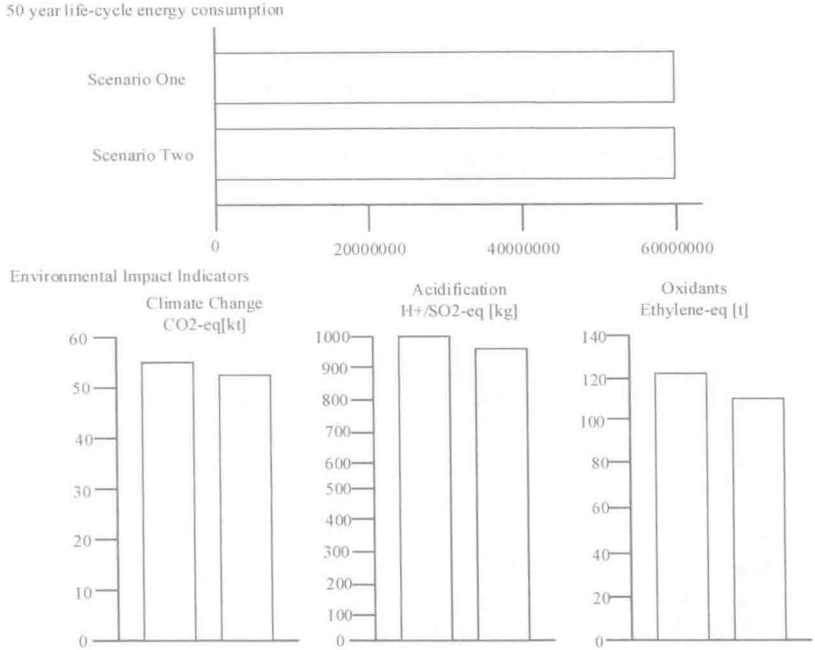

Figure 4 LCA analysis for comparison of two design alternatives

Lifecycle analysis (LCA) was demonstrated for comparing the environmental impact of design alternatives. LCA is an important type of analysis that will be playing an increasingly important role in design-making. BIM provided the materials and energy used, extracted from the building model, and was crucial for LCA analysis.

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