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SUSTAINABLE BUILDING AND BIM

Tarja Häkkinen



Business from technology

SUSTAINABLE BUILDING

- Sustainable construction brings about the required performance with the least unfavourable environmental impact, while encouraging economic, social and cultural improvement at a local, regional and global level.

SUSTAINABLE BUILDING AND BIM

- Aspects of SB include the aspects of
 - building performance,
 - environmental, economical, and social impacts.
- Sustainable design and life cycle (LC) management of buildings need new type of information compared to traditional building process.
- Because of the abundance of needed information, efficient information-technological solutions are needed.
- BIM should also be able to support the supply, integration and management of information throughout the building LC.

LC INFORMATION

- LC information can be given in terms of
 - product data and
 - different kinds of assessment and simulation models.
- With help of this information, aspects of
 - energy,
 - indoor environment,
 - environmental impacts,
 - LC costs and
 - service life
- BIM in its different stages should be provided with all initial information that is needed in the implementation of LC methods.
- The results of assessments should be integrated with the different stages of BIMs in terms of indicators and guidelines.

BIM

- BIM - creation and use of coordinated, consistent, computable information about a building project during design, construction and building operation and management.
- Software applications of BIM work with 'objects'
 - represent elements of building construction including physical components, spaces, processes, actors involved, and relationships between these objects.
- Complete design information of a building consists of several domain specific design BIMs, such as architectural, structural, HVAC, electrical BIM.
- Integrated BIM is a combination of these individual BIMs.

BIM

- BIM = integrated BIM
- repository of all BIMs containing the information of a building
- covers not only geometry, spatial relationships and geographic information and quantities, but also properties of building components.
- quantities and shared properties of materials can be extracted.
- can be used as source of information for analysis of the solution as well as to store the results of analysis.
- can be used to represent the entire LC of the building including the processes of construction and facility operation.

POTENTIALS FOR SUSTAINABLE BUILDING MANAGEMENT WITH HELP OF BIM

- Because of enabling the **sharing of information** and because of working with **objects**, BIM can support the management of information needed in design for SB.
- Important questions:
 - how to integrate and
 - what is the degree of linkage or inclusion of different data bases and tools with domain specific BIMs.
- *In most cases, the BIM should offer a framework and source of information concerning the design solution, while the specific assessment and simulation models and the needed background data are not embedded but linked with help of identities and interfaces.*

USE OF BIM IN SUSTAINABLE BUILDING AND CONSTRUCTION

- The Finnish Senate Properties is one of the forerunners in mobilizing BIM.
- "BIM Requirements 2007 in different phases of the design and construction process". Phases of construction projects and related BIMs are:
 - Analysis of needs and objectives
 - Requirement model: Project requirements and requirements of the authorities
 - Design of alternatives
 - Alternative mass and spatial models
 - Early design: Architectural model, structural model, HVAC model, Electrical model
 - Detailed design: Architectural model, structural model, HVAC model, Electrical model
 - Bidding phase
 - Approved detailed design and Construction model
 - Construction and commissioning
 - Construction model and As-built model
 - Facility management and maintenance
 - Maintenance model

STANDARDISATION OF SB METHODOLOGIES

- necessary in order to integrate SB aspects with BIM processes
- necessary to standardise the definitions and semantics of this information.
- General principles on LCA of products and services have been agreed upon and made public with help of ISO standardization.
- Applied methods for building products are being standardized by ISO.
- Standards rather work with principle methodologies.
- In order to enable integration of SB methodologies with BIM, the definitions of information contents should be further developed.
- The specifications for data representations that have exact representation syntax which could be made use by software are missing.

STANDARDS

- ISO TC 59 SC 17 "sustainability in building construction"
 - ISO CD 15932-2 General Principles;
 - ISO/PTR 21932 Terminology;
 - ISO /TS 21929-1 Sustainability indicators;
 - ISO DIS 21930 Environmental declarations of building products; and
 - ISO DTS 21931-1 Environmental performance of construction works.
- ISO TC 59 SC 14 "service life planning"
 - ISO 15686-1, general principles for service life planning
 - ISO 15686-2, service life prediction
 - ISO/DIS 15686-8.2, guidelines for reference service life
- CEN TC 350 "Sustainability of construction work"
 - voluntary horizontal standardised methods for the assessment of the environmental performance of new and existing buildings and for the environmental product declaration of construction products
- EC standardisation mandate M/330 EN / CEN
 - methodologies for the calculation of the energy uses and losses for heating and cooling, ventilation, domestic hot water, lighting, natural lighting, passive solar systems, passive cooling, position and orientation, automation and controls of buildings, and auxiliary installations.

IFC

- IFCs aim at providing an open definition for data structures to capture and exchange information
- IAI buildingSMART initiative
 - development, maintenance and implementation of IFC:
 - enabling interoperability between AEC/FM software applications
- IFCs express common agreements on
 - content,
 - structure and
 - constraints
- of information to be shared and exchanged by several participants in construction and facility management projects using different software applications.
- IFC incorporates a mechanism called Property Sets which allows information publisher to allocate new properties to an object.
- enables IFC to be used for representing also product specific information.

INTEGRATION OF SB TASKS WITH BIM

- There are different solutions for integrating LC analysis software and BIM:
 - Separate software that can use file exchange with BIM or is integrated with a BIM server using a specific API. The analysis software can then have its own library for those pieces of information that are not included in BIM.
 - The analysis software could also be implemented by programming new functionality to BIM software.
 - An intermediate solution for these is integration with help of parametric formats (e.g. GDL) that allow representing not only product information but also calculations used in this analysis.
 - *a separate software connected to BIM is the most likely in terms of easiness to realise and use*

SB TASKS

- Service life design
- Environmental assessment
- Energy consumption estimate
- Maintenance manual
- Optimization on building refurbishment
- Sustainable building rating

Service life design

- Service life design needs information about the age behaviour of building elements and components.
- Service life prediction methods have been developed for construction products which are exposed to weather conditions.
- Integrating service life assessment with BIM:
 - The initial data needed in the assessment for defining the values of parameters should be available through the properties of the model or with help of integrated databases.
 - Part of the needed data could be made available with help of an integrated database; this may concern for example material properties.
 - Also the design solution itself affects service life. Thus for example the structural model should include all information about the quality of structures that is needed as initial information for the service life assessment of structures. The structural model software should support the designer to define the structural parameters needed in the assessment of service life.
 - The assessment software itself can remain a separate tool that is compatible with the model. The interfaces can be made by converting native data formats into IFC representations.

Environmental assessment

- Information needed from BIM includes data about properties and quantities of different components and elements.
- This information should be linked to a database that includes the environmental profiles of building components and elements.
- The environmental assessment of a building can be integrated to BIM similarly as cost assessment is already done at present.
- The integration requires that product specific and energy related environmental profiles are available, for example, in the form of an XML database.
- The final result from assessment should be enclosed as environmental impact indicators to BIM (design model).
- Different kind of environmental information is needed in different stages of the process.
- Environmental information may also include instructions for the building use and final disposal.

Energy consumption estimate

- The initial data needed in design for energy efficiency includes information about local environmental conditions, technical performance and capacity of building elements and HVAC units and systems, position of the building in the building lot, spaces, arrangement of spaces, and intended user profiles.
- Different kinds of assessment and simulation methods and tools are available for the assessment of energy consumption of buildings.
- To enable the energy consumption assessment with help of BIM
 - 1) the model should provide all data needed in the calculations
 - 2) there should be a suitable interface between the model and the assessment software.
- Probably the best solution is that the assessment is not done within the model but with help of software that is compatible with the model.
- The results should be imported as energy-efficiency indicators of the design model and later stages of BIM.
- These indicators should follow the formats and expressions (units etc.) agreed upon in standardisation

Maintenance manual

- VTT have proposed simple methods for sharing and integrating product-specific instructions-type-of-information with BIM.
- A framework for a web browser based database was created where manufacturers can store all product specific service life information. The service life information was defined with using XML description language.
- Operating the process:
 - the concept-developer requires all the suppliers of the concept to include service life information into the database
 - with help of which the compiler of the maintenance information collects and arranges the building information to form organised and scheduled product information for care and maintenance.
 - The maintenance model should be provided with methods and tools with help of which product specific maintenance information can be arranged and collected as building system specific information.
 - The contents of this information should enable the effective implementation of maintenance considering the different periods and types of inspections, care, repair and renewals.

Optimization on building refurbishment

- MaintenanceMan is a tool, which supports the optimization of building refurbishment measures.
 - uses service life models with help of which it is possible to predict the service life of building modules
 - allows studies at different risk levels
 - optimization criteria are life cycle costs (LCC) and environmental impacts.
- Integration with BIM:
 - maintenance model should include the needed initial data,
 - design model software and the construction model software should support the designers to provide all needed initial data to the model (information about materials, structures and environmental conditions)
 - maintenance model should support the maintenance managers to update this information
 - LCC information should be available through a separate integrated database (because it is both product specific and user specific information)
 - The results should be imported to the maintenance model.

Sustainable building rating

- The majority of the existing environmental assessment methods of buildings evaluate environmental performance of buildings relative to explicitly declared or implicit benchmarks.
- Integration with BIM:
- Requires that the BIM processes supports the determination of the building specific values for the indicators and calculation of the final results with reference to given benchmarks.
- With regard to LCI/LCA related indicators and indicators that are based on the characteristics of building products and energy-efficiency indicators, the determination of indicators' values can be done as described earlier.
- With regard to some indicators - like accessibility, adaptability - the development of specific model-checking software might be the best solution.

CONCLUSIONS

- Tools of LCI/LCA assessment, energy consumption assessment, service life assessment, maintenance manual, optimization of refurbishment and sustainability rating are important methods in design for sustainable buildings and in sustainable use and refurbishment of buildings.
- The use of these methods requires the availability of tools and a lot of additional information compared to a traditional building process.
- In order to rationalize the use of these methods and to support the use of methods during the design processes, the methods should be integrated with BIM processes.