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Optimizing Sustainable Building's Performance through Integrated Building Information Modeling Technology

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Abstract. With the rising cost of energy and growing environmental concerns, the demand for sustainable building facilities with minimal environmental impact is increasing. Sustainable building is rapidly transforming the design and construction industry around the globe. Simultaneously, a growing numbers of industry practitioners are taking the advantages of building information modeling (BIM) to upgrade the sustainable performance of building. BIM tools encourage an integrated lifecycle sustainable building management from design, construction, and prefabrication to operation and maintenance, and sustainable buildings are designed and constructed with the intention of reducing resource use (e.g., energy, water, and raw materials), greenhouse gas emissions, and debris with regard to the entire lifecycle of the building, BIM can also provide support during the operational lifespan of buildings. This paper outlines the newly development of BIM technology to upgrade sustainable building objectives and performances.

Introduction

A. Sustainable building has largely emerged from construction communities of practitioners working to define beneficial processes and practices and create mechanisms to recognize and encourage their use in the world. Sustainable building is transforming the construction responsibility and impacts on the environment from siting, design, construction, operation and maintenance. In developed countries like U.S.A, U.K., Canada, Singapore, Germany, Australia, Norway and Brazil etc. 94% of architects, engineers, consultants and owners report engaging in some level of sustainable building, either project certified to a global green building rating system or built to qualify for a system. Today, many countries have developed a combination of processes and tools, including consensus-based rating systems, rigorous third-party review and certification. The green building assessment tools usually include LEED, BREEAM, SBTool, CASBEE, Green Globes, Green Calc, Ecoprofile, HK-BEAM, BCA-GM, Green Star, NABERS, and Green Building Label. For example, LEED of the U.S.A. certifies the project to satisfy prerequisites and credits in seven categories. Namely: sustainable sites; water efficiency; energy and atmosphere; materials and resources; indoor environmental quality; innovation and design process; regional priority.

B. BIM (Building information modeling) is a model-based technology linked with a database of project information which is available throughout the entire design, construction and operation process, and can be accessed and shared among different project participants, and also can be integrated with other programs for construction estimating, scheduling, and project management. Furthermore, cloud-based BIM solutions have enhanced the experience with BIM software, some of the companies like Autodesk, Bentley Systems, and Nemetschek etc. have developed cloud-based tools for advanced data management which includes a model viewer, model variance, and automated estimating that allows any Revit file and AutoCAD file can be uploaded to assemble

database, which can be shared via the web with other team members. The BIM software market in the Americas is the fastest growing market segment and will continue to grow rapidly for the next few years. The increasing establishment of organizations and buildings in various countries in the region is augmenting the adoption of BIM software in the country.

C. Integrated Multi-discipline Building Models: Integrated BIM technology allows the project teams to develop integrated multi-discipline building models and collaborate with various stakeholders to work simultaneously on the design, and provides an opportunity for the owner, users, key suppliers and design teams to select the best building orientation that results in minimum energy costs, to analyze building form and optimize the building envelope, to reduce water needs in a building, to reduce energy needs and analyze renewable energy options such as solar energy and to reduce material needs and to use recycled materials early in the design stage. Such as for projects pursuing LEED certification, BIM software produces a wealth of information for many other aspects of sustainable design, schedules of building components to determine percentages of material reuse, recycling, or salvage. The advanced visualization techniques of BIM can convince skeptical clients that sustainable design performs well and LEED certification can be facilitated using BIM. BIM can also make facilities management more efficient and cost-effective, which means that operational performance is promoted in terms of energy, water and materials.

BIM Technology Application in Design and Construction Industry

The most effective decisions related with sustainable design of a building facility are made in the early design and preconstruction stages. BIM technology has obtained widespread applications in the architectural, engineering and construction industry at present in industrialized countries, in which building information modeling is increasingly part of any and all construction activities. Furthermore, 3D laser scanning technology collects required information that improves the efficiency and optimizes the BIM process, such as project scheduling, planning, coordination, cost estimation, sustainability, and facility management. The implementation of BIM software reduces rework, saves time, reduces dependence on paperwork and enhance the productivity especially as follows:

N-Dimensional Visualization of Buildings. Both advanced and mature BIM software applications which can generate n-dimensional (n-D) models to simulate the planning, design, construction and operation of a built facility. When simulating or coordinating constructions sequencing by integrating schedule data with the model data, can be virtually viewed as 4D (four dimensional) model, and when using the model data to quantify materials and apply cost information can be virtually viewed as 5D (five dimensional) model, which helps to visualize what is to be built in simulated environment and to identify potential design construction or operational problems.

Change Management. Although BIM methods have motivated architects, owners, engineers, and other construction project actors to evaluate the traditional methods of working with architectural designs and estimating, scheduling project management, cost controls and tracking requests for information change orders etc. Collaborative teamwork functions will make it easily to view, merge and further process multiple BIM files, with tracking of changes in models and alerts about such changes being made. Alterations to building structures and furnishings can be automatically checked, conflicts identified, and quality improved. A reporting system to pick out useful information now and in the future, such as the information for a bill of quantities or the highlighting of project conflicts after a change order or variation is readily to all the project participants.

Construction Safety Simulation. BIM tools will help to reduce errors in transfer of information and help build better value constructions than ever before. By identifying clash detection and safety hazards, BIM prevents errors creeping in at the various stages of development and construction, and correct errors in 3D designs before they happen in real life, or fix them faster afterwards, with which carry out different designs and optimize for the best cost-performance ratio while ensuring overall construction soundness and safety.

Data Management. BIM software like Autodesk and Nemetschek etc. have actively promoted common building data formats. BIM data can be viewed as a 3D model, and can be integrated with other programs for construction estimating, scheduling, and project management, then the applications of this use throughout the planning, design, construction and facility operation processes. Attach project data of many kinds (schedules, photos, scans of handwritten notes) to be able to find it all again in one place. For example, team members of mobile application for Android and iPhone/iPad device users will be able to access and interact with BIM data in a project conveniently.

Operational Management. The most effective decisions regarding sustainability in a building facility are made in the early design and preconstruction stages. The provision of as-built information for handover, improving facility management and enabling the verification and improvement of the building's environmental performance. A facilities management handover service to make relevant information available to clients or other parties, it means check building performance (energy consumption for example) over the lifetime of a building and gain in efficiency in remodeling or extensions from the early start of the project at design stage. It also enables smoother operations with increased operational safety and without unexpected interruptions.

Benefits of integrated BIM Tools to Sustainable Building Performances

Integrated BIM and Sustainable Building Design. New BIM technology provides immediate insight into how design decisions impact sustainable building performance, and provide an innovative new approach to building design, engineering, and construction management. BIM technology allows project team to more quickly and easily create a basic building model to help simulate the performance and cost of renovations. Sustainable design is best served by an integrated design process, with a holistic approach to all design and construction disciplines, and BIM adoption is in part based on its ability to facilitate integrated design. Many of the tools of BIM, including energy use modeling and day lighting studies provide better information on how design changes impact building performance than any traditional design tool. BIM can also provide more information to product manufacturers for greater use of prefabrication, which can eliminate waste and makes the construction process greener and faster. With a more comprehensive understanding of the relative performance of the sustainable building, the project team can recommend and prioritize an overall building modernization program, and focus detailed design efforts and construction on the projects with the greatest impact on sustainability. BIM tools can utilize control design to reduce the consumption of energy, water, and materials in sustainable building renovations.

Integrated BIM and Green Building Certification Credits. Based on a green building model, project team can analyze, compare renovation options, or audit potential renovation projects based on owner's financial or environmental criteria. For example in the U.S.A, BIM models are now used in calculating LEED credits: BIM tools are used to analyze green building performance for energy simulations, lighting analysis, water conservation modeling and optimize the building

envelope and evaluate sun position, solar radiation, shading, and daylight alternatives that may increase with both a higher level of sophistication of LEED rating requirements and improved functionality of technology. The project team can also incorporate local weather and electric grid data to estimate building energy consumption and carbon emissions, and renovate buildings to reduce water usage or to utilize more reclaimed water, and select recycled or renewable materials or finishes during building renovations from the design, construction to operation. Those are all key sustainable building performance considerations and LEED rating requirements.

Integrated BIM and Sustainable Building Construction. Besides BIM technology facilitates sustainable design, BIM tools enable highly sustainable outcomes through construction simulation and prefabrications. Combination of n-dimensional BIM technology, the project team can take constructability review by means of visualization. Construction management team can visualize what is to be built in a simulated environment, and make project scope clarification and design validation. Then, construction management team can make construction sequencing planning/phasing, and consider more "what if" scenarios, such as looking at various sequencing options, site logistics, hoisting alternatives and costs; and conduct walk-throughs, fly-throughs analysis and virtual mock-ups to identify building element collisions and reduce errors and corrections in the field which may affect operation and safety. Analysis using a BIM model can identify ways to reduce resource consumption, increase on-site renewable opportunities, build consensus, review investment grade audits, increase the public's confidence, and improve employee morale. Providing BIM models to building product manufacturers to prefabricate building elements off-site offers many green benefits, including time saving, cost saving and the reduction of waste produced by onsite fabrication. Such as prefabricated elements can include complicated HVAC or electrical systems in buildings. By using BIM, contractors realize efficiencies that can reduce consumption to reduce material waste and resource consumption to improve the overall carbon footprint of a sustainable project.

Integrated BIM and Sustainable Building Operation and Maintenance. Utilizing BIM program after taking over completed building, operation team can create a comprehensive operation and maintenance plan to make actions based decisions in a cost-effective manner, and focus on information exchange in order to achieve full energy management control and improve the energy efficiency and performance of the building, which maintains the largest impact for sustainability and efficiency of the building. Owners can track quantifiable returns on their investment, which could in turn lead to higher levels of sustainable building investment. Improved indoor conditions such as climate and lighting, driving improved occupant well-being and productivity, lower life cycle cost and environmental impact of the sustainable building at operational phase delivering will enhance asset value greatly.

Conclusion

With the integration of BIM technology, sustainable objectives of sustainable building can be achieved in full potential when technical obstacles will be surpassed. BIM's integration by construction industry will be greatly increased in the near future. BIM will be a key driver for the building sustainability and support for green initiatives. Moreover, the increasing demand of sustainable building will drive the growth prospects for the global BIM software market in turn. However, BIM-Sustainable building integration is the diversity of software applications and the variety of domain information needed for discipline-specific building simulations and analyses, the complexity of sustainable building could cause confusion and miscommunication between project members. BIM tools need further development and improvement in connect and interaction with

aspects of green process, so it will enables the project team to maximally provide added value to its customers and make further progress towards future sustainable projects for its customers.

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