BIM and Its Application into a Building at HandongUniversity

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Abstract

Current trend in Construction Technology is to integrate with ICT (Information & Communication Technology). BIM(Building Information Modeling) is one of the most conspicuous applications of ICT into Construction Field to deal with Big Data, which was not possible even a decade ago.This paper introduces BIM, including its definition, history, and future prospect. It also presents an application example of BIM intoa real case, Power Plant Building at HGU (Handong Global University). This example demonstratesa new attempt in terms of two aspects; 1) covering the whole life-cycle ranging from structural analysis to building operation, and 2)focusing on environmental matters rather than construction managements. Some conclusions are drawn based on the results.

1. Introduction

Construction Engineering has been regarded as a relatively low technology in terms of productivity. The main reason seems thatit has enjoyed its high benefit ratios with respect to investments despite its low technology. However, things are changed now, and it already faces serious crisis due to fierce competition. It has desperately searched a new breakthrough, without which it will not survive. Such efforts inevitably lead to integration with ICT, the most developed high technology.Some examples of integration include Intelligent Building, Smart Structure, Smart River, Ubiquitous City, etc. Among them, BIM is one of the most promising applications of ICT in construction industriesto deal with big data, which was not possible even a decade ago.

The tasks of our research include, 1) applying BIM into the whole life-cycle of Power Plant Building at HGU rather than a phase like design, construction, and maintenance, 2) making a new attempt to analyze echo-environmental problems, and 3) remodeling the building to achieve the most optimum environment-energy efficiency.

This paper explains what BIM is, including its short history, and future prospect, in order to introduce a successful example of integration of Construction Technology and ICT.

In addition, it will present briefly the results of the tasks, 1) and 2) of our research,as mentioned above. Some conclusions will be discussed.

The task 3) is not presented here, partially because it is on-going, and mainly because it purely belongs to the field of Construction Engineering.

2. What is BIM?

2.1. Definition

BIM (Building Information Modeling) is defined as a digital representation of physical and functional characteristics of a building displayed as a 3-D model, with the added capability to integrate a whole array of design and construction data related to cost, schedule, material, assembly, maintenance, energy use, and more.[1]

The term BIM is to describe an activity (meaning building information modeling), rather than an object (building information model). Thus, BIM is not a thing or a type of software but a human activity that ultimately involves broad process changes in design, construction, and facility management. [2]

2.2. Short History

In the past, the outputs of a design were composed of 2-D drawings, used for construction at sites. Along with the rapid development of the computer technology, 2-D drawings were also evolved to 3-D CAD models in the late of 90's. And then, it was attempted to integrate 3-D model with a whole array of design, construction, and operation data in the early 2000. However, it was not successful in the early stage, because the software technology to deal with such big data was not supportive.

In recent years, it has been possible to apply BIM in construction fields due to the implementation of various software tools. BIM has evolved from 3-D into 4-D for scheduling, 5-D for cost analysis, 6-D for environmental sustainability, and further n-D for future. For instance, Autodesk provides commercializedcomputer programs; such as Revit for

parametric modeling with various attributes and properties in additionto 3-D geometrical data;Robot for structural analysis and design;Navisworksfor scheduling and costing analysis; and Ecotech for eco-friendly environmental analysis and design. These are used to apply in this paper.

In Korea, construction projects over 50 million dollars initiated by the government have been mandatory to utilize BIM since 2012, and the policy is expected to expand for all the projects by 2016. [3]

2.3. Future Prospect

To date, the potential uses and impacts of BIM seem to have been partially explored. BIM is certain to continue to evolve as the development of new technologies, for example, having close to infinite computing power available everywhere, with integrated sensors increasingly leading toward smart buildings, and new smart materials, and tablet-based access. BIM keeps faster, less expensive, and more reliable, leading to improve our ability to build sustainably, and to build more effectively, creatively, and economically. [4]

3. Example Building for Application

To apply BIM into a real case, Power Plant Building an existing building at HGU was selected. That building is supposed to be used as the exhibition space for the products of energy-environment companies near HGU. The building lies along south to north, about 50m long, 20m wide in plan, and 2 stories high. Figure 1 shows the picture of the building.

Figure 1. Picture of Power Plant Building

4. BIM Analysis

4.1. BIM Model

At first, 3-D architectural BIM model was formed using Revit, similar to a CAD model. However, CAD is composed of only lines as 3-D space data, but the BIM model has various attributes and properties, such as material, finish, insulation, etc. of walls and windows, in addition to the 3-D geometrical data like thickness, width, and height. Input results of the 1st, 2ndfloor, and the whole view are shown in Figures 2, 3, and 4, respectively. [5]

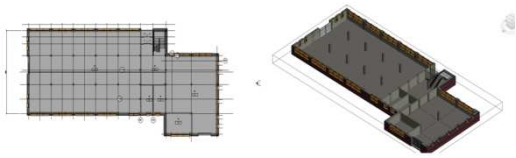


Figure 2. Input of 1st floor

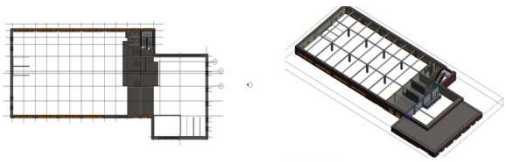


Figure 3. Input of 2nd floor

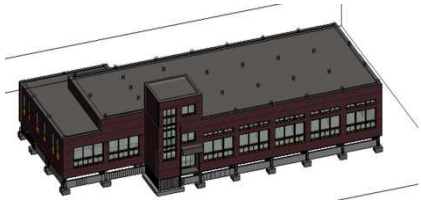


Figure 4. Whole View of 3-D BIM Model

And then, 3-D structural model was completed inputting beam, column, and footing data. The structure is a reinforced concrete type, thus, corresponding reinforcing bars are added in accordance with the drawings. The structural model and reinforcement are shown in Figures 5, and 6.

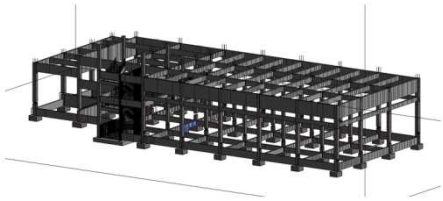


Figure 5. Structural 3-D BIM Model

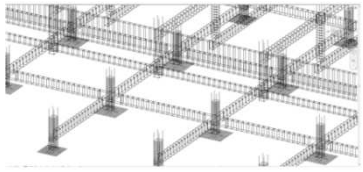


Figure 6. Input of Reinforcements

Once a3-D BIM model is given, it is easy to estimate the quantity of material and the cost. An example of such estimation on walls is shown in Figure 7.

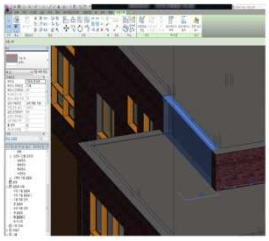


Figure 7. Estimation of Material Quantity and Cost

4.2. Structural Analysis

Structural Analysis is conducted to compute stresses, member forces such as axial forces, shear forces, and bending moments, reactions, and displacements. The results are used to design structures or to check the safety. Robot is a computer program for structural analysis, compatible with the Revit BIM structural model. Robot analysis was carried out, using the structural model of the building. The results are shown in Figures 8, and 9. [6]

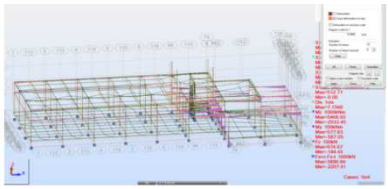


Figure 8. Output Results of Robot Analysis (1)

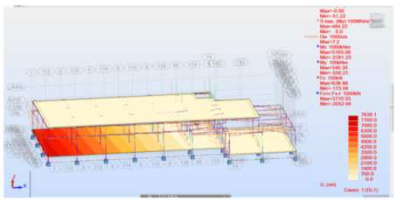


Figure 9. Output Results of Robot Analysis (2)

4.3. Scheduling Analysis

Scheduling is one of the most important elements in Construction Management. BIM is such a powerful tool in schedule managements that it shows 3-D views for checking easily the corresponding progress, and any potential conflicts. Navisworks is a BIM software tool to conduct scheduling in construction.

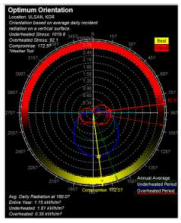
The example building is not a new one for construction, but an existing one. Thus, the results of Navisworks analysis are not given in this paper.

4.4. Environmental Analysis

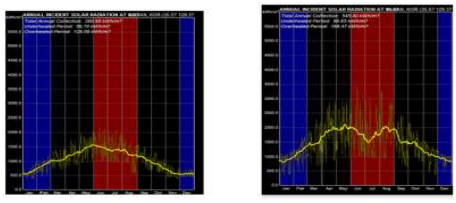
The development of engineering and science provides human beings with convenientand comfortable lives. However, on the other hand,it results in environmental issues, such as damage on nature, and global warming. This phenomenon threatens the survival of the next generation. As a result, sustainable and eco-friendly design has become the new paradigm in the construction fields. Consideration on energy and environment is not an option, but an essential factor in any design and construction projects.

Ecotech is a BIM software tool to analyze sustainability and environment. Ecotech analysis was conducted on the example building. The results are analyzed as follows. [7]

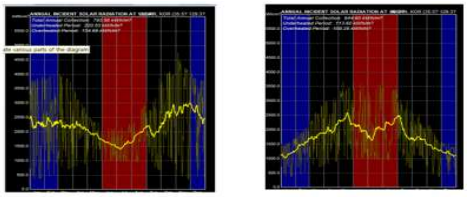
At first, the annual quantity of solar radiation is analyzed, and shown in Figures 10, 11, and 12. According to the results, the orientation of maximum radiation is 172.5^{o} in winter and minimum 82.5^{o} in summer. Thus, during the winter, we can save heating energy due to the solar radiation, but during summer, we should spend much cooling cost. The building is long in the north-south direction, thus it is not good in terms of solar radiation.



Annual Radiation



Radiation in North and East



Radiation in South and West

Figure 10. Annual Solar Radiation

Figure 11 shows the eco-friendly feasibility in terms of solar energy and natural wind, respectively. The parts marked yellow representcomfortable region, thus solar energy can be used for heating, and natural wind for cooling.

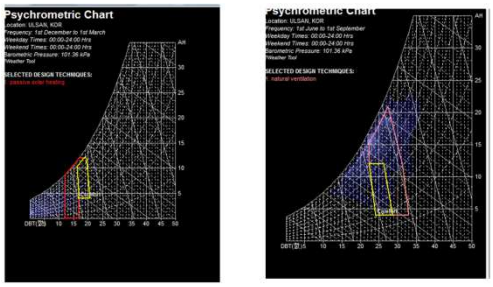


Figure 11. Comfortable Region

Figure 12 indicates the monthly and daily change of temperature, humidity, and wind speed. Figure 13 shows the hourly and weekly change of temperature. Thus, we can figure out environmental conditions, which can be used for sustainable designs.

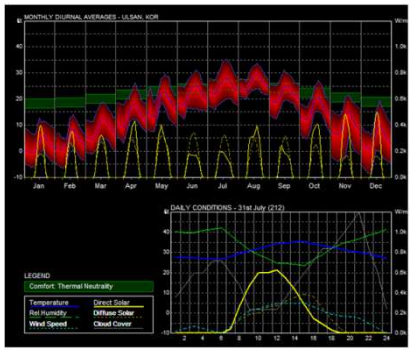


Figure 12. Monthly and Daily Temperature, Humidity, and Wind Speed

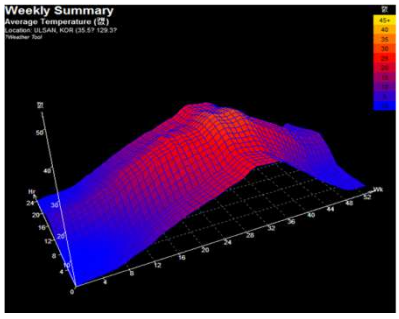


Figure 13. Hourly and Weekly Temperature Change in a Year

Figure 14 shows the orbits of sun in a year, and the results were obtained that 100% of sunshine couldbe cut off during the hour between 8:30 to 11:00 toward the east, and 94% between 12:00 to 16:00 toward the west, by installing sunshades.

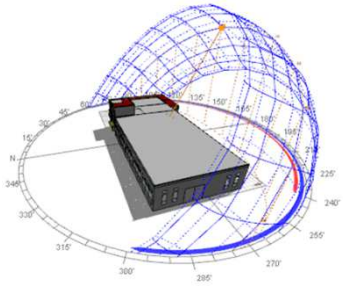


Figure 14. Orbits of Sun

Figure 15 shows sunshine illuminations, which enable us to reach the most optimum illumination design.

Figure 16 shows the various orientations of solar panels and corresponding efficiencies. According to the results, 30^{o} of solar panel turns out to be most efficient.

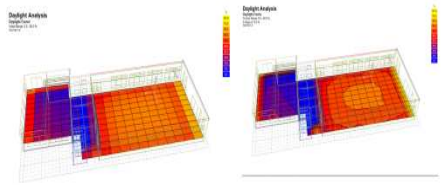


Figure 15. Sunshine Illumination

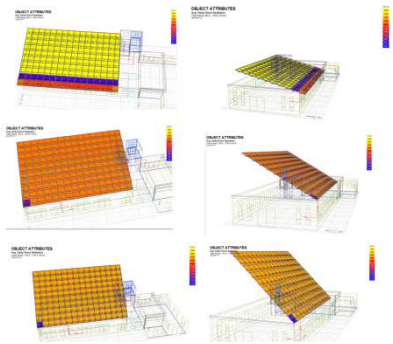


Figure 16. Orientations of Solar Panel

5. Conclusions

BIM is one of the most promising applications of ICT in construction industries to deal with big data, which was not possible even a decade ago.It is a digital representation of physical and functional characteristics of a building displayed as a 3-D model, with the added capability to integrate a whole array of design and construction data. It is certain to continue to evolve as the development of new ICT technologies, having close to infinite computing power available everywhere.

As an example of applications of BIM, Power Plant Building at HGU was selected, and BIManalysis was performed, especially focusing onan innovative eco-friendly analysis.The results include 3-D BIM model, structural analysis, solar radiation, change oftemperature, humidity, wind speed, orbitsof sun, sunshine illumination, solar panel, etc. It proves that BIM is very efficient and useful for design, construction, and operation.

Acknowledgements

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References

[1] Barbara J. Jackson, *Construction Management Jump Start, 2nd edition*, Wiley Publishing Inc., Indiana, 2010.

[2] Chuck Eastman, Paul Teicholz, Rafael Sacks, and Katheleen Liston, *BIM Handbook, 2nd edition*, John Wiley & Sons, Inc., New Jersey, 2011.

[3] Posco Const., *BIM in Practice*, Seijin, Seoul, 2013.

[4] Karen M. Kensek, Douglas E. Noble, *Building Information Modeling, BIM in Current and Future Practice*, John Wiley & Sons, Inc., New Jersey, 2014.

[5] Jungdae Park, *Architect Design BIM Process: REVIT*, YoungJin.com, Seoul, 2013.

[6] Yongwha Kim, Namhyuk Ham, and Byoungdo Lee, MUST BIM for the 3-D Structural Design, Seoul, 2012.

[7] DongwhanKoh, and Hyukyung Choi, *Learn Ecotect, Green Simulation & BIM Guide Book*, Moonwun dang, 2011.