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BIM as a Design and Construction Quality Control Medium

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OWING TO THE NATURE OF THE CONSTRUCTION INDUSTRY, construction projects require the cooperation of domain experts from diverse fields. As the scale of the construction industry increases in size and complexity, the domain actors generate various kinds of information. Therefore, interdisciplinary and step-by-step cooperation requires a considerable amount of communication and information transmission. Currently, the method for communicating information in design works has changed from paper-based drawings to three-dimensional building information modeling (BIM) that enables efficient data management and quick decision-making.

Public organizations and private companies in several countries have successfully led many BIM-based projects with considerable interest and effort. In fact, several public organizations have recommended delivering BIM data, which is checked with quality control according to BIM modeling standards. The high quality control of BIM can be applied to both physical and logical conditions.

At present in Korea, attempts have been made to implement BIM in the delivery of a public project. While efforts have been made with considerable interest, the attempt has not yet been fully realized due to the lack of BIM standards. Therefore, it is extremely important to establish BIM quality control systems related to 1) physical elements (level of shape execution, object collision and boundary condition); 2) logical elements (regulations and codes); and 3) object definitions (definition of objects and their attributes). In this sense, this manuscript is an effort to establish a BIM quality control system in Korea.

IMPORTANCE OF BIM QUALITY CONTROL

For a BIM-based design competition or design-build contract, it is important to establish a BIM quality control system. To that end, providing a checklist will play the same role of a speed camera on an expressway. If a proposal with poor quality is selected in a competition or for a turn-key project, the client will encounter considerable difficulties. To prevent this, a preliminary review of the quality of the functional, aesthetic, engineering and environmental aspects of the facilities can be carried out by using software tools prior to the final evaluation.

Since the BIM quality check is based on BIM guidelines and standards, a quantitative review is possible, and in most cases, automatic verification can be done through the software itself. Such a system can help in the prevention of the initial selection of poor designs.

Moreover, the BIM visual review will be helpful in reducing the possible distortion of computer graphic images, as it is based on precise building information. In addition, BIM-based quality validation will contribute to the elimination of any unnecessary factors in the design and design-build evaluation processes. For instance, the review based on BIM will help reduce the costs of outsourcing works for the construction of physical models or costly computer images. As a consequence, design and construction companies can enhance their price competitiveness as well.

On average, if ten bidders compete at a design or design-build competition in Korea, the cost savings can amount to as much as one million U.S. dollars. A notable BIM-based design competition case is the Norway Statsbygg, sponsored by an international competition put on by the National Museum of Art in Vestbanen. buildingSMART Korea has been developing BIM submission guidelines for several public organizations for design competitions. **FIGURE 1** shows an evaluation process diagram for the BIM-based design competition buildingSMART Korea recently developed for the Korea Power Exchange Headquater project.

BIM QUALITY CONTROL BASED ON SOFTWARE TOOL

It is difficult to carry out BIM quality checks using only construction drawings and documents. Since BIM is an object-oriented database with shapes information, it can be verified by means of automatic quality control software tools with rule-based check functions.

There are many software tools available that can check the validity of the BIM data. If you're interested in learning about these tools and who is already using them, please contact us.

BIM QUALITY CONTROL

BIM requirements on public projects are gradually increasing in Korea, albeit a BIM quality control system has not yet been established. It's crucial though, that one is. In this regard, buildingSMART Korea has developed a BIM guideline for the Korean government and has also conducted a case study with the design

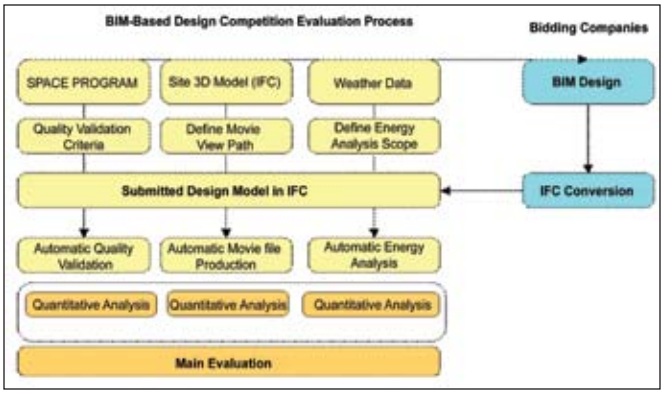

Figure 1. BIM-based design competition evaluation process.

company Hyundai Architects & Engineers. The following case (**FIGURE 2**) introduces a BIM quality control system that focuses primarily on the model of a main stadium at the stage of design development.

Unfortunately, there were no clear BIM requirements for the turnkey competition. Therefore, the quality check items were derived from the general BIM requirements pertaining to the main stadium, and was conducted by using Solibri Model Checker. The quality check items were categorized into physical elements, logical elements and object definitions.

Physical elements: Physical elements refer to the collision and overlap of objects and the level of shape execution. For a successful design, each architectural, structural and HVAC model should not allow for the collision and overlap of the objects. Further, these models should not collide and overlap with other models in an integrated model. Additionally, they should be placed in relation to the spaces in the building, the number of stories of the building, and the building itself, without negatively affecting the shape of each model (**FIGURE 3**).

Logical elements: These refer to logical checks such as the calculation of space areas, space programs, calculation of elevator numbers, circulations, safety of evacuation stairs, and safety-related regulations. Further, they are dependent on the BIM standards that include modeling methods with requirements; thus, logical checks can be carried out by developing rule sets according to the requirements of the BIM standards.

Object definitions: These are dependent on the BIM standards that include object definition methods with requirements. Object definitions include the names, attributes and properties of the objects that can be developed into a variety of forms corresponding to the business purposes and their functions. The quality check related to this will evaluate whether the BIM elements are modeled according to the object definitions. For instance, if a window object is defined as a door object and a handrail object is defined as a stair object, the quality control will indicate errors (**FIGURE 4**).

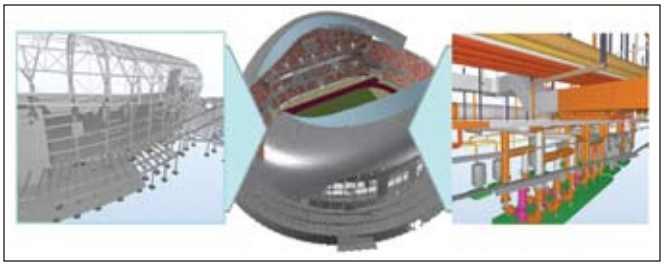

Figure 2. An architectural, structural and HVAC BIM model for the test case.

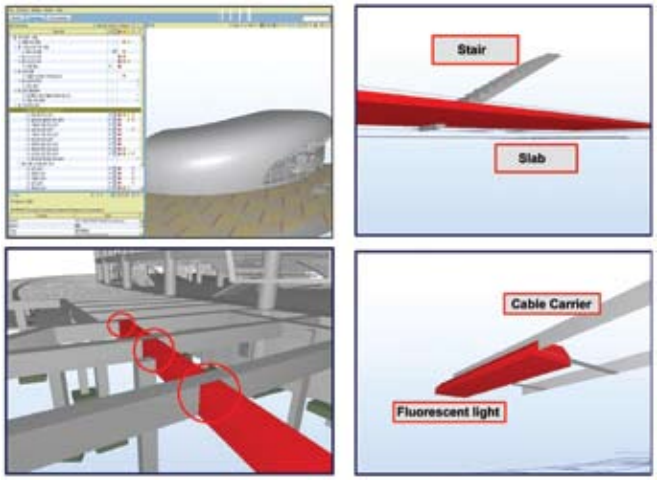

Figure 3. Check on physical elements.

Following the quality checks, many problems were found relating to object collision, object definition and space programs. This is because the designers did not follow the BIM guidelines in their entirety. After the results were reported, the BIM models were reworked. Thereafter, BIM quality checks were conducted for a second time and it was found that the number of problems had considerably decreased. Thus, BIM quality checks can be extremely useful in improving the quality of design and construction projects. Moreover, the BIM quality control system is dependant on business purposes and their functions. Hence, for the BIM quality control system to be successful, the BIM guidelines need to be established in detail, taking into consideration BIM quality. The BIM quality control system needs to be implemented at the software level, using a software tool, with quality control elements following the BIM standards.

CONCLUSION

The potential benefits of BIM will result from industry-wide standardization. This requires considerable effort and it is beyond the scope and control of individual companies and engineers. In other words, it is difficult to ascertain the overall effects of BIM standardization in an individual research project, unless the standards are applied in the general construction industry.

However, the developments in both commercial software tools and standards (BIM quality control system and BIM guidelines) have provided researchers, practitioners and public organizations with a variety of opportunities to apply BIM to real projects. Therefore, a BIM quality control system needs to be established and applied as a successful project management plan that can contribute to eliminating any risk factors in the lifecycle of a building, making it a crucial element with regard to competitive advantage. ■

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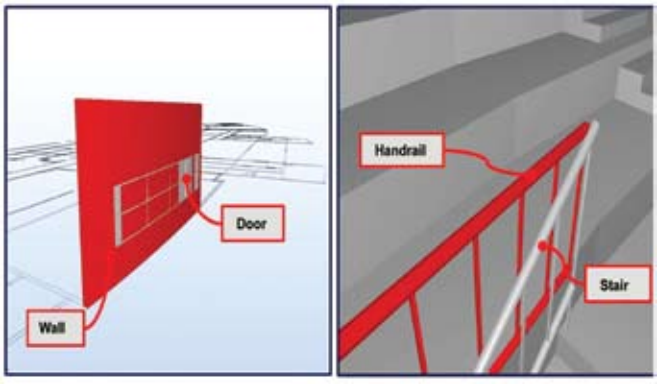

Figure 4. Check on object definition elements.