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BIM for Sustainable Design:
Results of an Industry Survey

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RECENTLY, GROWING ENVIRONMENTAL concerns and rising energy costs have tremendously increased the demand of sustainable buildings. More and more, both public and private organizations are requiring architects, engineers and constructors to design and build with minimal environmental impact (Azhar and Brown, 2009).

The most effective decisions related to the sustainable design of a facility can be made in the early design and preconstruction stages. Traditional CAD planning environments typically do not have the capability of performing such analyses in early stages of design development. Building performance analyses are typically performed after the architectural design and construction documents have been produced. This lack of continuous analysis leads to an inefficient process of retroactively modifying the design to achieve a set of performance criteria (Schueter and Thessling, 2008).

To assess building performance in the early design and preconstruction phases, access to a comprehensive set of data regarding a building's form, materials, context and technical systems are required. Because building information modeling (BIM) allows for multi-disciplinary information to be superimposed within one model, it creates an opportunity for sustainability measures to be incorporated in the design process (Autodesk, 2008).

RESEARCH OBJECTIVES AND DESIGN

In order to evaluate the state-of-the-art and benefits of BIM-based sustainability analyses and design, a questionnaire survey was conducted. The target audience consisted of design and construction firms who use BIM technology and/or sustainable design/construction practices in most of their projects. These firms were identified through a published list of the top 100 green contractors as of 2009, members of the AGC BIMForum, members of the buildingSMART alliance™, and direct contacts made within the architecture and construction industries.

The questionnaire was launched on October 12, 2009, and closed on January 8, 2010. Of the 145 respondents, the majority worked for architecture (44 percent) and construction companies (34 percent), followed by design/build firms (16 percent) and BIM consultants (6 percent). It is important to note that the survey population was not selected using any statistical methods and hence the results should not be considered as statistically significant.

The questionnaire was designed based on a skip-logic method, in which the selection of the next question is based on the answer of the previous question. The skip-logic method prevents respondents from answering questions which they are not qualified to answer. The questionnaire had two skip-logic questions. The first skip-logic question identified the survey respondents currently using BIM. Of the 145 respondents, 131 (90 percent) were using BIM technology in their projects; while 14 respondents (10 percent) were non-BIM users. No further questions were asked from the later group and the rest of the respondents were directed to the second skip-logic question which identified the respondents currently employing BIM-based sustainability analyses/design measures in their projects. Of these 131 respondents, 87 (66 percent) were using BIM-based sustainability practices; while 44 (34 percent) were not using BIM for this purpose. The rest of the questions were directed to the earlier group and the important findings are discussed in the following section.

MAJOR FINDINGS

In the first question respondents were asked to select the types of building performance analyses (or sustainability analyses) they typically perform for building projects. The terms sustainability analyses or building performance analyses, as used in this paper, refers to various assessments and evaluations conducted to determine a building's environmental performance.

The results are shown in **FIGURE 1**. The most common analyses were found to be energy analysis, daylighting/solar analysis, building orientation analysis, massing analysis and site analysis. Forty-five (52 percent) respondents also indicated that they prepare LEED® documentation as part of the building performance analyses. Four (5 percent) respondents selected the other option and their responses were structural and mechanical systems analyses.

The next question inquired about the project stage(s) in which sustainability analyses are typically performed. Sixty-seven (77 percent) respondents indicated that they are using BIM-based sustainability methods at the design/preconstruction stage. Fifty-one respondents (59 percent) answered that they are employing these methods at the planning/pre-design stage. All these respondents were architectural and design/build firms. Seventeen (19 percent) answered construction stage and 10 (11 percent) answered post-construction stage (mostly construction firms). Three (3 percent) respondents selected the other option and their responses were GIS Mapping and Building Automation. These results are illustrated in **FIGURE 2**.

In the following question, respondents were asked to subjectively estimate the amount of time savings realized through the use of BIM-based sustainability analyses as compared to the traditional analyses. The available choices were significant time savings, some time savings, no time savings, some time losses, and significant time losses. Of the 87 respondents, 47 (54 percent) stated that they are realizing some time savings, 20 (23 percent) respondents stated they are experiencing significant time savings, while 17 (19 percent) respondents selected no time savings. Three (4 percent) respondents chose some time losses. These results are shown in **FIGURE 3**.

Respondents were also asked to subjectively estimate the monetary savings.

The available choices were significant cost savings, some cost savings, no cost savings, some monetary losses, and significant monetary losses. Similarly to the last question, the majority of respondents, 44 (51 percent), answered that they are achieving some cost savings. Twenty-three (26 percent) respondents answered that they are achieving significant cost savings. The remaining 20 (23 percent) respondents answered that they are achieving no cost savings. No respondents selected some monetary losses or significant monetary losses as shown in **FIGURE 4**. Based on the results of these two questions, it can be inferred that most of the firms are experiencing some-to-significant time and cost savings through BIM-based sustainability analyses as compared to the traditional methods.

Respondents were also asked to select the building performance analyses software(s) being used by their firms. Fifty-one (59 percent) respondents selected Autodesk® Green Building Studio (GBS)™. Thirty-six (41 percent) respondents chose Integrated Environmental Solutions®' Virtual Environment (VE)™. An equal amount, 36 (41 percent), stated that they are using Autodesk® Ecotect™. Twelve respondents (14 percent) selected other software, including Hevacomp™, Energy Plus™, Delight™, Radiance™, HEED™, Homer™, Virtual DOE™, Bentley HEVACOMP™, Bentley TAS™, and Climate Consultant™. These results are shown in **FIGURE 5**, which indicates that the three most popular building performance analyses softwares are Green Building Studio™, Virtual Environment™, and Ecotect™. This paper does not endorse any software in any capacity.

At the end, respondents were asked to rate the levels of satisfaction realized through BIM-based sustainability analyses as compared to the traditional methods of sustainability analyses. The results are shown in **FIGURE 6**. Twenty-three (27 percent) respondents were highly satisfied while 40 (46 percent) respondents achieved some level of satisfaction. Nineteen (22 percent) respondents stayed neutral while 4 (5 percent) respondents were dissatisfied. As a whole, it can be concluded that most of the respondents were satisfied up to a certain degree.

CONCLUSIONS

Based on the stated results, the major findings of this research project can be summarized as follows:

- The majority of practitioners who are employing BIM-based sustainability analyses are primarily architects and design/build firms.
- Practitioners typically use BIM-based sustainability analyses at the planning and design stages.
- The analyses types with the most prevalent use are energy analysis, daylighting/solar analysis, building orientation analysis, massing analysis and site analysis.
- Practitioners implementing BIM-based sustainability analyses are realizing some-to-significant time and cost savings as compared to the traditional methods.
- The software types which seem to have the most use, at the time of this research, were Autodesk Ecotect™, Autodesk Green Building Studio (GBS)™, and Integrated Environmental Solutions (IES)®' Virtual Environment (VE)™.
- Practitioners are achieving some-to-high degree of satisfaction in regard to results when compared with the traditional sustainability analyses. ■

References to this article are available by emailing ssavory@matrixgroupinc.net.

Dr. Salman Azhar is an Assistant Professor in the McWhorter School of Building Science at Auburn University, Auburn, Alabama. *This study is part of an ongoing research project to examine the use of BIM for sustainable design and LEED® rating process. Acknowledgements are due to College of Architecture, Design and Construction (CADC) at Auburn University for supporting this research via a 2009 CADC Seed grant.*

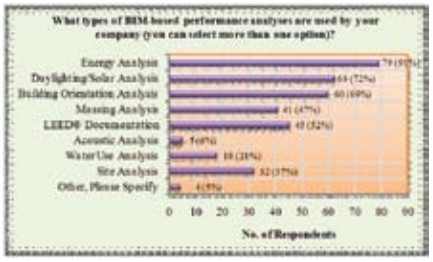

Figure 1. Types of BIM-based performance analyses typically performed in the respondents' firms.

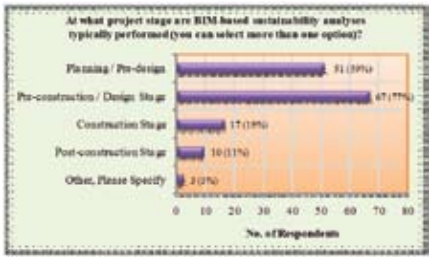

Figure 2. Project stages for employing BIM-based sustainability analyses.

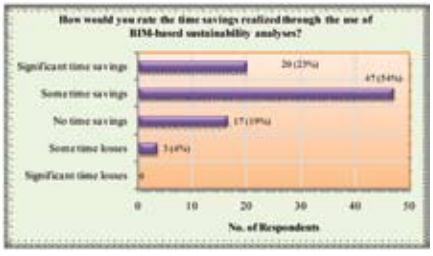

Figure 3. Time savings realized through BIM-based sustainability analyses.

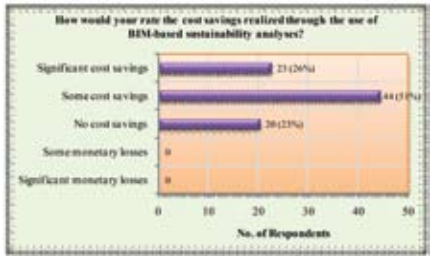

Figure 4. Cost savings realized through BIM-based sustainability analyses.

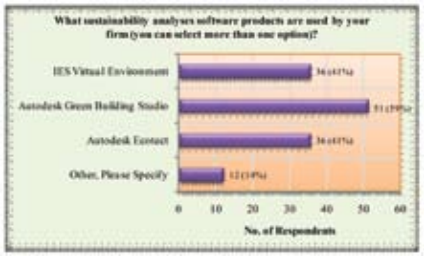

Figure 5. Building performance analyses software preferences.

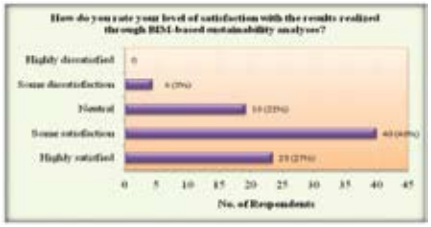

Figure 6. Level of satisfaction for BIM-based sustainability analyses as compared to traditional methods.