Investigating Owner Requirements for BIM-Enabled Design Review

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Abstract

The emergence of BIM represents a considerable opportunity for stakeholders in the AECO industry to more effectively deliver and manage the built environment. Of the lifecycle opportunities that have been documented for these stakeholders, none have apparently more to gain than large built asset owners. There is a challenge, however, in moving from theoretical applications of BIM to implementation, especially for large organizations such as public owners. This study aims to uncover how BIM can be effectively used for design review in a large owner organization. The research team undertook a retrospective case study and analyzed a series of design review comments on 12 different projects. During the analysis, prevailing, and recurring issues were extracted and characterized to better understand how a BIM-enabled design review process could benefit the owner compared to conventional 2D drawing-based review methods. The results of this study showed that 26% of the design review comments were related to information content or structure. This suggests that the current method being used to convey information is inefficient, and considerable amount of time is being spent simply retrieving and processing information. Examples of BIM-enabled design review are also provided to demonstrate the potential benefits of BIM from an owner's perspective.

INTRODUCTION

Design Review, the process of reviewing project documents to validate design intent and insure its accuracy, completeness, and correctness, is an integral part of the project delivery process. It allows owners to ensure that their technical and functional requirements as well as their business needs are met by the proposed design. Over the course of a project, these design reviews are conducted at specific milestones like schematic design, design development, 50% construction document, 90% construction document, and so on. The number of design reviews for each project depends upon the size and complexity of the project, the contractual requirements,

and the procurement method used to procure the facility. The owner plays a significant role in the review process by checking the design and the documentation for deficiencies and compliance to their standards and technical guidelines. However, little research has been conducted that focuses on improving the design review process from the facility owner's perspective, especially in the context of BIM-enabled project delivery. In the traditional approach, which involves a 2D-representational method of design communication, design reviewers have limited time to review large amounts of project information contained in project documents, including drawings and specifications. This leads to ineffective design review and can result in dissatisfaction upon project completion if the design does not meet the requirements and needs of the owner. Hence, there is a need to find a more efficient method in order to check for design compliance within the limited time frame of most projects. BIM-enabled design review, which includes automated checking, shows promise in this regard.

The research presented in this paper aims to address this gap by investigating how a large public owner can initiate the transition to BIM-enabled project delivery to support project review activities. The objective of this paper is to present the findings of the first phase of this research that entails understanding and benchmarking current project review practices. The benefits and potential of BIM-enabled design review for a facility owner are also investigated by examining the design review process during the stages of a project on a number of medium to large capital projects. Design review comments made by the reviewers were coded and categorized and the potential of existing BIM tools in aiding this design review process for the owner were evaluated. The contributions of this portion of the research project were twofold, including: (1) a characterization of issues identified during the design reviews and (2) an understanding of where and how BIM-enabled design review could help. The research team found that almost 26% of issues identified during design review were related to information content or structure and did not involve the design itself - hence they could be considered waste in the design review process. The research team proposes mechanisms that could minimize this waste through the use of BIM, should proper requirements be formulated by the owner at the onset of a project. The type, scale and scope of requirements necessary to facilitate BIM-enabled design review are discussed.

LITERATURE REVIEW

Design Review is the process of evaluating a design to check for compliance with technical, functional and operational guidelines and requirements. The British Property Federations 1997 survey showed that more than ⅓ of major clients who responded were not satisfied with the consultant's performance with respect to coordination, value for money, design and innovation (Egan (1998)). Over the past few decades, we have seen owner's gradually leaning towards BIM for these reasons. In a survey conducted in 2007, 30% of the building owners said that they have used BIM in one or more of their projects whereas 12% had been implementing it for five or more years (FMI CCMA (2007)). According to Eastman et al (2008), some of the major uses of BIM for owners are program and space compliance checking, design review, energy analysis, quantity take-off and cost estimation, asset management

among the many benefits of BIM for facility owners. Sullivan (2007) identifies the various BIM tools with which the AEC industry can achieve better design during the review process be reducing uncertainties, clashes and by increasing coordination between various disciplines. But, it does not talk about how BIM can help facility owner improve their design review process to make a better use of their limited time. Lee et al (2012) demonstrates mapping an external space database to the space IFC in the model to automate a spatial compliance checking to the project requirement. Barnes and Castro-lacouture (2009) describes a BIM-enabled optimization tool to help the stakeholders to make decisions while choosing the most sustainable material depending on the cost estimate. East et al (2004) proposes an improved design review process with the help of web-collaboration, but mainly limited to A/E industry. There have not been many studies on improving the design review process for the facility owner. The facility owner has certain requirements for each project and depends on the information provided by the design consultants for assessing the design, i.e., usually in the form of CAD drawings and PDFs. The information in the 2D documents and the accuracy of the information provided, hence, plays a major role in the design assessment process and the result of the review done by the owner, which in turn influences project outcome. Hjelseth (2015) demonstrates how BIM-based model checking (BMC) can be used to check spatial compliance, conflict, model discrepancies and requirement compliance using rule based checking by employing many BIM tools which is more accurate and less time consuming. But lack of relevant information required for the rule based checking is one of the reason for the limited use of BMC. This paper tries to answer this gap by analyzing design review process and comments made by a facility owner to investigate the potential of BIM-enabled design review process for owners and identifying information that facility owner should request for BIM-based design review.

METHODOLOGY

The research project's overarching objective is to investigate a large public owner's BIM adoption and implementation process and highlight the key benefits, challenges and lessons learned. This research is segmented into smaller pieces each investigating different aspects of the BIM adoption and implementation process. The scope of the project discussed here involves investigating BIM for design review by the owner. The objective was to extract common issues and comments from design reviews and identify which type could potentially be addressed by BIM. The research team performed data collection and analysis on 12 different projects at various stages in design as shown in Table 1. Overall, A total 1314 design review comments made by the owner's technical services branch was analyzed by the research team. To build the characterization, the research team analyzed the design review comments made by the owner on Project 12 at 50% CD and identified the recurring types and scopes of the issues. The characterization is shown in Table 2. The research team also interviewed ten people from six different disciplines in the technical services branch who perform the design review and provide disciplinary expertise for the owner. The purpose was to investigate the current design review process and understand their perception on the BIM-enabled design review. The coding scheme, i.e. the emerging categorizations, was developed by two researchers and subsequent analysis was

performed by three coders and validated by the owner and the personnel from the technical services branch through a series of workshops.

Table 1. Case Study Projects

Project No.	Facility Type	Project Type	Design Phase					
			SD	DD	CD 50%	CD 60%	CD 90%	CD 95%
Project 1	School	New construction		X		X		
Project 2	School	Renovation	X			X		
Project 3	School	Renovation				X	X	
Project 4	School	New construction				X		X
Project 5	School	Renovation	X	X		X		X
Project 6	School	Renovation	X					
Project 7	School	Renovation					X	
Project 8	School	New construction	X					
Project 9	Hospital	Fit out					X	
Project 10	Hospital	Fit out	X					
Project 11	School	Renovation					X	
Project 12	Museum	New construction			X		X	

(SD: Schematic Design, DD: Design Development, CD: Construction Document)

FINDINGS

Current Design Review Practices

The project managers assigned for each project send the consultant's design documents to technical services branch for a detailed design review. The documents are again distributed to each discipline, including architectural, structural, electrical, mechanical, roofing, building envelope, control and interior design. At regular milestones of the project, each discipline generally has 1-2 days at the most to review all the documents and provide the approval to the project managers. It became apparent during the investigation that the reviewers have a hard time to perform their duty fully as they don't have enough time to review all the project's documentation. It was mentioned by some of the interviewees that there was a need for a more efficient way to review the design because if they miss something in this review stage, it would be found out later in the project which would have a bigger impact on the cost and schedule of the project. Thus, studies on improving the design review process by an owner are important in terms of saving time, effort and cost.

Characterization of Design Review Outcomes

Our findings suggest two interrelated characterizations of design review comments: the type and the scope. These are shown in Table 2. Firstly, the comments are classified into five categories based on the type of the comments. This indicates what the reviewer was trying to convey or achieve or what type of action she or he was performing. Next, the scope of the comment was determined to understand whether it was the medium (information content/structure) or the actual design itself (component/space) that brought up the comment. In addition to these, the comments

were also analyzed to determine if they had any reference to guidelines or specifications.

The results of the analysis are shown in Figure 1. Out of the 1314 comments analyzed, about 26 percent of them were related to the information content and structure. This result demonstrates that the current format used to convey information is lacking efficiency. From the chart, we can also observe that 59 percent of the comments on the medium were related to requirement which indicates that the current mode of design presentation was falling short of the owner's requirements. This might also suggest that the owner's requirements were not communicated clearly during planning phase on the project and hence were not met by the design team. These initial findings suggest that similar studies must be conducted on a larger data sets to determine common types of design review issues, the inefficiencies with the current procedures and the best practices to be employed to communicate requirements on time to the design team.

Table 2. Comment Type and Scope Categorization

Comment Type

Category	Description	Example Comments
General	A general comment/introduction about the document	"Overall, this drawing package is progressing nicely."
Query	A question being asked to the team	There appears to be an existing site sign. Please confirm and label this on the site plan. Does it require piles or lighting?
Suggestion	An idea or a recommendation put forward for consideration	"Suggest showing the electrical transformer in context with the south-east enlarged floor plan segment."
Observation	A remark or a statement made on detection	"School sign with metal letters at grade could be a target for vandalism."
Requirement	A demand made when something is needed or wanted	"Two roof drains are needed per roof area to comply with AI's Technical Design Requirements."

Comment Scope

Category	Description	Example Comments
Information Content (Digital)	Related to what information is shown	"A number of wall sections are still in progress. Notes, references and dimensions are missing."
Information Structure (Digital)	Related to how information is shown	"Line weights are too light to read in many instances."

Component (Physical)	Related to tangible element or object	"Vapour barrier ground cover should be a heavy weight material so as not to be damaged during installation or concrete placement."
Space (Physical)	Related to space or spatial relationship	"Consider closing off the odd-shaped corner space in the clean holding room to improve cleanability."

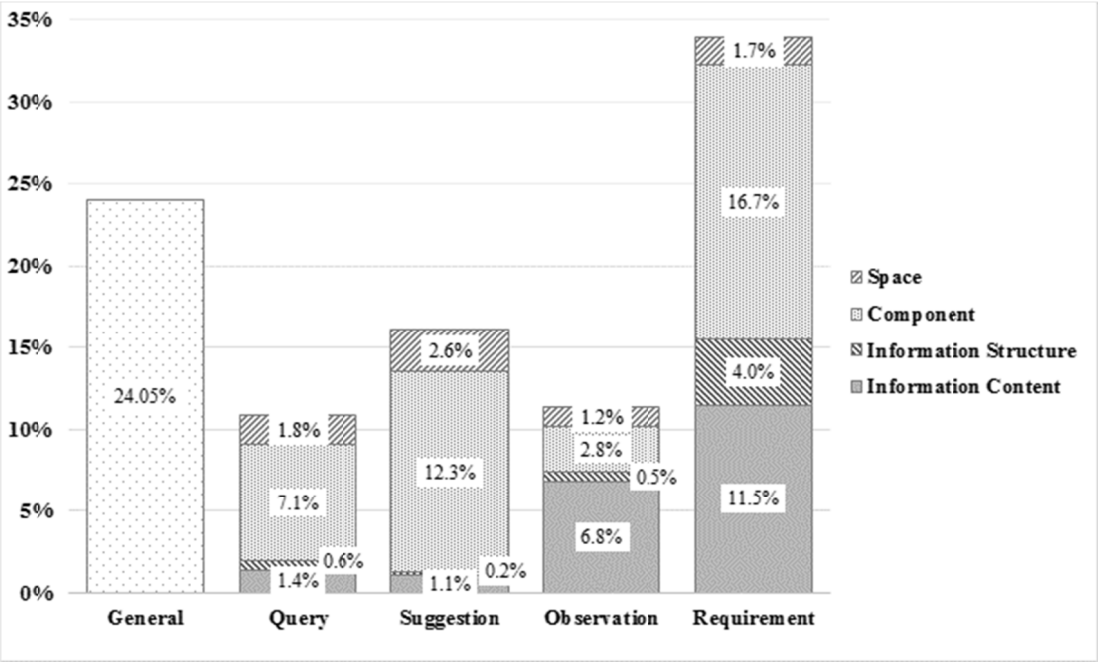

Figure 1. Type and Scope Distribution of Design Review Comments

Examples of BIM-Enabled Design Review

The principal hypothesis here is that BIM-enabled design review will cut down on the time it takes to perform review, not only by eliminating misinterpretations or poorly communicated information on an asset, but also by allowing reviewers to focus on value adding activities such as technical and functional review. To demonstrate how a BIM-enabled design review can be more efficient than traditional method, here we provide three examples of comments related to information Content and Structure to examine how BIM-enabled design review might have supported the review process or solved the issues. The examples are drawn from the design review comments on 50% CD and 90% CD stage of Project 12 in Table 1.

Example A

- Comment: "W2B. Point supported laminated glazing connected to structural framing is listed. I couldn't find this in the drawings. Is this assembly used?"
- Type and Scope: Query-Information Content

In this comment, the reviewer asked if a certain type of glazing is used in this building. The reviewer wanted to locate the W2B type glazing as it was listed in the schedule, but couldn't locate it as there were too many detail drawings and the

reviewer did not have enough time to go through all the documents. So instead, the reviewer asked for a clarification from the consultant. Whereas, as Figure 2 shows, if BIM was used for design review, the user could have searched the 'Type Mark' or any other information related to the component to see if that component was actually used in the design. The component would be highlighted if it exists in the model. Therefore, the reviewer could have easily solved the query without asking and having to wait to clarify the information with the design team.

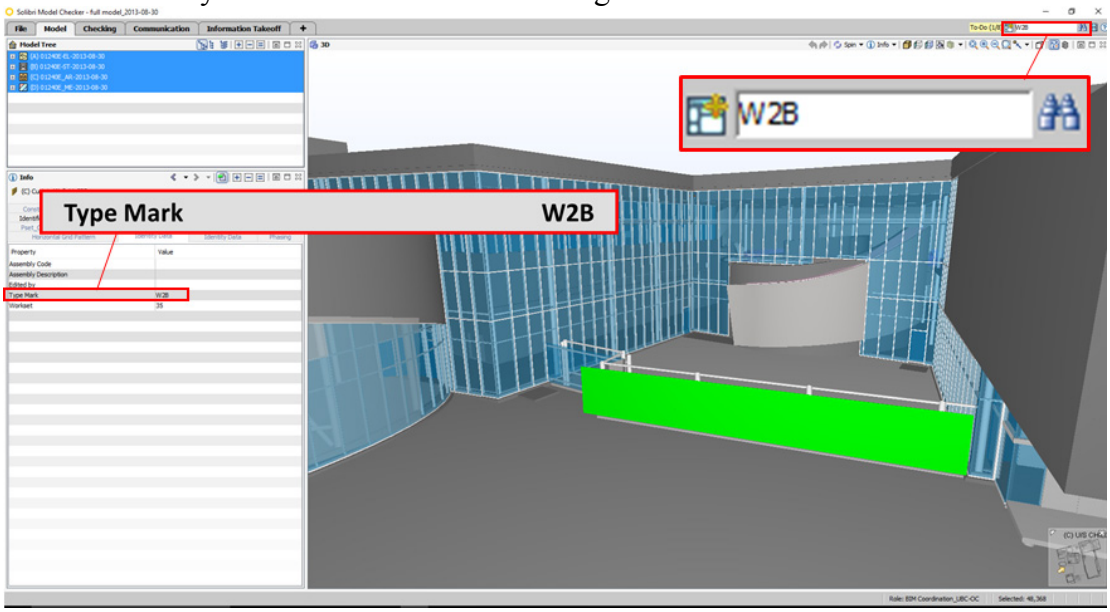

Figure 2. BIM-enabled Design Review Example A

Example B

- Comment: "Concerned with areas of the building envelope that come together at an acute angle. Need more resolution on these details."
- Type and Scope: Requirement-Information Structure

In 2D drawings, the reviewer should go through the drawings back and forth to coordinate the views such as floor plans, sections and the details, which demands time and effort. And if the provided details drawings are not enough, the reviewers should ask the consultant to submit more details and wait for the feedback. On the other hand, with BIM, the reviewer can open the associated views at the same time in one screen, which makes it easier and faster to understand the detail. Also, even if the detail view is not provided, the reviewer can create any detail view he/she wants while reviewing the design. Figure 3 shows the 3D view from outside, inside, and detail plan view of the building envelope.

Example C

- Comment: "There is a lot of remaining work on these drawings regarding dimensions, labelling and notes."
- Type and Scope: Observation-Information content

With 2D drawings, it's difficult to know the dimensions or any related information of the components unless they are labeled or written in the drawing. On the other hand, with BIM, the reviewer can measure the dimension in the model and

view the properties such as the material, by just clicking the component (Figure 4). This would have saved the time of the reviewer asking every detail numbers to the consultants.

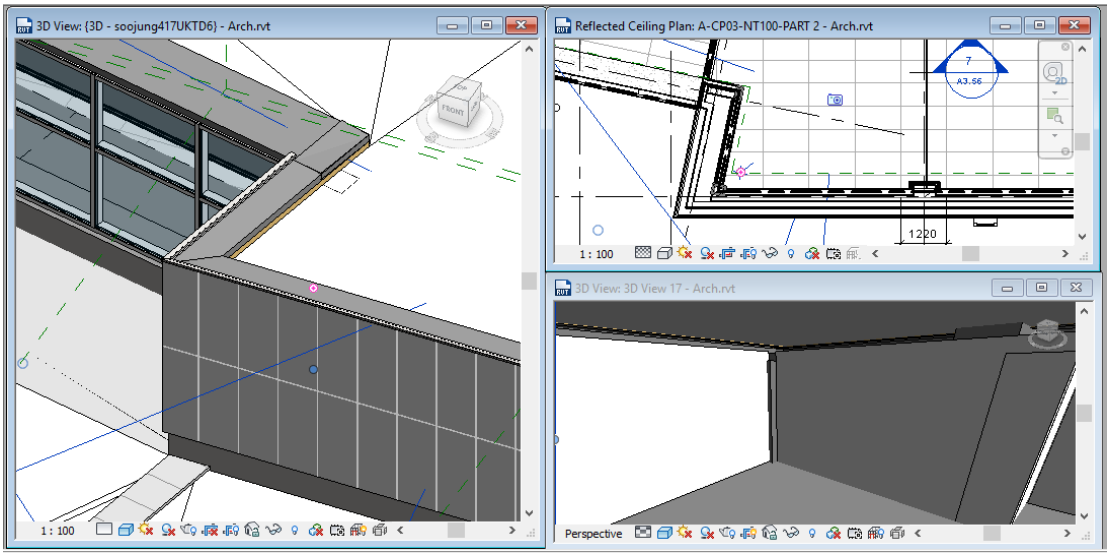

Figure 3. BIM-enabled Design Review Example B

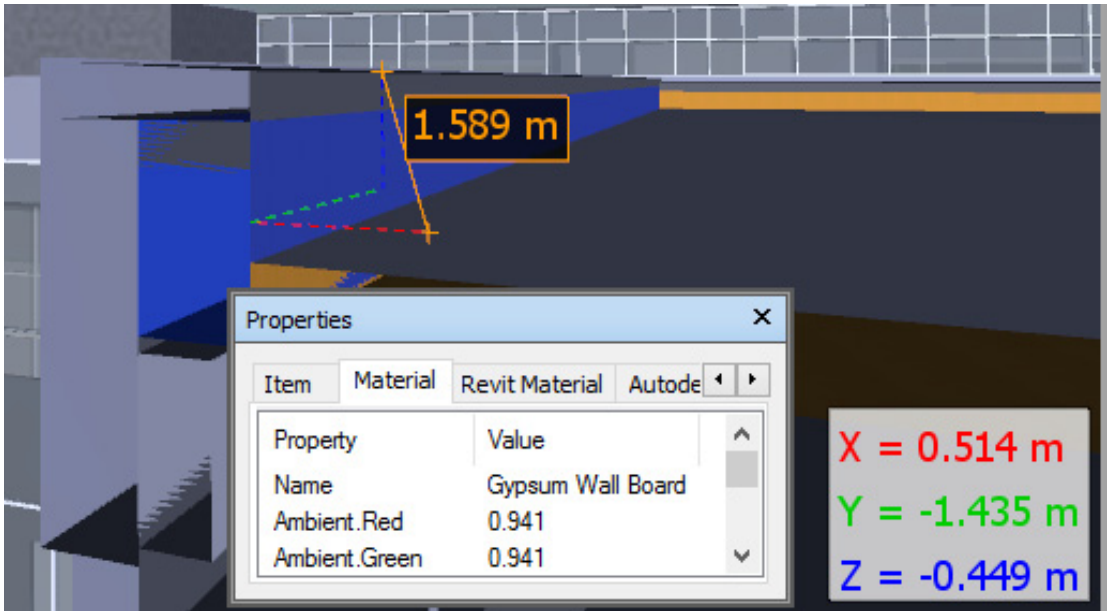

Figure 4. BIM-enabled Design Review Example C

The examples above indicate that the BIM-enabled design review could have solved a significant amount of issues related to information content and structure without asking feedback from the consultant, which would save both of their time and effort. The prerequisite for this is that the model should have the required information in it when it's delivered to the owner for the review.

DISCUSSION

Despite these potential benefits of BIM-enabled design review, the interview revealed that there are some internal challenges to the transformation. Among ten interviewees, five of them showed doubts about BIM-enabled design review process.

1) They doubt the efficiency in terms of time and effort. Four respondents said, "It would take much more time and effort to use BIM for review, as we are not used to it." Also, only two of the review team had previous experiences using BIM for design review.

2) They don't have the proper hardware and software to perform BIM review. As the current design review practices have been done with 2D drawings, there is no proper software installed on their computers to view the models, and most of the computers in the technical services branch don't have enough horsepower to handle the software. They said "It will take a lot of time and money to support this transformation. I don't think that's gonna happen soon."

3) There are liability issues. One of the interviewees said "Most of the reviewers here have more than 15 years of experience. Their knowledge and experience are more reliable than the automatic review." And said, therefore, automating project review would introduce liability issue into the process.

4) There are concerns on the maintainability of the data; who will keep updating the models, what happens if the software gets upgraded, and what if the data is lost.

5) Lastly, they feel unnecessary to change the current process as they are used to it. They also think they don't have to do the detail review like conflict detection or automatic checking saying that those tasks should be done by the consultants. Two interviewees said "We don't need this function. But it would be helpful if the consultants use this and inform us of the result."

These interview results indicate that even though BIM can support the design review process, the internal change to a new process is a big challenge for a large owner. For the owner, this points to the need to develop internal BIM practices and an organizational BIM standard. In terms of practices, having access to the right tools, training and the appropriateness of BIM for certain tasks were highlighted. To improve the review process, a well-structured model with the appropriate content is required and that those requirements must be explicitly stated. In this regard, both information structure and information content are significant aspects that need to be addressed. Tools and standards exist, such as NBIMS-US; however, the realities of context and practice require that these more generic tools be adapted and refined for a specific organization. That is not to say that they can't be aligned; however, they need to reflect the reality of the organization implementing it.

CONCLUSION

This paper described a subproject of a larger research endeavor investigating the BIM adoption and implementation process. This particular project entailed the analysis of design review comments made by the technical service branch of a large public owner on 12 different projects conducted during the various stages of the design process. More than 1300 review comments were classified, and a framework was developed which characterized the type and scope of comments. The research

team found that about 26 percent of the comments were related to the information content and structure, indicating that the current 2D method is not efficient for design communication. A few examples are provided to show how BIM-enabled design review could have saved the time and effort of both consultant and the owner by providing owner's requirement in terms of the information. The study quantified the poor documentation of design and explored potential BIM-enabled design review process to overcome the problem dealt with while using the current design documentation method.

To further investigate the owner requirements in the design, the research team is developing the scope of the characterization of comments to better uncover specificities in the type of issues, such as the properties of the elements being highlighted and their attributes. Employing this, further analysis is being done on the review comments to determine specific owner BIM requirements for BIM-enabled design review.

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