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What is a Critical Factor for Determining the Issue-Resolving Time in the BIM-based Coordination Process?

Sejun Jang[1], Dongmin Lee[2] and Ghang Lee[3*]

Abstract: This study analyzes critical factors that affect issues of resolving time in BIM-based coordination using a case study. According to recent buildings that are meant to be more complex, BIM-based design coordination is regarded as an essential stage of the project delivery process. In the design coordination phase, a relocation of architectural, structural, mechanical, and electrical elements is conducted to avoid interference. In addition, the procedure of the development of each element in detail for the actual construction is carried out. Delays in coordination can affect delays in the entire delivery schedule of the project, and therefore many researches have focused on efficient coordination methods and how to shorten the period. In this study, we conducted a detailed analysis of the issue-resolving process using a case study, and found out that the participation of decision-makers for issue-resolving and the physical combination of trades affect delays in coordination time. In particular, we proposed the concept of organizational relation, indicating the level of decision-makers for issue-resolving, and the concept of physical relation, indicating the physical complexity of the issue, and we analyzed the effects of coordination delays.

Keywords: BIM, Coordination time, Pre-construction, Design management

I. INTRODUCTION

According to the trend of increasingly complex building, BIM-based coordination is regarded as an essential step for project delivery. In the BIM-based design coordination phase, design errors that can cause problems in the construction phase are resolved and details in the design are changed. Due to these reasons, the BIM-based coordination process is considered the essential link that connects the design phase and the construction phase (Korman, 2006).

As BIM-based design phase coordination is established as an essential stage before the construction phase, recent research has focused on the effective implementation of BIM-based MEP coordination. Riley (2005) proposed the concept of MEP density (MEP cost/floor area) in order to analyze the factors affecting the time and cost of MEP coordination. Also, Khanzode (2011) introduced the concept of lean to maximize the effect of the BIM-based coordination stage. Lee (2014) suggested the concept of MEP density (MEP volume/plenum space) and analyzed the efficiency of BIM-based coordination according to the coordination strategies for the reduction of coordination time. Thus, these various attempts are efforts to ensure the effectiveness of the design coordination stage and to reduce the overall project delivery time leading up to the construction phase.

In this study, we analyze the BIM-based design coordination stage in detail to analyze the factors that influence the issue-resolving time. The procedure is as follows. First, we analyze the progress of BIM-based design coordination and the resolving process for 95 issues. To analyze the factors that affect delays in the issue-resolving time cycle, we proposed the concept of organizational relation levels, indicating the involvement of decision-makers for issue-resolving, as well as the concept of physical relation, indicating the physical complexity of the issue. The correlation analysis analyzes the cause of the delay in coordination

Ⅱ. CASE STUDY OVERVIEW

The case study project is the automotive exhibition complex located in Gyeonggi-do, Republic of Korea, shown in Fig. 1. The building has 4 underground floor and 9 above-ground floors; there is a business segment, an exhibit space, and a car repair space. After the design phase, BIM modeling was carried out with the subcontractor's participation. The trades that participated in the BIM-based coordination stage are reinforced concrete (RC), steelwork, exterior, interior, fire protection, general water, heating-ventilation-air conditioning (HVAC) water, and electrical.

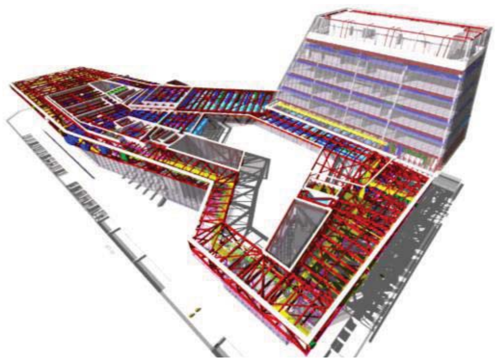

Fig. 1. An automobile exhibition center

[1] BIM Manager, R&D Division, Hyundai Engineering and Construction, Korea and Ph.D. Student, Department of Architecture Engineering, Yonsei University, Korea, sj.jang@hdec.co.kr
[2] BIM Engineer, R&D Division, Hyundai Engineering and Construction, Korea, dongminlee@hdec.co.kr
[3] Associate Professor, Department of Architecture Engineering, Yonsei University, Korea, glee@yonsei.ac.kr (*Corresponding Author)

Ⅲ. BIM-BASED COORDINATION PROCESS

A BIM model created by the subcontractor was confirmed by the BIM manager. The BIM manager reviewed the clash and the clash was reorganized as a major issue. Clash detection was conducted utilizing Autodesk Navisworks. As a result, 11,808 clashes were found. The result of clash detection can be represented by the number of clashes; on the other hand, it can be resolved by only one solution in content. Therefore, a coordination meeting for every clash may be inefficient. So, the BIM manager regrouped the clashes into 95 major issues by eliminating errors in the BIM model and grouping clashes associated with the same problems. Through BIM-based coordination meetings, 95 main issues were assigned to the parties in charge, and directions were given to resolve issues.

In the procedure up until BIM-based coordination meetings, design problems are located, schematics indicating directions are created, and the parties in charge of problem-solving are determined. However, issues cannot be resolved by performing these procedures. To solve an issue, each party goes through a detailed re-engineering and decision-making process. After such a process, the BIM model is finally modified by the detailer and the issue can be closed.

In this study, we track the process of resolving each issue after a BIM-based coordination meeting. Furthermore, during the tracking process, we analyzed the issue-resolving time, the related trades, and the participation of parties in resolving issues. Fig. 2 shows the total process of BIM-based coordination.

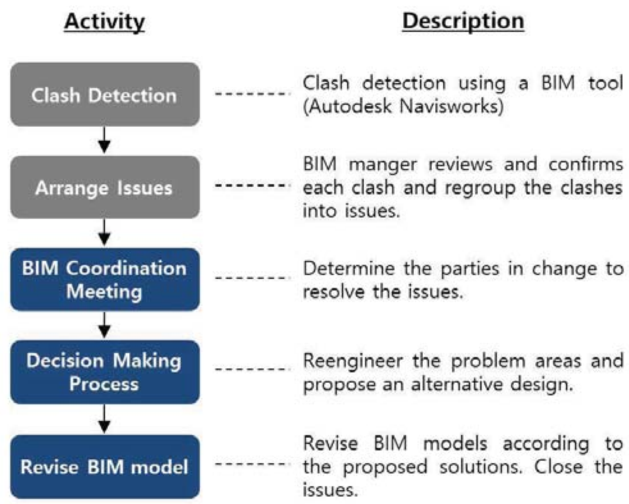

Fig. 2. BIM-based Coordination Process

Ⅳ. RESULT OF BIM-BASED COORDINATION PROCESS

The results of all 95 issues are shown in Fig. 3. The issue of steel trade accounted for 29%, with 19% accounted for by RC trade. This was followed by interior trade at 15%. This result is expected to be due to the fact that the design of the building form is irregular and the structure is complex.

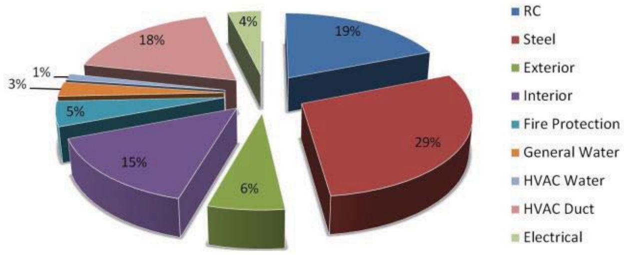

Fig. 3. Portion of Issues in BIM-based Coordination

For the 95 main issues, we tracked the problem-solving process. In the process of tracking the issue-resolving process, the participation of organizations and the time spent to solve the problems were measured. For example, Fig. 4 shows the case that the HVAC duct is interfering with the interior ceiling. Fig. 5 shows the process of resolving this issue. This issue has been discussed in BIM-coordination meetings; first, the shop drafter of the HVAC duct trade was determined to try to reset the path. Then, the HVAC subcontractor tried to create an alternative path but found that this is impossible without lowering the interior ceiling to solve the problem. So, the HVAC subcontractor passed this information to the HVAC duct manager of the general contractor (GC). Then, the HVAC duct manager of the GC asked permission to lower the ceiling from the interior manager of the GC. The problems of lowering the ceiling were actually delivered to the owner through a review of the designer, and the owner's opinion on resolving the issue in a way that does not involve lowering the ceiling was delivered to the designer. Designers adopted the system of ceiling return of HVAC system and reduced the length of the HVAC duct that was causing interference. After the GC reviewed the cost and constructability process, the modified design concept was delivered to the subcontractor and the issue was resolved by modifying the 3D shop drawing by the HVAC shop drafter.

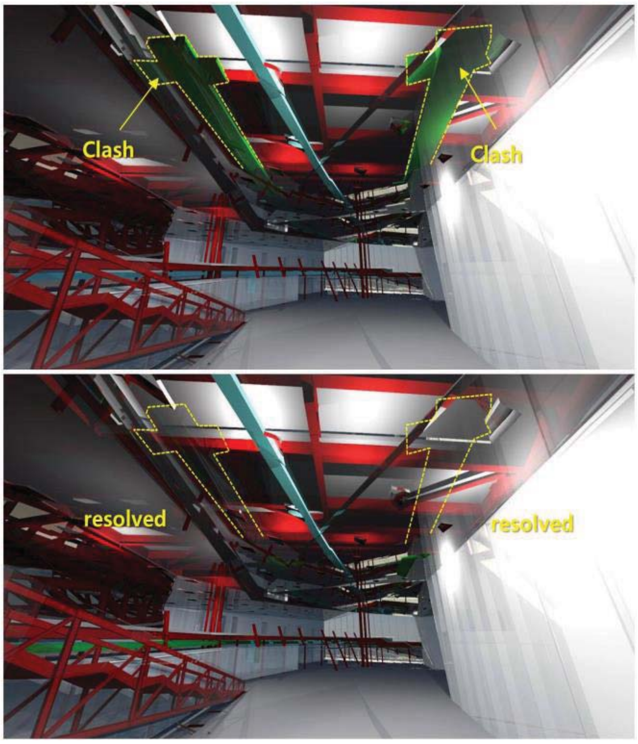

Fig. 4. (Top) Issue - A clash between HVAC ducts and the interior ceiling, (Down) Solution - The HVAC system has been changed. The duct length has been shortened.

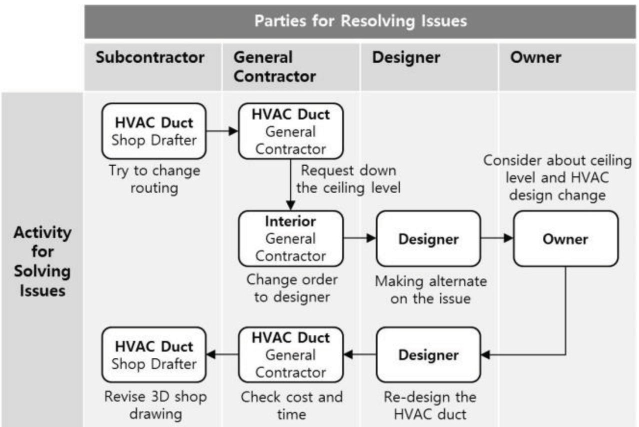

Fig. 5. Example of Issue-Resolving Process

As examples of the above, in order to resolve a single issue, it is required that the process involves the participation of different organizations. In addition, depending on the issue, the participation of decision-making processes is necessary from the subcontractor to the GC, the designer and the owner. In this study, we analyze the participation of organizations and the cycle time for resolving issue-s by tracking the issue-resolving process.

The analysis of issue-resolving time according to trade is shown in Fig. 6. The issue-resolving time was an average of 3.19 weeks. The issues related to the exterior took an average of 5.00 weeks to resolve (the longest time). The issues related to fire protection took an average of 2.67 weeks to resolve (the least time). According to trade, the variance of issue-resolving times showed a big difference.

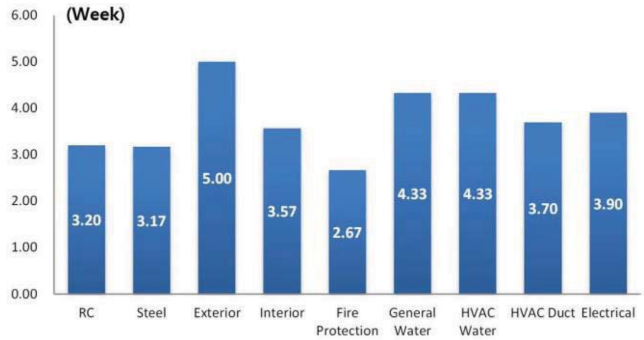

Fig. 6. Issue-resolving time according to trade

As a result, the ratio of the issue-resolving time is shown in Fig. 7. Rate resolved in one week is 25.6%, a rate resolved in two weeks is the most 29.8%. It shows that a significant difference can occur according to different trades and also within the same trade.

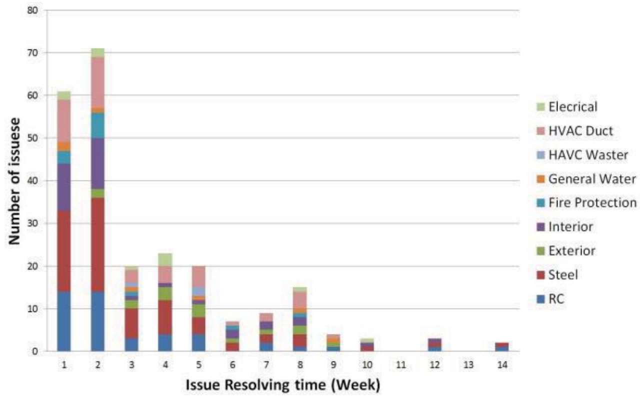

Fig. 7. Coordination Issue-Resolving Time

V. ANALYSIS CORRELATION RELATED WITH CYCLE TIME

In this study, to analyze the factors affecting the delay time of the issue resolution, we introduced the concept of "organizational relation" and "physical relation." Physical relation was used to indicate the physical complexity, as in the number of trades associated with one issue. For example, if one issue is physically associated with three trades in order to solve the issue, then the physical relation level is 3, as shown in Fig. 8. Organizational relation refers to the level of difficulty determined by the final decision-maker in order to resolve the issue. For example, if a simple issue that can be completed only by an agreement between the subcontractors has an organizational relation level of 1. If a decision by the general contractor is needed to resolve the issue, then the organizational relation level is 2. The issue shown in Fig. 8 is organizationally related to the shop drafter, the general contractor, and the designer. This issue's organizational relation level is 3. Thus, the proposed concept of organizational relation level is determined by the level of the final decision-maker.

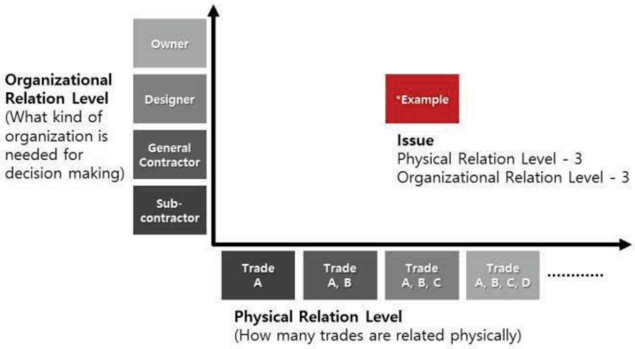

Fig. 8. Example of Physical and Organizational Relation Levels

In this study, correlation analysis was performed to analyze the effect of physical relation and organizational relation on the cycle time for resolving issues. The analysis results showed a correlation between the cycle time and the physical relation of 0.375, and a correlation between the cycle time and the organizational relation of 0.477. Therefore, the cycle time for resolving issues is more influenced by organizational relation than physical relation.

VI. CONCLUSION

In this study, we conducted a detailed analysis of the process of resolving issues in the BIM-based coordination stage. In the process, we presented a new concept of physical relations and organizational relations in order to analyze the impact on the issue-resolving time. As a result of the correlation analysis, organizational relation levels were analyzed and found to have a greater impact on issue-resolving times than the number of related trades (physical relation). The results of this study can be utilized in organization and communication strategies for the efficient operation of BIM-based coordination.

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