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Parallel vs. Sequential Cascading MEP Coordination Strategies: A Pharmaceutical Building Case Study

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ABSTRACT

We analyze the impact of parallel vs. sequential design coordination strategies on coordination productivity and information sharing. Previous studies have shown how building information modeling (BIM) could improve interorganizational design coordination between architecture, structure, and mechanical, electrical, and plumbing (MEP) components of buildings (MEP coordination, for short) and thus improve the quality and efficiency of a design and construction project in terms of the reduced numbers of errors and requests for information. This paper presents a unique case where two MEP coordinators were hired for a BIM-assisted project, which was a pharmaceutical company headquarters office building in Silver Spring, Maryland. The first coordinator coordinated MEP designs concurrently with other trades, whereas the second coordinator coordinated MEP designs step-by-step in a sequential process. The results of our analysis showed that the two different coordination processes largely affect the number of clashes in the first run of clash detection, coordination meeting time and efficiency, ease in finding root causes of the clashes, and number of coordination cycles to complete the coordination. As such, the sequential coordination strategy was about three times faster than the parallel strategy in terms of coordination productivity. A further examination of these two processes from an information-sharing perspective showed that the sequential coordination process reduces the concentration of information, thus reducing the overload of a coordinator with decision-making tasks, and facilitates information sharing between heterogeneous project participants. The findings of this study have potential as a basis for future development of BIM-based MEP coordination best practices and strategies as well as providing the metrics for understanding, measuring, and predicting the performance of BIM-based MEP coordination and strategically planning the coordination process.

1. Introduction

Design coordination of a building is an iterative process for finding solutions to design errors and conflicts between different building elements, such as walls, doors, beams, columns, pipes, ducts, and lighting fixtures that have interwoven dependencies. Design coordination is complex and challenging because when one part is moved, the change affects the other parts of the building and often creates new problems. What makes the coordination process more difficult is the large number of project participants involved in design coordination. Different experts from different organizations design, engineer, fabricate, and manage different building elements. Even with medium-sized buildings, it is common to have more than 50 project participants involved in a project. The decision regarding which person should make changes should be negotiated between the participants, taking into consideration the limited budget and time in addition to the physical constraints between different building elements.

The availability of increased computing power and three-dimensional (3D) and intelligent computer-aided design (CAD) technologies has automated the detection of potential conflicts between building elements. This has made detection easier and more efficient than when potential problems were probed by overlaying two-dimensional (2D) drawings. The process of generating and deploying 3D intelligent CAD models throughout a lifecycle of a building is commonly termed building information modeling (BIM) [26,33]. Previous studies [6,7,17,25] have reported the effectiveness and economic benefits of "design coordination between architecture, structure, and mechanical, electrical, and plumbing (MEP coordination)" using BIM in terms of the reduced numbers of errors and requests for information. The Associated General Contractors compiled lessons from previous projects and released an MEP coordination guide, which briefly specified the minimum qualifications for an MEP coordination team and other basic requirements for MEP coordination [1].

This study takes the MEP coordination issue one step further and examines the impact of different design coordination strategies on the level of information sharing among project participants and on the

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overall productivity of design coordination, focusing on design coordination during construction. It analyzes a unique case where two different MEP design coordination strategies were employed for two different zones of the same building.

In this project, two MEP coordinators, A and B, with similar levels of BIM experience and proficiency, led BIM-assisted MEP coordination using two different strategies. Of the 11,255 m^2 (121,143 ft^2) of the total building area, A coordinated a zone with a total floor area of 7371 m^2 (79,336 ft^2) and B a zone with a total floor area of 3884 m^2 (41,807 ft^2). Both zones had a similar level of design complexity and a similar level of MEP density. However, B could coordinate the same amount of floor area 3.5 times faster than A could. We investigated what caused this difference by comparing the design coordination strategies of the two teams and by analyzing the data exchange networks based on graph and network analysis theories [5,36]. We discuss the implications of the different strategies on information sharing among the project participants.

2. Background and previous studies

A building is mainly composed of three parts: architectural, structural, and MEP parts. These are similar to, respectively, the skin, skeletal, and cardiovascular systems of a human body. As a design matures, the amount and complexity of information to be coordinated between participants from different organizations increase exponentially as do the chances of errors. Interorganizational coordination becomes a key factor in reducing these errors and improving project performance and eventually in achieving the scheduling, cost, and quality objectives of a project [15,29].

Despite the complexity of MEP coordination and the advances in computer technologies, a common practice is still to coordinate designs by overlaying and comparing 2D drawings made by different project participants. This traditional design coordination process is very challenging and error prone for several reasons. First, the number of drawings from various participants is enormous and the drawings can differ widely in type. As building designs mature, the number of systems to be coordinated as well as the numbers and types of drawings increase exponentially. The MEP cost of heavily equipped buildings, such as hospitals and laboratories, exceeds 50% of the total construction cost. In such cases, MEP coordination is more challenging. Second, the drawings are not easily intelligible, even by professionals. Fig. 1 shows a composite drawing in which architectural, structural, MEP, and fire protection systems are overlaid; the difficulty in detecting information errors from a composite drawing is clearly seen. Third, even if errors are found, coordination regarding who should change their designs creates many conflicts and negotiations between project participants. Fourth, design evolves continuously; while correcting one area, designs of other areas may change. Fifth, design changes in architectural and structural elements have a chained impact on other elements. Sixth, only a very short feedback cycle is given. Seventh, soft clash issues, such as clearance issues, constructability issues, and access and maintenance requirements, are not explicitly depicted in designs and they are difficult to detect. Eighth, too many people are involved in the coordination process. MEP coordination involves many specialty contractors from various domains, including fire protection, heating and cooling, ducting and piping, electricity, and telecommunication services. Design coordination during construction usually focuses on the coordination of MEP elements (thus, the design coordination process is called MEP coordination for short). However, changes in architectural or structural elements are sometimes inevitable during the design coordination process. In those cases, the architects and structural engineers should also be summoned.

For these reasons, the 2D-drawing-based design coordination process usually leaves many design errors undetected until construction, and these design errors typically lead to rework. Love et al. [30] reported

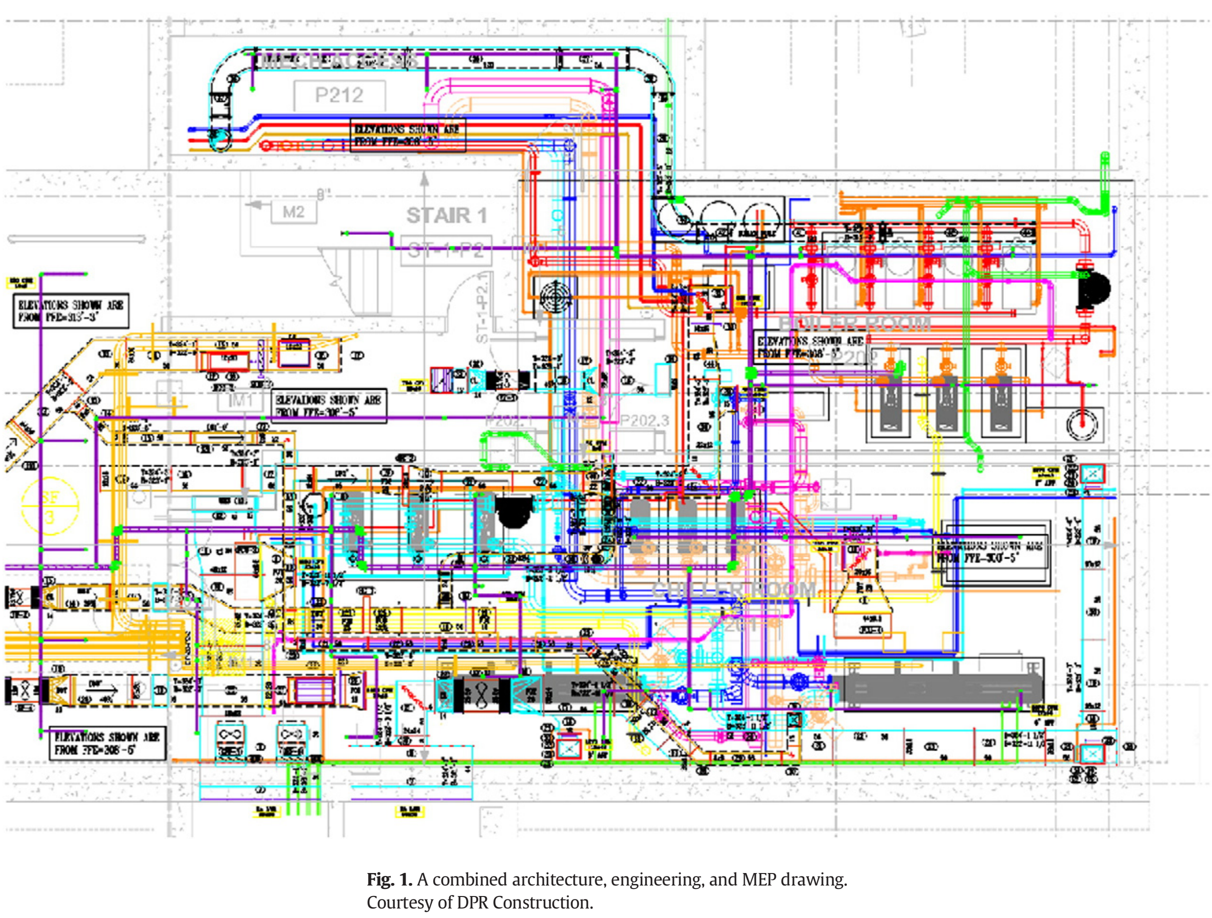

Fig. 1. A combined architecture, engineering, and MEP drawing.
Courtesy of DPR Construction.