A study on the inter- and Intra-Organizational Coordination in Large-Scale Campus Construction Project: A Case Study on design coordination issues

Abstract

Effective coordination among multidisciplinary stakeholders is crucial for successfully delivering large-scale construction projects. However, these projects often encounter delays, cost overruns, and quality issues due to coordination challenges. This study investigates inter- and intra-firm coordination through the issue iteration process in a digital common data environment, using a mixed-methods approach. The study evaluates delays and iterations across six disciplines involving the project management consultancy (PMC), client engineering works division (CEWD), and architectural engineering design consultancy (AEDC). The study captures the information flow among the stakeholders during the early stages of the project delivery phase using three distinct time estimates, including the planned and achieved time estimates for various categories of design rework. The campus development project has been taken as a case study. The results from the case show that architectural design issues have the highest numbers under the high urgency category for their resolution, while mechanical (HVAC/FIRE) issues exhibit the longest resolution times under the medium urgency category for their resolution. Further, a strong negative correlation (-0.72) is observed between the number of design iterations/information cycles/design rework and total resolution time for architecture and structure disciplines, with a moderately strong correlation (-0.64) for electrical, landscaping, and plumbing disciplines. Prioritizing architectural design issues and ensuring consistent communication with mechanical subcontractors is critical for reducing delays. Standardizing information exchange, and delineating subcontractor timeframe responsibilities in contracts are recommended to minimize delays. The study reinforces the need for discipline-specific strategies and contractual conditions to optimize coordination in large-scale construction projects.

Keywords: Inter-Firm Coordination, Intra-Firm Coordination, Issue Iteration, Digital Environment, Construction Projects

1. Introduction

Coordination among multidisciplinary stakeholders is essential for the effective execution of large-scale construction projects. Notwithstanding the growing use of digital collaboration platforms, coordination challenges remain a principal factor contributing to delays, budget excesses, and rework. This study examines the fundamental causes and patterns of coordination inefficiencies by evaluating design-related issue iteration procedures within a common data environment during the early phases of a campus development project.

2. Aim and Objectives

Aim:
To evaluate the inter- and intra-organizational coordination mechanisms influencing issue resolution and design rework cycles in large-scale construction.

Objectives:

- To track the flow of information across stakeholders during issue resolution.
- To analyze the duration and frequency of issue iterations across six design disciplines.
- To identify discipline-specific coordination challenges and propose improvements.

3. Scope

This study examines design coordination issues throughout the initial project delivery phase of a large campus construction project. The scope includes information flow between the project management consultancy (PMC), client engineering works division (CEWD), and architectural engineering design consultancy (AEDC) as shown in figure 1. Six design disciplines—architecture, structure, mechanical (HVAC/FIRE), electrical, landscaping, and plumbing—are examined within a digital coordination based on the information requirements defined by ISO 19650-1 (2018).

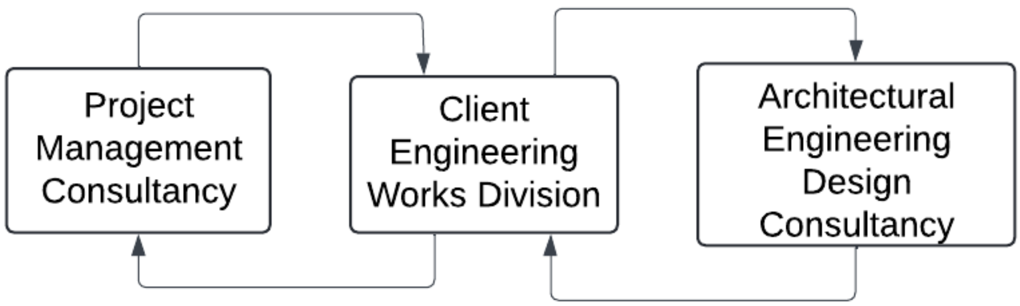

Figure 1: Representation of one cycle of information flow

4. Methodology

A mixed-methods case study approach was adopted. Data related to issue tracking and resolution were collected from the project's digital common data environment (CDE). The study classified issues based on urgency and discipline, and calculated resolution times using three key time metrics:

- Planned resolution time (Defined as the time difference (in days) between planned and due date)
- Actual resolution time (Defined as the time difference (in days) between planned and actual issue closing)
- Lag resolution time (Defined as the time difference (in days) between the planned resolution time and the actual resolution time for an issue)
- Iteration count (Defined as the number of one full cycle of information flow)

Correlation analysis was conducted to evaluate the relationship between iteration count and resolution time followed by an unstructured interview with the stakeholders to identify the challenges of issue closing. The policies and recommendations of the issue tracking and resolution is obtained from the content analysis of the unstructured interview.

5. Results and Discussion

5.1 Preliminary Issue tracking analysis

A total of 1,478 issues were gathered from the CDE, of which 2.23% are void issues, 5.48% are open issues, 10.35% are answered issues, and 81.94% are closed issues. The study exclusively considers closed topics, as this focus is essential to its objectives. The distribution of urgency levels versus six disciplines is presented in Table 1. The predominant design problems are categorized as medium urgency, whereas the architecture and structural disciplines account for the greatest quantity of high-urgency difficulties requiring immediate attention. Conversely, mechanical (HVAC/FIRE) exhibited the longest average resolution times, particularly under medium urgency, signifying extended coordination lead times within that discipline and subcontract management issues. Design concerns generate additional information cycles and delays relative to coordination issues, as they mostly pertain to alterations in pre-established operations. The study of the design iteration cycle indicates that efficient information management through workflow is achievable in a CDE, enhancing the transparency of information flow and thereby reducing the lead time for RFIs.

Table 1: The urgency level vs discipline distribution of closed issues

Discipline	Urgency Level		
	High (within 1 Day)	Medium (2-3 Days)	Low (5 to 7 Days)
Mechanical (HVAC/FIRE)	9	34	8
Landscape	31	33	1
Plumbing	19	50	4

Electrical	25	52	12
Structure	140	111	10
Architecture	182	179	23

Table 2 illustrates the distribution of various types and subtypes of design and coordination challenges found across different disciplines in the case study of a large-scale campus building project. Design-related difficulties, particularly within the "Design" subtype, predominate across all disciplines, with architecture (276) and structure (176) exhibiting the highest frequencies. Coordination challenges, including conflicts, are substantial, indicating the necessity for enhanced early-stage design integration and interdisciplinary coordination methodologies.

Table 2: The types of issue distribution in six disciplines

Type of issues	Subtype of issues	Architecture	Electrical	Land scape	Mechanical (HVAC/ FIRE)	Plumbing	Structure
Commissioning	Commissioning	1					
Coordination	Clash	13	1			2	8
	Coordination	77	12	22	3	15	58
Design	Building Code						1
	Change due to site conditions	3	1	2		1	6
	Client Feedback	6	4	2	7	5	3
	Design	276	71	39	40	48	176
	Requirement Change	4			1	2	5
Observation	Observation	4					4

5.2 Correlation analysis of issue tracking

The figure 2 shows the distribution of the number of information iterations required for issue resolution across various disciplines and the actual resolution time. The chart illustrates the distribution of problem counts among several fields for the amount of information iterations. Architecture has a pronounced peak initially, signifying a high incidence of difficulties early in the process, whereas disciplines such as Electrical and Plumbing have more steady trends. The frequency of issues markedly diminishes with an increase of iterations.

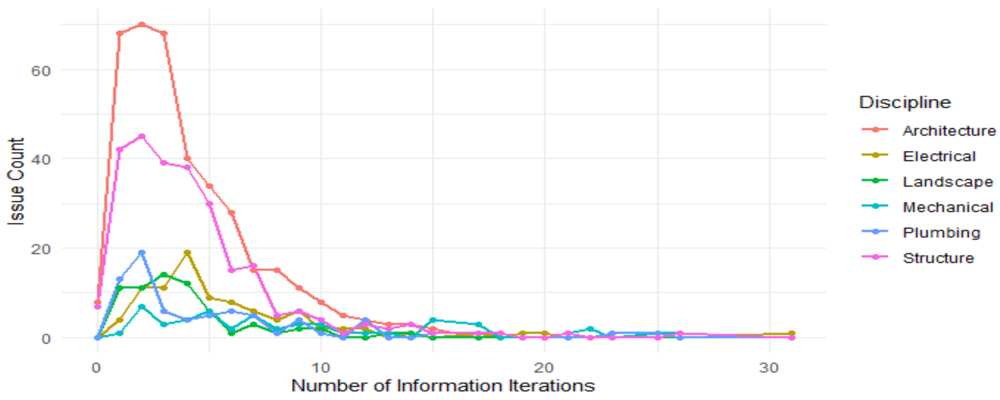

Figure 2: Variation in Issue Resolution Count with Number of Information Iterations Across Disciplines

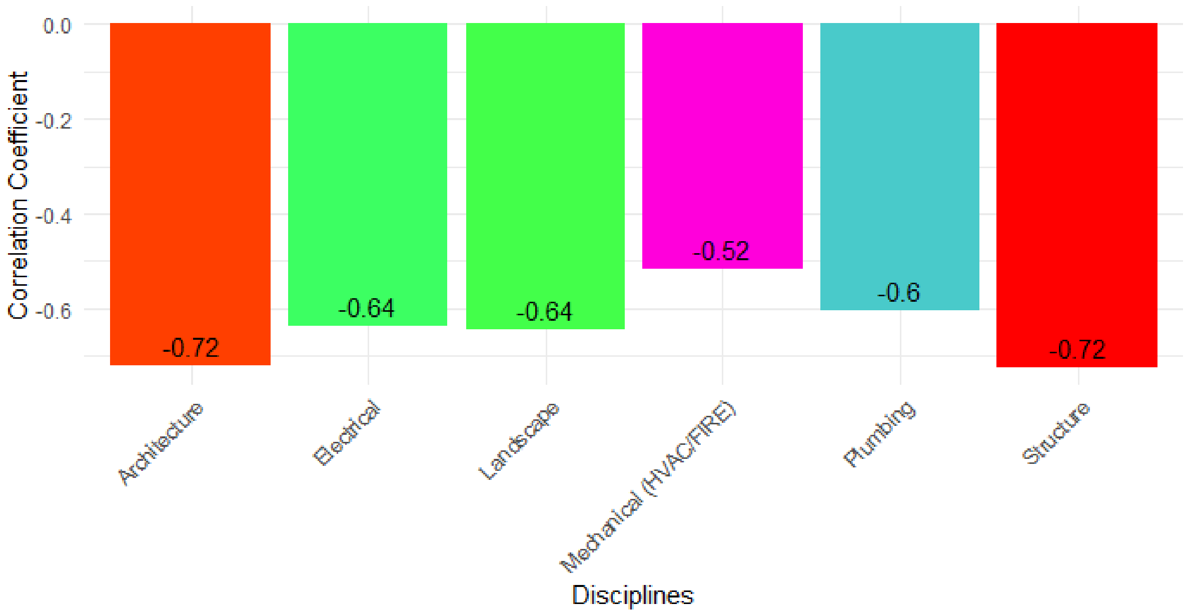

Figure 3: Representation of Correlation Between Information Flow and Issue Resolution Time Across Disciplines

The figure 3 illustrates the correlation coefficients among several disciplines. A strong negative correlation (-0.72) was observed between the number of design iterations and total resolution time for architecture and structure disciplines, suggesting that iterative engagement facilitated faster resolution. A moderate negative correlation (-0.64) was found for electrical, landscaping, and plumbing, indicating discipline-dependent coordination dynamics.

These insights underscore the importance of consistent communication and early issue identification, particularly in architecture and mechanical systems. Lack of clearly defined responsibilities and inconsistent data exchange protocols were observed as recurring barriers to effective coordination.

From the content analysis table of the unstructured interview with the key stakeholders, gives the following results in table 3

Table 3: The content analysis table of the unstructured interview with the key stakeholders

Code/Theme	Description	Quotes (from Interviews)	Policy/Recommendation Mapping
Digital issue management	Lack of centralized system to track and manage issues	“Sometimes we lose track of who is responsible for what. Within the organization issue closing is getting delayed even the required information is arrived.”	a. Implement Digital Issue Management Platforms
KPI monitoring	Need for discipline-specific accountability	“MEP team issues keep recurring. We don’t have data to show who’s delaying what as the AEDC is given subcontract to “X” for the same.”	b. Discipline-Specific KPI Monitoring
Coordination meetings	Communication gaps between teams	“By the time we know there’s a clash, rework is already done. We need to sit together more often with effective communication.”	c. Regular Interdisciplinary Coordination Meetings
Root cause analysis	High iteration issues rarely analyzed	“Some issues go back and forth endlessly. No one really asks *why* it happened again unless it is a high urgency issue.”	d. Mandatory Root Cause Analysis for High Iteration Issues
Transparency	Lack of visibility in issue progress	“I have no idea how many of my raised issues of MEP are still unresolved or who’s working on them in MEP issues as it is subcontracted to “X”.”	e. Visual Dashboards for Transparency

Penalties for iteration	Frustration over repeated iterations without consequence	"They just keep sending revised designs without sufficient information clarifications, and we lose time nothing happens to them."	f. Contractual Penalties for Excessive Iterations
Early design involvement	Problems arising due to delayed specialist involvement	"If we were consulted for design changes, this wouldn't be an issue unless it is difficult to execute."	g. Early Involvement of Specialists in Design Stage
Issue categorization	Difficulty tracking causes of recurring issues	"We treat all issues the same, whether it's design, site, or client no wonder we can't prioritize other than the urgency level with may be randomly chosen without any standard norms."	h. Structured Issue Categorization

6. Conclusion

This study highlights the importance of discipline-specific coordination strategies to improve project outcomes. Policies and recommendations to improve issue iteration and information flow are:

a. Implement Digital Issue Management Platforms: Adopt centralized digital platforms (e.g., BIM-based Common Data Environment or CDE) to track, assign, and resolve issues systematically, reducing delays caused by fragmented communication.

b. Discipline-Specific KPI Monitoring: Establish key performance indicators (KPIs) for each discipline (e.g., average resolution time, iteration count), and review them regularly to enforce accountability.

c. Regular Interdisciplinary Coordination Meetings: Conduct weekly or milestone-based meetings with representatives from all disciplines to proactively address clashes and pending design clarifications.

d. Mandatory Root Cause Analysis for High Iteration Issues: Enforce a policy requiring RCA for issues that exceed a defined threshold of iterations (e.g., >5 cycles), to eliminate recurring problems.

e. Visual Dashboards for Transparency:
Deploy real-time dashboards that display issue resolution progress and bottlenecks to all stakeholders, enhancing visibility and ownership.

f. Contractual Penalties for Excessive Iterations:
Introduce contract clauses that discourage excessive back-and-forth on issues by assigning penalties beyond a set number of allowable iterations.

g. Early Involvement of Specialists in Design Stage:
Engage structural, MEP, and landscape teams early in the planning stage to identify discipline-specific concerns before construction begins.

h. Structured Issue Categorization:
Classify issues based on type (design, coordination, site condition, client feedback) to analyze trends and prioritize long-term process improvements.

The insights from this case study are expected to inform better planning and coordination practices for future large-scale construction projects.