Interface Management Factors Affecting Time Performance and Communication Quality in Phased Tender Building Projects

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ABSTRACT : *Phased tendering allows construction work to begin before all design and procurement packages are completed, but it also increases technical, organizational, contractual, and information interfaces among project participants. This study develops a relationship model involving six variables measured through 24 indicators, comprising interface management processes and activities, interface risk factors, stakeholder requirements, interface management information systems, time performance, and communication quality. The case study involved a privately owned hotel building project in Bali, Indonesia, where foundation, structural, architectural, and mechanical, electrical, and plumbing packages were tendered in stages. Data were collected through a structured questionnaire from 40 respondents selected using purposive sampling. The data were analyzed using IBM SPSS Statistics version 27 through validity, reliability, homogeneity, Spearman correlation, factor analysis, and multiple linear regression. The time-performance model produced an Adjusted R^2 of 0.513, while the communication-quality model produced an Adjusted R^2 of 0.566. Interface management processes, stakeholder requirements, and information systems had significant positive effects on both outcomes, whereas interface risk factors had significant negative effects. Stakeholder requirements showed the strongest positive effect on time performance. The findings provide an empirical basis for developing a risk-based interface management system for phased tender building projects.*

KEYWORDS - *communication quality, interface management, interface risk, phased tender, time performance*

I. INTRODUCTION

Construction projects involve multiple stakeholders, technical disciplines, contractual responsibilities, and interdependent work packages. These interactions create technical, organizational, contractual, and information interfaces. Poor interface management may result in unclear responsibilities, coordination failures, delayed decisions, design conflicts, and rework [1], [2].

The interface challenge becomes greater in phased tender projects, where procurement and construction are divided into successive work packages. Although this arrangement allows earlier packages to proceed while subsequent packages are still being developed, it increases dependencies among separate contracts and requires controlled transfer of information, responsibilities, and deliverables [4]. A formal interface management system can support the identification, recording, monitoring, and resolution of these dependencies [3].

This study examines a privately owned hotel building project in Bali, Indonesia, where the foundation, structural, architectural, and mechanical, electrical, and plumbing packages were tendered in stages. Different contractors entered the project at successive phases, creating potential interface problems related to design changes, document consistency, technical approvals, scope boundaries, and coordination between work packages.

Stakeholder engagement and communication are important because interface resolution depends on cooperation, decision-making authority, and timely information exchange [6], [7]. Database-supported and BIM-based systems may also improve interface communication by supporting document control, responsibility assignment, issue tracking, and resolution monitoring [8].

Previous studies have examined interface management processes and practices [1], [2], interface management systems [3], stakeholder engagement [6], project communication [7], and digital interface platforms [8]. However, limited research has simultaneously examined how interface management processes, interface risks, stakeholder requirements, and interface management information systems affect time performance and communication quality in phased tender building projects. Therefore, this study aims to develop a quantitative relationship model between these four interface management factors and the two project outcomes.

II. LITERATURE REVIEW

2.1. Interface Management in Phased Tender Building Projects

Construction projects involve technical, organizational, contractual, and information dependencies among owners, consultants, contractors, subcontractors, and suppliers. These dependencies create interfaces through which responsibilities, information, physical works, and contractual deliverables are transferred. Interface management provides a structured approach for identifying, documenting, coordinating, monitoring, and resolving these interdependencies [1]. Formal interface management practices are particularly important in projects involving multiple stakeholders, overlapping activities, and uncertain work scopes [2].

An interface management system can record interface points, responsible parties, required deliverables, target dates, and issue-resolution status [3]. Its application becomes increasingly important in phased tender projects because design, procurement, and construction activities may overlap across separate work packages. Although phased tendering can support earlier construction commencement, changes or delayed decisions in one package may affect the scope, sequence, and execution of subsequent packages [4].

2.2. Interface Management Factors

This study examines four interface management factors. Interface management processes and activities include interface identification, responsibility assignment, coordination, monitoring, issue resolution, and formal closure [3]. Interface risk factors include unclear scope boundaries, incomplete information, design changes, delayed decisions, fragmented responsibilities, and weak coordination, which may disrupt interconnected project activities [1].

Stakeholder requirements concern the information, coordination, reporting, decision-making authority, and technical support needed by the parties involved. Communication, cooperation, managerial capability, technical support, and contractual relationships influence interface management performance [6]. Interface management information systems support these requirements through interface registers, document control, responsibility assignment, issue tracking, and deadline monitoring. Database-supported and BIM-based platforms can improve the recording, communication, response, and monitoring of interface issues [8].

2.3. Time Performance and Communication Quality

Time performance reflects the ability to complete activities, decisions, deliverables, and work packages according to the planned schedule. Unresolved interfaces may delay dependent activities, disrupt work sequences, and generate rework. Integrated information technologies can improve schedule visibility by providing timely information on production, delivery, and construction progress [9].

Communication quality refers to the accuracy, timeliness, completeness, clarity, and traceability of project information. Poor communication may cause delayed decisions, repeated clarification, inconsistent implementation, and coordination failures. Effective communication procedures and appropriate information channels are therefore essential for maintaining project performance [7].

Previous studies have examined interface processes, stakeholder engagement, digital systems, schedule performance, and project communication in different construction settings. However, limited research has simultaneously evaluated the relationships between interface management processes, interface risks, stakeholder requirements, and interface management information systems with time performance and communication quality in phased tender building projects. This research gap provides the basis for developing the relationship models examined in this study.

III. RESEARCH METHODOLOGY

3.1. Research Design

This study employed an explanatory quantitative approach with a cross-sectional design to analyze the relationships between interface management processes and activities, interface risk factors, stakeholder requirements, and interface management information systems with project time performance and communication quality. Data were collected through a structured questionnaire administered to 40 respondents selected using purposive sampling based on their professional experience and involvement in building construction management, coordination among work packages, risk management, and phased tendering processes.

The respondents included representatives of the owner, design consultants, construction management consultants, contractors, and other relevant parties directly involved in a privately owned hotel project in Bali or those with experience in building projects with similar phased tender characteristics. The collected data were used to test the validity and reliability of the research instrument, analyze the relationships among variables, and develop regression models explaining the effects of X1, X2, X3, and X4 on project time performance and communication quality.

Based on educational background, 82% of the respondents held bachelor's degrees, 13% held master's degrees, and 5% held doctoral degrees. In terms of work experience, 57% had 5–10 years of experience, 28% had 11–20 years, and 15% had more than 20 years of experience. Based on organizational position, 55% of the respondents represented contractors, 25% represented consultants, including design consultants and construction management consultants, and 20% represented the owner.

3.2. Research Variables

This study examines four independent variables and two dependent variables related to interface management during phased tender transitions in building projects. The variables were developed from the literature review, expert validation, and conditions identified in the case study project. The measurement indicators were assessed using a five-point Likert scale.

(1) X1 Interface Management Processes and Activities. The indicators cover interface identification, assignment of responsibility, coordination meetings, information exchange, progress monitoring, issue resolution, and interface closure.

(2) X2 Interface Risk Factors. These conditions include unclear scope boundaries, incomplete documents, design changes, delayed decisions, fragmented contractual responsibilities, coordination problems, and inconsistencies in project information.

(3) X3 Stakeholder Requirements. The indicators reflect the clarity of information needs, access to project data, response requirements, decision authority, coordination procedures, and reporting expectations.

(4) X4 Interface Management Information System. Its indicators include interface registration, document control, responsibility assignment, issue tracking, change recording, deadline monitoring, notification, reporting, and integration of information among project stakeholders.

(5) Y1 Time Performance. It is measured through schedule compliance, response time, issue resolution time, prevention of work interruption,

reduction of rework, and timely completion of interdependent work packages.
(6) Y2 Communication Quality. Its indicators include information accuracy, completeness, timeliness, clarity, consistency, traceability, and delivery to the appropriate parties. Effective communication is expected to reduce repeated clarification, information distortion, and delays in project decision-making.

The relationships between the four independent variables and the two dependent variables were examined through two separate regression models. The first model evaluates their relationships with time performance, while the second model evaluates their relationships with communication quality.

3.3. Expert Validation of Instrument

Prior to data collection, the questionnaire was reviewed by experts through face validity and content validity. Face validity assessed the clarity, readability, terminology, and comprehensibility of each questionnaire item. Content validity examined the relevance, completeness, and consistency of the indicators with the research objectives, variable definitions, and the context of phased tender building projects.

The expert review covered 24 indicators representing six variables, namely interface management processes and activities, interface risk factors, stakeholder requirements, interface management information systems, time performance, and communication quality. Items considered unclear, overlapping, or insufficiently relevant were revised based on the experts' comments before the final questionnaire was distributed to the respondents.

3.4. Data Analysis Methods

Data were analyzed using IBM SPSS Statistics version 27 :
(1) Normality Test. The Shapiro-Wilk test was used. Data were considered normally distributed when the significance value was greater than 0.05.
(2) Homogeneity Test. The Kruskal-Wallis test was used to examine differences among respondent groups. A significance value greater than 0.05 indicated homogeneous perceptions.
(3) Data Sufficiency Test. The data were considered sufficient when the required sample size was equal to or lower than the available sample.
(4) Validity Test. An item was considered valid when the calculated correlation value was greater than the r-table value. With 40 respondents, the degree of freedom was $df = n-2 = 38$. At a significance level of 0.05, the r-table value was 0.312. Therefore, an item was considered valid when r-calculated > 0.312 and the significance value was below 0.05.
(5) Reliability Test. A variable was considered reliable when Cronbach's Alpha was at least 0.60.
(6) Spearman Correlation. Spearman's two-tailed correlation was used to examine the direction, strength, and significance of relationships. A significance value below 0.05 indicated a significant relationship.
(7) Factor Analysis. Factor analysis was conducted using the KMO and Bartlett tests. The data were suitable when KMO exceeded 0.50 and Bartlett's significance value was below 0.05.
(8) Multiple Linear Regression. Multiple regression using the Enter method was applied to test the effects of X1, X2, X3, and X4 on Y1 and Y2. The model and individual coefficients were considered significant when the significance value was below 0.05.

IV. RESULTS

4.1. Statistical Tests

The Shapiro-Wilk test produced significance values below 0.05 for all questionnaire indicators, indicating that the item-level data were not normally distributed. Therefore, Spearman's rank correlation was used for the bivariate relationship analysis.

The Kruskal-Wallis test showed no significant differences in respondents' perceptions based on education level and organizational position. Most indicators also showed no significant differences based on work experience. However, X1.2 differed significantly among experience groups in both the time-performance dataset and the communication-quality dataset, with significance values of 0.032 and 0.037, respectively. Overall, the respondents' perceptions were considered sufficiently comparable for further analysis.

The overall Cronbach's Alpha values were 0.810 for the time-performance dataset and 0.825 for the communication-quality dataset. Construct-level testing of the independent variables produced Alpha values of 0.944 for X1, 0.642 for X2, 0.936 for X3, and 0.926 for X4 in the time-performance dataset. In the communication-quality dataset, the values were 0.936 for X1, 0.647 for X2, 0.930 for X3, and 0.933 for X4. All corrected item-total correlations for the independent-variable indicators exceeded 0.30. Therefore, X1, X3, and X4 demonstrated high reliability, while X2 met the acceptable threshold for exploratory research.

4.2. Correlation Analysis

Spearman's two-tailed correlation was conducted to examine the bivariate relationships between the four independent variables and the two project-performance variables. The results are presented in Table 1

Table 1. Spearman Correlation Results

Variables (X)	Y1	Sig.	Y2	Sig.
X1	0.291	0.069	0.351	0.026
X2	-0.300	0.060	-0.357	0.024
X3	0.429	0.006	0.412	0.008
X4	0.352	0.026	0.354	0.025

For time performance, X3 showed a significant positive relationship with Y1, with a correlation coefficient of 0.429. X4 also had a significant positive relationship with Y1, with a coefficient of 0.352. X1 showed a positive but statistically non-significant relationship, while X2 showed a negative but statistically non-significant relationship at the 5 % level.

For communication quality, all four independent variables were significantly related to Y2. X1, X3, and X4 showed positive relationships, while X2 showed a negative relationship. The strongest bivariate relationship was found between X3 and Y2, with a coefficient of 0.412.

4.3. Factor Analysis

The factorability of the independent-variable indicators was examined using the Kaiser-Meyer-Olkin measure and Bartlett's Test of Sphericity. For the time-performance dataset, the KMO value was 0.678 and Bartlett's Test was significant, with a chi-square value of 453.605, 120 degrees of freedom, and a significance value below 0.001. For the communication-quality dataset, the KMO value was 0.716 and Bartlett's Test was also significant, with a chi-square value of 432.571 and a significance value below 0.001. These results confirmed that the data were suitable for factor analysis. Principal Component Analysis with Varimax rotation produced four distinguishable components corresponding to X1, X2, X3, and X4.

The factor loadings for the time-performance dataset ranged from 0.913 to 0.934 for X1, 0.596 to 0.742 for X2, 0.900 to 0.929 for X3, and 0.874 to 0.934 for X4. In the communication-quality dataset, the loadings ranged from 0.901 to 0.922 for X1, 0.580 to 0.779 for X2, 0.898 to 0.920 for X3, and 0.899 to 0.931 for X4. All indicators had primary factor loadings above 0.50. The results support the proposed four-factor structure, although X2 had relatively lower loadings than the other constructs.

4.4. Multiple Linear Regression

Multiple linear regression using the Enter method was conducted separately for time performance and communication quality. The regression model for time performance produced an R value of 0.750, an R Square value of 0.563, and an Adjusted R Square value of 0.513. This indicates that X1, X2, X3, and X4 jointly explained approximately 51.3 % of the adjusted variation in time performance.

The model was statistically significant, with an F value of 11.254 and a significance value below 0.001. The regression results indicate that all independent variables significantly affect time performance. X1, X3, and X4 have positive effects, while X2 has a negative effect. Based on the standardized Beta value, X3 is the most dominant predictor of time performance, followed by X1, X4, and X2. The results are presented in Table 2.

Table 2. Regression Coefficients for Time Performance

Variable	B	Standardized Beta	t	Sig.
Constant	2.595		5.500	< 0.001
X1	0.233	0.402	3.534	0.001
X2	-0.511	-0.359	-3.155	0.003
X3	0.257	0.458	4.086	< 0.001
X4	0.224	0.378	3.374	0.002

All four variables had statistically significant partial effects on time performance. X1, X3, and X4 had positive coefficients, while X2 had a negative coefficient. The resulting regression equation is expressed as follows :

$Y_1 = 2.595 + 0.233X_1 - 0.511X_2 + 0.257X_3 + 0.224X_4$ (1)

The communication-quality model produced an R value of 0.781, an R Square value of 0.610, and an Adjusted R Square value of 0.566. The four independent variables therefore explained approximately 56.6 % of the adjusted variation in communication quality.

The model was statistically significant, with an F value of 13.697 and a significance value below 0.001. The regression results indicate that all independent variables significantly affect communication quality. X1, X3, and X4 have positive effects, while X2 has a negative effect. Based on the standardized Beta value, X1 is the most dominant positive predictor, followed closely by X3 and X4, while X2 shows the strongest negative effect. The results are presented in Table 3.

Table 3. Regression Coefficients for Communication Quality

Variable	B	Standardized Beta	t	Sig.
Constant	2.675		6.055	< 0.001
X1	0.242	0.406	3.829	< 0.001
X2	-0.585	-0.404	-3.792	< 0.001
X3	0.232	0.403	3.821	< 0.001
X4	0.243	0.403	3.799	< 0.001

All independent variables had significant partial effects on communication quality. X1, X3, and X4 had positive effects, while interface risk factors had a negative effect. The resulting regression equation is expressed as follows :

$Y_2 = 2.675 + 0.242X_1 - 0.585X_2 + 0.232X_3 + 0.243X_4$ (2)

4.5. Interpretation of the Regression Models

The regression results show that interface management processes, stakeholder requirements, and interface management information systems positively affect both time performance and communication quality, while interface risks have negative effects. Stakeholder requirements had the strongest positive effect on time performance, with a standardized Beta of 0.458, indicating the importance of timely information, coordination, decision authority, and reporting in maintaining the project schedule.

For communication quality, the standardized effects of X1, X3, and X4 were relatively balanced, while X2 produced a significant negative effect. This finding indicates that effective communication depends on structured interface processes, clear stakeholder requirements, adequate information-system support, and reduced interface risks.

Although the Spearman correlations of X1 and X2 with Y1 were not significant, both variables were significant in the regression model. This indicates that their contributions become more evident when assessed simultaneously with the other interface management factors.

V. DISCUSSION

The regression results demonstrate that interface management processes, interface risks, stakeholder requirements, and interface management information systems jointly contribute to time performance and communication quality in phased tender building projects. The adjusted explanatory power reached 51.3 % for time performance and 56.6 % for communication quality. These values indicate that the proposed model explains a substantial proportion of both project outcomes, although other technical, financial, contractual, and organizational factors remain outside the model.

Interface management processes and activities had significant positive relationships with both time performance and communication quality. Formal activities such as interface identification, responsibility assignment, coordination, monitoring, issue resolution, and interface closure help reduce uncertainty between work packages. This result is consistent with previous research showing that structured interface management practices support project teams in dealing with organizational complexity and interdependence [2]. In phased tender projects, these activities become particularly important because contractors may enter the project at different stages and depend on information and deliverables produced during earlier phases.

Interface risk factors had significant negative coefficients in both regression models. This finding indicates that unclear scope boundaries, incomplete documents, design changes, delayed decisions, fragmented responsibilities, and coordination problems reduce time performance and communication quality. This result supports previous research emphasizing that interface risks should be identified throughout the project lifecycle and managed through standardized procedures, stakeholder coordination, and digital information support [5]. The negative relationship was stronger in the communication-quality model, indicating that interface risks directly disrupt information exchange and may subsequently affect project execution.

Stakeholder requirements produced the strongest positive standardized effect on time performance. This result indicates that timely decisions, clear information requirements, defined authority, and appropriate reporting arrangements are essential for maintaining the construction schedule. In a phased tender project, the output of one party frequently becomes an input for another work package. Failure to identify stakeholder requirements may therefore delay approvals, design clarification, procurement, and construction activities. This finding is consistent with previous research showing that stakeholder communication, cooperation, managerial capability, technical support, and contractual relationships influence interface management performance [6].

The interface management information system also had significant positive relationships with both dependent variables. A system that records interface points, controls document versions, assigns responsibilities, tracks changes, and monitors deadlines improves the availability and traceability of project information. This finding is consistent with previous research showing that database-supported and BIM-based interface platforms can improve the recording, communication, response, and monitoring of interface issues [8]. The result indicates that digital support should be integrated with formal interface management procedures, rather than used only as a document-storage facility.

The communication-quality model had a higher Adjusted R Square than the time-performance model. This difference suggests that interface management variables are more directly related to communication quality, while time performance may also be affected by external conditions such as financing, resource availability, construction methods, weather, and supply-chain disruption. The standardized coefficients in the communication model were also relatively balanced, indicating that effective communication requires the simultaneous implementation of formal processes, risk control, stakeholder involvement, and information-system support.

The Spearman analysis showed that X1 and

X2 were not significantly related to time performance at the 5 % level when examined separately. However, both variables became significant in the multiple regression model. This difference occurs because Spearman correlation measures the separate bivariate relationship between two variables, while regression estimates the unique contribution of each variable after controlling for the other predictors. The result suggests that interface processes and interface risks should be evaluated as parts of an integrated management system rather than as isolated factors.

For the case-study project, the results imply that the transition between foundation, structural, architectural, and mechanical, electrical, and plumbing packages should be supported by a formal interface register, clear assignment of responsibilities, defined information requirements, risk monitoring, and an integrated information platform. These measures are expected to reduce repeated clarification, prevent inconsistent documents, accelerate decisions, and maintain continuity between tender and construction phases.

VI. CONCLUSION

This study demonstrates that time performance and communication quality in phased tender building projects are influenced by the combined implementation of interface management processes, interface risk control, stakeholder requirements, and interface management information systems. The principal advantage of the proposed model is its integrated perspective, as it evaluates managerial processes, risks, stakeholder needs, and information-system support within the same analytical framework. The results also indicate that stakeholder requirements play an important role in maintaining time performance, while communication quality depends on the balanced contribution of all interface management factors.

The model can be applied by project owners, consultants, construction managers, and contractors to improve coordination between successive work packages. Its practical applications include establishing a formal interface register, defining responsibilities and information requirements, monitoring interface risks, controlling document changes, tracking deadlines, and recording the resolution of interface issues. These measures can support timely decision-making and reduce coordination failures during transitions between tender and construction packages.

This study is limited by the use of 40 respondents, purposive sampling, cross-sectional data, and a single privately owned hotel project in Bali. Therefore, the findings should be interpreted within the characteristics of the examined project. Future studies should test the model using larger samples, multiple building projects, different procurement arrangements, and longitudinal data. Further research may also extend the model by incorporating contractual, technological, organizational, and supply-chain factors or by applying structural equation modelling to examine direct and indirect relationships among the variables.

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