Leadership in Sustainable Infrastructure
Leadership en Infrastructures Durables

Vancouver, Canada
May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

ASSESSMENT OF CONSTRUCTION PROJECTS' IMPACT ON INTERNAL COMMUNICATION OF PRIMARY STAKEHOLDERS IN COMPLEX PROJECTS

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Abstract: In construction projects, multiple parties are involved and communication becomes critical as project complexity increases. Effective internal communication can be an element of contributing to project success; however, there are limited number of studies in the field of construction, which focus on the internal communication of primary stakeholders. Therefore, the objective of this paper is to assess the internal communication of primary stakeholders including owners, designers, and contractors in the construction industry and their related variables/parameters. In this paper, through a comprehensive literature review, the potential project-based communication variables were identified and categorized. Then, a survey focusing on project-based internal communication variables was developed and distributed among construction project participants active in the construction industry. Forty-four survey responses were collected. Through several statistical analysis, including two-sample *t*-test, Chi Squared Test, and Analysis Of Variance (ANOVA), researchers were able to determine significant project characteristics affecting the effectiveness of communication within the owners, designers, and contractors stakeholders. The results of the analysis concluded, (1) number of design/engineering organizations involved in the project, (2) number of financial approval authority thresholds, and (3) clarity of the project scope have a significant impact on internal communication of the primary project stakeholders. The findings of this research will help construction managers to improve internal communication of primary stakeholders and as a result reduce the potential risk of failure in terms of miscommunication specifically in complex projects.

1 INTRODUCTION

A major and challenging area of study within the project-based engineering and construction industry is communication for efficient knowledge sharing across an organization (Javernick Will, 2011).The construction industry is one of the most information dependent industries (Tam 1999) where effective communication should exist during the project's development and execution life cycle. Adequate communication leads to enhance team performance in a construction project (Ehrlich and Chang 2006). However, in some projects, there is a lack of assimilation between design and construction entities, which influences the quality of final project outcome. Moreover, the social aspects of construction projects such as communication and interdisciplinary interaction have become critical success factors in the delivery of projects (Malisiovas and Song, 2014). In addition, Scanlin (1998) found that ineffective communication is a root cause of most project failures.

Construction project process involves extensive information exchange among members of multidisciplinary project teams (Wong and Lam, 2010). Communication is a two-way process between the sender(s) and

receiver(s) through commonly used media (Cleland and Ireland, 2002). In construction management field, communication components are related to the project and its characteristics and both sender and receiver are project stakeholders. Therefore, this study focuses on communication effectiveness of primary stakeholders based on project characteristics.

In construction industry, complex organizational structures and fragmented supply chain often cause communication problems (Dainty et al. 2006). Higgin and Jessop (2013) believed problems related to the communications within each of the design construction teams are one of the substantial challenges in the construction industry.

Therefore, communication as a way to exchange thoughts, messages, or information by speech, signal, and writing has a pivotal role in construction projects. There are some construction studies, which focused on defining communication and its difficulties (Murray et al, 2000), identifying effective communication indicators and its impact on project success (Murray et al, 2000). It should be noted that construction projects are considered successful when the ultimate cost and schedule performance have less than 10 percent overrun/underrun (Kermanshachi, 2016). However, the effective project-based communication indicators within each of the three primary stakeholder entities (owners, consultants and contractors) have not been focused and studied. Earlier studies revealed that ineffective communication within construction stakeholders leads to major reworks and low-quality end-product delivery, which would cause adversarial relationships and serious conflict between project's parties (Cheung et al., 2014).

Therefore, the objective of this paper is to identify the project-based effective communication indicators within the three project primary stakeholders (owners, consultants and contractors). It is worthwhile to mention that this study focuses on large-scale complex projects, which have multiple partnered organizations within each of the primary stakeholders.

Initially, the existing literature on the communication definition and construction communication indicators were reviewed. Followed by the background studies, the research methodology and statistical analysis to identify the significant project-based communication indicators within each of the primary stakeholders were presented. At the end, the overlap of the identified communication indicators between the three primary stakeholders were analyzed and discussed.

2 BACKGROUND

Lately, the importance of effective communication in the construction industry has been recognized and since there are multiple parties involved in a single construction project, communication between parties/entities with diverse skills is a key factor for the success of construction projects. The definition of communication is referred to relationship and collaboration emerged when there is an interaction between and within project teams (Senescu et al., 2012). Higgin & Jessop (2013) was among the first researchers who studied communication problems of construction projects. This study concluded that communication difficulties exist at several levels within the building industry, such as communications within the design team.

Armstrong (2001) believed that good communication in a construction environment leads to achieve coordinated results, good change management, employee's motivation and better understanding of workforce's needs. Murray et al. (2000) also recommended that improved communication between the construction team could improve project execution performance.

Thomas et al (1998) developed a tool for quantifying communication effectiveness by using questionnaire, requiring survey participants to provide their perception of communication effectiveness. This study analyzed communication effectiveness using 72 projects to find out the impact of effective communication on project success. This study, which was considered as a breakthrough in the field of construction engineering and management, identified and measured critical categories for the accuracy, timeliness,

completeness, understanding, barriers and procedures of massage context and information. This study also suggested that accuracy of information is the most important and completeness of information, is the least between the six critical categories.

Murray et al (2000) investigated the critical communication variables as a means of ensuring the fulfilment of time, cost, and quality targets in construction projects. In this study, the researchers selected nine projects to study the most critical variables in communication. These researchers used both open and closed-ended questions while interviewing the key players in construction environment.

In 2001, Cheng developed a supporting mechanism, which determines the intra and inter-organizational roles to achieve efficient and effective communication. This study investigated several aspects of communication between different parties in a construction project such as Intra- and inter-organizational communication, close contacts and distant connections. It was concluded that inter-organizational communication should take place in the alliance teams composed of several joint parties. It was suggested that representatives from each organization should play the communicating role with other entity's team members. It was also found out that utilization of multiple channels would enhance communication significantly. Channels for close communications can be meetings, workshops, face-to-face visits, and/or small group communication.

Senescu et al. (2012) defined some influential criteria to establish the relationship between communication and complexity. This research concluded that some project characteristics contribute to the communication effectiveness such as: fast information exchanges, clarity of explanations or processes, consistency of information between team members, integrated decisions, common process knowledge, planned coordination, and well connected team.

Complexity theory generally defines what a complex system is within a specific area of interest and studies the interfaces between the components in mentioned system. A complex system, otherwise conventional systems includes elements that have unfixed relationships, behavior, or quantities (Dao et al, 2016). Edmonds (1999), defined complexity as a property of a model, which makes it difficult to formulate its overall behavior.
In general, number of components and degree of interaction between these components, degree of activities within each component and interactions of the system with outside entities are considered as criteria, which define project complexity (Sbragia, 2000). Zhu and Mostafavi (2014) concluded that construction projects are complex systems composed of interconnected human agents, information, resources, and tasks.

Recently, few researchers have studied complexity as a standalone topic in construction industry. Kermanshachi et al. (2016) utilized Delphi method to identify complexity indicators and their associated weights as well as top industry-based strategies, which help in the management of complex projects. In another study, Dao et al. (2016) defined complexity as "degree of differentiation of project elements, interrelatedness between project elements, and consequential impact on project decisions". Then, Through a comprehensive literature review and statistical data analysis, Dao et al., (2016) identified 11 areas which make a construction project complex as following: 1) Stakeholder Management; 2) Project Governance; 3) Legal; 4) Fiscal Planning; 5) Interfaces; 6) Scope Definition; 7) Location; 8) Design and Technology; 9) Project Resources; 10) Quality; and 11) Execution Targets.

3 RESEARCH METHODOLOGY

The research process for this study is visually depicted in Figure 1. The methodology utilized in this study encompassed the following five consecutive tasks:

(1) The existing literature on the definition of the communication and its indicators in the construction industry was reviewed. In addition, since this study focuses on the effective communication indicators in complex projects, project complexity in the field of construction was studied.

(2) Identified communication indicators and attributes found through literature review were categorized.

(3) A survey collecting information on project-based communication indicators of complex projects within each of the primary stakeholders was developed and distributed. Since the focus of this study is large complex projects, it is investigating the effective communication indicators between two or multiple organizations in one entity (e.g. owners).

(4) Several statistical analysis including two sample *T*-Test, Chi Squared Test, and Analysis Of Variance (ANOVA) Test were utilized to identify the significant effective communication indicators within each of the owners, consultants and contractors entities; and

(5) Overlap of the common indicators among three stakeholders were determined and the statistical results were discussed.

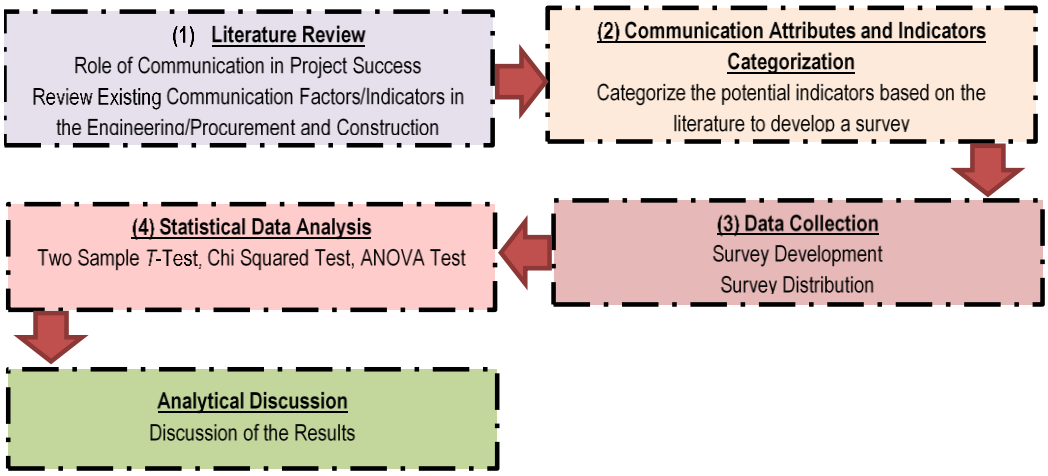

Figure 1: Research Framework

4 DATA COLLECTION AND ANALYSIS

To conduct this study, a survey containing 50 questions about potential communication indicators were developed. This survey, which was distributed among active construction practitioner with at least 10 years of experience, required participants to fill the survey based on a selected complex construction. The survey provided clear instructions for the participants to select a complex construction project. Through several follow-up emails, 30 completed survey responses were collected.

The questionnaire responses were in one of the three continuous, Likert scale and binary formats. Depending on the type of the collected data, appropriate statistical test was utilized. The collected data was divided to two groups of projects with effective and ineffective communications within primary stakeholders in complex projects. This process was performed once for each of the owner, consultant and contractor entities. Two-Sample T-Test (continuous data), ANOVA (Likert scale data) and Chi-squared (binary) were used to test if there is a significant difference between effective and ineffective potential communications indicators for each of the mentioned parties. This analysis was done at both 0.05 and 0.1 significance levels (p-value<0.05 and P-value<0.1) to ensure all significant communication indicators within the primary stakeholders were identified.

5 RESEARCH RESULTS

5.1 Preliminary Data Analysis

Table 1 illustrates the industry type, project delivery method, contract type, and project baseline budget and schedule distribution for the 30 collected complex projects. As it is shown in this Table, the majority of the collected data are heavy industrial type projects, which adopted Design-Build delivery method. Preliminary data analysis also indicated that most of the complex projects used cost reimbursable contract type to perform design and construction phase tasks; however, lump sum contract type was selected to supply and provide materials during the procurement phase. The same analysis revealed that the collected data had an average 30 months duration with an average budget of $366,030,240.

Table 1: Projects' Characteristics Information

Project characteristics Information			
Industry Type	Heavy Industrial		70.00%
	Light Industrial		6.67%
	Buildings		16.67%
	Infrastructure		6.67%
Average Project Baseline Schedule	Total Project Schedule		30 Months
	Detailed Engineering/Design		9 Months
	Procurement		11 Months
	Construction		18 Months
Project Delivery Method	Design-Bid-Build		30.00%
	Design-Build (EPC)		40.00%
	CM at Risk		6.67%
	Multiple-Primes		23.33%
Contract Type	Detailed Engineering/Design	Lump Sum	44.83%
		Cost Reimbursable	55.17%
	Procurement	Lump Sum	59.26%
		Cost Reimbursable	40.74%
	Construction	Lump Sum	46.67%
		Cost Reimbursable	53.33%
Average Project Baseline Budget	Total Project Cost		$366,030,240
	Detailed Engineering/Design		$39,502,307
	Procurement		$162,849,912
	Construction		$163,382,009

5.2 Statistical Data Analysis

The collected survey responses on potential 50 Communication Indicators (CIs) were statistically tested. The results indicated 20 project-based CIs were significant in differentiating between effective and ineffective communication within the three primary stakeholders. The 20 significant CIs were initially categorized into the 8 following groups: (1) bureaucracy coordination, (2) interface (quantity and quality of stakeholders' interactions), (3) location, (4) quality of material resources, (5) project targets (cost and schedule targets compared to industry benchmarks), (6) project economic issues, (7) technology and (8) scope definition (clarity of scope).

Table 2 presents the list of significant communication indicators within each of the owner, consultant and contractor entities. Initially, the significance level of 0.05 and 95% confidence level was chosen to test the significance of each of the effective communication indicators in complex construction projects. However,

the significance level was ultimately increased from 0.05 to 0.1 to include larger pool of communication indicators.

Table 2: Significant indictors related to effective communication within owners, designers and contractors

Category	CI #	Indicator	Primary Stakeholders		
			Owner	Designer	Contractor
Coordination	CI-1	Number of Financial Approval Authority Thresholds	0.009**	0.022**	0.018**
	CI-2	Number of Required Total Permits	0.020**	0.019**	0.030**
	CI-3	Number of External (Regulatory) Agencies Required to Approve Design	0.053*	0.090*	0.116
Interface	CI-4	Number of Decision Making Entities Above Project Management Team-Project Execution Plan	0.116	0.036**	0.058*
	CI-5	Number of Owner Organizations	0.017**	0.322	0.207
	CI-6	Number of Designer/Engineer Organizations	0.000**	0.025**	0.011**
	CI-7	Number of Contractor Organizations	0.116	0.000**	0.079*
	CI-8	Number of Contractor Project Management Leadership Team Members	0.127	0.022**	0.039**
	CI-9	Number of Permitting Agency Organizations	0.024**	0.239	0.348
	CI-10	Alignment Quality of Internal Stakeholders	0.484	0.059*	0.038**
Location	CI-11	Number of Execution Locations-Procurement Phase	0.016**	0.595	0.191
Scope Definition	CI-12	Clarity of Projects Scope During Designer/Contractor Selection	0.024**	0.082*	0.075*
Technology	CI-13	Number of New Systems Tied into Existing Systems	0.813	0.319	0.026**
	CI-14	Company's Familiarity with Technologies Involved in Operation phase	0.447	0.095*	0.280
Material Resources	CI-15	Delay in Delivery of Permanent Facility Equipment	0.447	0.023**	0.026**
	CI-16	Degree of Additional Quality Requirements - Construction Specifications	0.728	0.408	0.055*
Project Targets	CI-17	Cost Target at the Authorization Compared to Industry Benchmarks	0.237	0.006**	0.009**
	CI-18	Schedule Target at the Authorization Compared to Industry Benchmarks	0.340	0.074*	0.198
Economic Issues	CI-19	Project Funding Delays	0.310	0.225	0.035**
	CI-20	Clarity of Funding Process during Front End Planning	0.006**	0.134	0.069**

** denotes significance with 95% confidence level.
* denotes significance with 90% confidence level.

Based on the results presented in Table 2, nine CIs belonging to four communication categories have an impact on communication effectiveness within owner organizations such as number of financial approval authority thresholds, number of required total permits, number of external agencies required to approve design and number of owner organizations. In addition, 13 indicators belonging to six categories were found significant in communication effectiveness within designer stakeholders such as number of decision-making entities above project management, number of designer/engineer organizations and companies' familiarity with Technologies. Furthermore, As Table 2 displays, communication effectiveness within contractor

organizations could be impacted by the 14 identified CIs such as number of contractor organizations, alignment quality of internal stakeholders and number of new systems tied into existing systems.

As mentioned earlier, this paper focused on communication effectiveness indicators within primary stakeholders. Since communication has been defined as a two-way collaboration process, therefore, it is justifiable that communication indicators related to the number of project participants (owner, designer and contractor) and their internal and external interfaces were found significant. Moreover, economic issues are very important in the project development an execution lifecycle and as a result, they could affect stakeholder's internal communication quality.

Figure 2 shows the overlap between effective communication indicators among owners, contractors and designers. As it is displayed in this Figure, two entities of designers and contractors have the maximum number of shared communication indicators, which is resulted from close collaboration between the designers and contractors with the adoption of Design-Build project delivery method (majority of the selected projects had Design-Build delivery method).

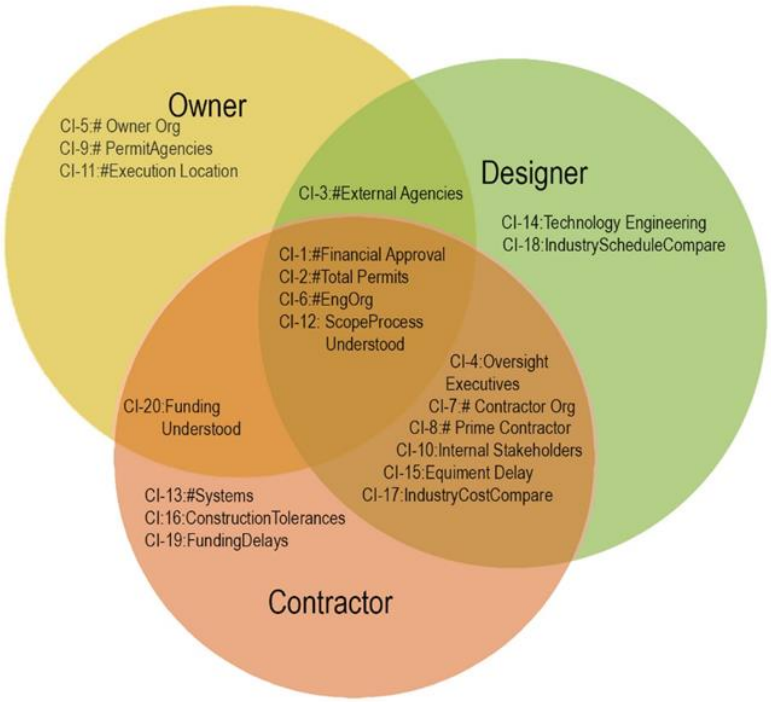

Figure 2: Significant indicators in communication effectiveness within primary stakeholders

It is worthwhile to mention that different roles and responsibilities of each of the primary stakeholders leads to the dissimilar authority and intervention level in the development and execution process of a construction project. Therefore, it is explainable why identified communication indicators are related to the stakeholder's responsibility and authority level.

Some of the indicators are relevant to all the three primary stakeholders such as understanding the scope of project and total number of required permits. If the scope of the project is not understood clearly and well within each of the three primary stakeholders, it will not be possible to communicate well and achieve project's ultimate goals.

Three effective communication indicators, which only belong to the owner entity, are "Number of owner organizations", "Number of permit agencies" and "Number of execution locations". The number of permitting

agencies is an owner organization's communication indicator since the owner has responsibility to acquire the required project permits. Obviously, number of owner organizations is another effective communication indicator since decision-making process while several organizations with different priorities are involved, could be time-consuming and challenging. In addition, number of execution locations is another effective communication indicator since multiple project locations require more managerial interactions between the owner organizations.

Company's familiarity with technology is one of the designer's/engineer's effectiveness communication indicator as new technologies may require more communications among engineer entities. In addition, the aggressiveness of the project schedule has a major impact on engineer's communication level, as design documents preparation of projects with tight schedules demand more interactions and communications among the project engineers.

Number of project's new systems is a contractor's communication indicator as more number of new systems tied into the project's existing ones calls for more contractor's communications regarding to the system's procurement logistics and execution. Funding delay, which was found as another contractors' communication indicator, is very critical to the contractors. Late funding approvals and authorizations which impacts project's execution plan, leads to ineffective communication among contractors as the project is halted and contractor's human, financial and machinery resources are wasted.

Clarity of funding process is a significant communication indicator within both owner and contractor entities as performance of these two parties is highly dependent on economic issues. In general, owners mostly offer financial resources and contractors utilize these resources to deliver the right project.

Number of external agencies is an effective communication indicator within both owner and designer stakeholders. In fact, the owner has a coordinative role in a construction project and therefore, based on their contract, the owner should get the required design permit approvals. As a result, both owners and designers should collectively cope with the difficulties imposed by external agencies and their requirements.

This study concluded that there are six effective communication indicators, which are shared between the two engineering and contractor entities. These six shared communication indicators are listed as following: (1) Number of decision-making entities above project management team in execution plan, (2) number of contractor organizations, (3) number of prime contractors, (4) cost target authorization compared to industry benchmark, (6) delay in delivery of permanent facility equipment and (5) alignment quality of stakeholders.

The results indicated there is a close working relationship between the designers and contractors. This relationship could be explained due to the nature of their roles as engineers design the technical specifications of a project and contractors use these plans to construct the physical facility. As an example, if there is any delay or disruption in delivery of project material and human resources, both of the mentioned stakeholders may bear significant financial and reputational losses.

6 CONCLUSION

This study provided a constructive way to identify project-based communication indicators for complex construction projects within the three primary stakeholders. These identified variables can help project manager to enhance the communication quality within the owners, designers and contractors. In addition, this study allows owner, consultant and contractor executives to predict the quality of communication effectiveness early in the project and increase the probability of project success by addressing communication issues and challenges before major conflicts arise.

This research concluded that some effective communication indicators such as number of financial approval authority thresholds, number of required total permits, number of designer/engineer organizations and clarity of projects scope during designer/contractor selection, are shared within each of the three primary

stakeholders. Furthermore, this study found that according to the stakeholders' authority, responsibility and intervention level, the reason behind the significance of 20 CIs could be justified. In other words, the three primary stakeholders send the related project information to other project parties. Although the content of these information and messages has not been discussed in this paper, however, potential communication areas, which could possibly cause disagreements and conflicts, have been discussed. As it was mentioned in the background section, communication is a two-way process and sender and receiver should have a common issue to have a relationship with each other. Obviously, in the first place, a construction project itself is the most important common point for the stakeholders and then, some related project details and characteristics, which influence stakeholder's communication effectiveness, is the other issue requiring two-way relationship. This study also found the shared effective internal communication indicators between the three primary stakeholders and suggested that these indicators should receive more attention to improve the overall quality of project communication. The findings of this research could help project managers and project primary stakeholders to identify the issues that may cause ineffective internal communications, and adopt proper strategies to avoid poor project performance and failures due to stakeholders' conflicts and adversarial relationships.

Review of the existing literature indicated that there are few studies which investigated stakeholders' communication and its influences on construction projects. Although the quality of internal communication within the three primary stakeholders may have a significant impact on project cost and schedule performance; however, quality of communication between project entities can also be another decisive factor in the overall success of construction projects. It is recommended that future studies focus on project physical and managerial characteristics which could potentially affect communication quantity and quality between project participants. In addition, further studies on issues which may cause conflicts and disputes between and within different stakeholder groups are suggested.

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