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RESEARCH ARTICLE

Effective communication management for mitigating potential risk in construction projects

Esam M. H. Ismaeil[1,*], Hareth Z. Alshamayleh[2], Abu Elnasr E. Sobaih[3,*]

[1] *Civil and Environmental Department, College of Engineering, King Faisal University, Al-Ahsa, 31982, Saudi Arabia*

[2] *Faculty of Business Studies, Arab Open University, Riyadh 11681, Saudi Arabia*

[3] *Management Department, College of Business Administration, King Faisal University, Al-Ahsa, 31982, Saudi Arabia*

*** Corresponding author:** emohamed@kfu.edu.sa; asobaih@kfu.edu.sa

ABSTRACT

Enhancing the quality of communication processes among all construction project stakeholders is an increasing concern among scholars and practitioners since it has substantial impact on the success of construction projects. Therefore, managing all potential risks arising from construction project communication processes is vital to construction project management success. This research addresses and analyzes potential risks in communication management processes. It also suggests an appropriate approach for dealing with such potential risks. The study methodology builds on a questionnaire survey conducted among 40 organizations working inside construction projects within the campus of King Faisal University (KFU), Saudi Arabia. The results achieved a comprehensive register of all potential risks related to communication management processes derived from statistical analysis. A flowchart was conducted to facilitate successful communication processes and reduce risks associated with communication. The results presented novel guidelines that could be widely applied in different construction project environments to improve the communication management processes and reduce associated risk.

Keywords: communication process; construction management; effective communication; risk management; stakeholders

1. Introduction

Construction projects are one of the top information-dependent in the construction industry [1]. The quality of the relationship between the clients, professionals, contractors, and sub-contractors is considered one of the important measures for the efficiency in construction projects [2]. Communication conflicts and problems during the execution of the project can directly rise unnecessary expenditure, affecting the progress and project's quality [3]. All construction stages and process execution depend on professionals transferring relevant project information to establish a buildable design and achieve the project goals. The construction project information includes drawings, specifications, bills of quantities, and conditions, considering the methods of communication among all project teams [4]. Communication is considered a term that embraces methods including transferring information, knowledge, skills, data, and technology, which affect the

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internal communication quality among project teams [5]. The quality of communication is affected by project goals, project location, design technology, project scope, resources availability, document deliverables, project management method, and material/ systems types [6].

Effective quality of internal communication with all stakeholders' management procedures, project resources management, and project targets clarity is essential and significant indicator of the successful project execution. This helps in improving project communications processes and reducing time and cost overrun [7]. Communication processes consider central nervous systems connect all project teams and all resources to perform approved project processes an d items toward achieving specific goals [8]. Construction project communication procedures, forms, contexts, and meanings have a multidimensional effect on project document information flow [9-11]. Construction project communication considers complex and dynamic process character, including sharing opinions, ideas, visions, and goals that lead to proper reactions, therefore, new organizational structure in practice revealed according to construction industry development [12]. On the other hand, poor communication leads to project risks, lower performance, and a staff higher turnover [13-15].

Effective construction project communication procedures through the organizational context facilitate instructions to the actions/behaviours of using and applying information and propagating enhanced collaboration and integration information flow within the construction team, which influences the construction project processes and achieves project success[16,17]. Communication can break down these barriers by working construction team together [18]. Understanding the risks and different elements of management ensures that all project processes are handled and has strengthened the long-term influences of different aspects of project management processes [19]. The first and most critical means of enhancing communication in any construction project is establishing an effective communication chain of command [20,21]. The clarity of information flow and required approvals procedures affect the internal communication quality between the owner's requirements, designers' documents, contractors/subcontractors' teams, and consultant organization. Effective construction project communication facilitates many cultural and organizational stakeholders with diverse levels of knowledge, perspectives, and interests to be involved in the implementation processes [22-24].

Communication planning is determining the project information flow for the stakeholders to identify the skeleton guideline approach of construction project communication [25,26]. The best-defined construction project communication is exchanging project information flow, ideas expressed using human capabilities, and other methods related to the construction projects [27,28]. The main construction projects communication levels in project management include three levels. The first level is exchange of internal information i.e., decision-making process, conduction of meetings, and daily scrums. The second level is project information management to communicate stakeholders' requirements/goals and project changes within project execution. The third level is project marketing through project presentation, and displays to employees, customers, sponsors, and end users [29,30].

This research builds on construction management and deals the matter of risk associated with communication management by using a study survey tool to support policy-makers in rectifying the communication tools and techniques and limiting the risk negative impacts on the success of communication and project success overall. This research focuses on the value of risk assessment in communication processes as a practical approach to vital construction management. This research draws on the results of survey conducted on companies operating at King Faisal University (KFU), a large public higher education institution, in Eastern Province, Saudi Arabia. The key research questions are: what is the proper tool to collect all risk elements inside communication processes in campus projects? How to manage the analysis of

collecting the study data? What are the benefits of supporting decision-makers in construction management with a robust communication approach? The next section structure of the paper explores the adopted methods and materials for the study, presenting and discussing these results, highlighting the conclusion, and study limitations with opportunities for future research.

1.1. Communication processes in construction projects

The most critical means of enhancing communication in a construction project is to establish an effective communication chain of command, which often ensures that the engineers responsible for a specific task fulfil their obligation with the right communication methods for different messages [16,17,21]. The influence of different forms of communication in illustrating how construction projects should be handled. Further influenced by the need to stick to facts and keep written communication professional at all times to promote its outcome in the long term. Besides the means of influencing positive communication, it is essential to underscore the influences of ineffective communication and how it hurts the construction process [24,32]. The impact of ineffective communication on construction can be devastating to the costs, process, and progress of the construction process and leads to poor outcomes [33,34]. Enhancing the willingness and effective communication establishes robust formal communication methods through all construction project organization teams during the construction projects accomplishing positive effect advantages of the communication procedures conflicts and overcoming the negative conflict effects within the construction project processes [35,36].

There are several reasons for building efficient and effective communication processes in construction project as would be discussed in the following. First, improving communication procedures between the owner team, consultant teams, contractor team, and the project manager could support project success and avoid failure. Second, it disseminate innovation and finding out suitable technical solutions. Third, it encourages effective involvement of all stakeholders. Fourth, it supports better decision-making solutions for updating events. Fifth, it improves formal and informal communication routes between all organizations working in the construction projects processes [37-39]. The four basic effective human and organizational communication types of construction networks routes, which represent the different construction networks links of organizations for different purposes. These four types are formal partnership, informal alliance, contractual relationships, project joint venture. **Figure 1** shows types of organization construction network. This different construction network presents contractual information relationships to connect the independent parties within contract conditions to organize activities and resources in impersonal and hierarchical relationships, without diffusion-restricted and poor flow information. The coordination structure remains hierarchical [16,24,40-42]. Communication management in construction project procedures includes three stages. First, planning and developing appropriate communications management approach based on stakeholders' information, goals, and available resources. Second, managing communications to create, collect, distribute, store, and retrieve project information. Third, controlling communications to monitor and control communication processes within the project life cycle.

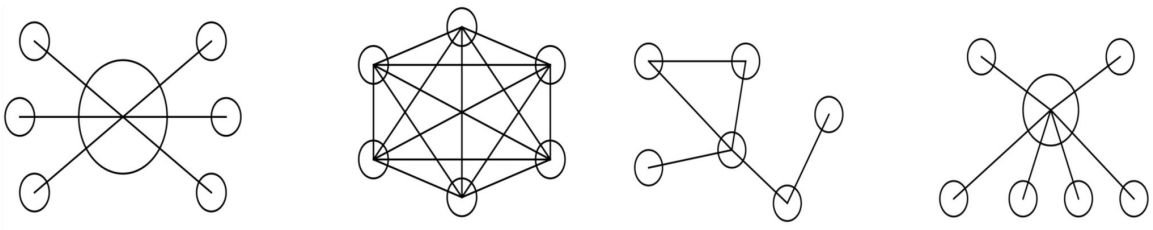

Figure 1. Types of organization construction network [24]

1.2. Communication Processes Characteristics

Researchers and engineers contend that cost and time overrun, increase in accident ratio, incorrect implementation of activities, and the possibility of rework and redesign existence are some potential outcomes of poor communication in construction projects[43,44]. The four communication theories form models to be considered in construction project communication and assessed by communication experts in various frameworks to enhance the different measurements managing different project management aspects [45-47]. These theories include the Aristotelian communication model, Berlo's communication model, the Shannon and Weaver model, and the helical model[48,49]. The essential three dimensions of communication, i.e., formal communication, informal communication, and willingness to communicate [50]. Informal communication helps team members to recognize culture, habits, and skills, thus, conflicts can be solved, and positive communication and sharing of information will increase among teams to facilitate construction project success [51,52]. The essential communication practices affecting the construction projects' success include establishing clarity of contact documents, and providing understandable clear information among all team members and stakeholders during the design and build D&B processes [54].

1.3. Risk management synergy with communication management

Risk management considers the systematic process of analysing, recognizing, and replying to methods to identify project risk, which includes maximizing positive events potentials, probability, and impacts of adverse events to achieve the project objectives [55]. Risk management considers the decision-making process to complete accepting of known risks and essential activities to decrease the influence of the risk event to decrease its complications and enhance the project's success [56].

The approach of managing risk in the construction industry include three stages: a) identifying risk, especially the vital risks, b) risk analysis and evaluation based on instinct, earlier experience, and the manager's professional judgment, and c) risk response based on sustainability, and available formal methods and managing risks starting arranging them according to two main methods are widely adopted. These include qualitative and quantitative risk analysis [57-60]. The quantitative method builds on the spreading of risk probability, while the qualitative method is built based on personal experience, intuition, and judgment [61-62]. Construction project communication risks according to their source consist of two groups: internal risks related to control communication of the project management team inside the project according to the organization i.e., the owner, designer, or contractor, while external are beyond the control of the project management team and the project environment initiated at the macro-level[63-66].

Communication risk management in public construction projects is essential in managing influences of the different communication aspects to control communication and ensure that all project processes are handled and prevent communication weaknesses [67]. The promotion of project management techniques has strengthened the long-term influences of different aspects of project management processes based on the understanding of communication in public construction projects' purpose and environment [68-69].

2. Methodology

Managing all communication processes around contractual documents information between all stakeholders and organizations involved in construction project processes should discover all potential risk types embodied inside the communication processes. This study aims to build a comprehensive communication risk management based on analysing all potential risks communication operations encounter in King Faisal University campus projects. The methodology used in this study includes a study of more than 20 organizations operating within the KFU campus in the Kingdom of Saudi Arabia. The organizations

involved in the projects of the King Faisal University campus include hundreds of members who communicate together to build more than 80 projects in an area of 4.5 km^2.

Statistical analysis was performed to assess all potential risks of all types of communications through conducting and distributing a robust and iterative study survey between a chosen sample of experts, representatives, and technical members to achieve the improvement approach proposal. The study survey was developed to elicit an answer aligned with the study objective and comprised two sections. A total of 125 questionnaires were collected and used for the study analysis. The survey represents more than 30% of the study sample, and 3% of the study society, and examined the likelihood of risk occurrence by adopting a five-point Likert scale and the degree of risk impact using a three-point Likert scale. Appendix A: Table 1. shows study field survey categories content.

All participants' identification information were not presented to protect the privacy of respondents were not presented in the findings. The first part of the study survey addressed respondents' demographics to determine the specialization of KFUs' construction project stakeholders and assess their diversity. The questions in this section included respondents' position, their type of activity, years of experience, number of communication risks solved, number of times a respondent communicated with KFU, and their percentage of success in project communication. In contrast, the other section elicited responses from different stakeholders, managing construction projects through the five main stages of construction (initiating-planning-executing-monitoring-closing) within the KFU campus regarding addressing all project's potential communication risks between KFU's teams and stakeholders. The first set of questions in the second section concerned collecting information about decision-making, technical, and administrative skills from all stakeholders within the construction sector. Second, the questions were asked to measure the effectiveness of communication processes needed to confirm the success of financial, technical, and administrative processes with five main stakeholders (the consulting organization, the technical team of the owner, the main contractor, the subcontractor, and the suppliers.

The assurance of questionnaire validity and reliability is a practical method that supports all involved members to reply and explain all information about all potential risks that occurred through the project lifecycle. It also important for ensuring valid and reliable results. The study team was keen to ensure valid and reliable results, which were first tested with 12 university professors for face and content validity. The study was conducted between December 2021 and November 2022. Data were collected via structured survey, which were also performed online questionnaire and later subjected to statistical processing. Appendix A: **Table 2** addresses the qualitative and quantitative risk analysis register form, which consists of five main categories to support the decision-maker to take proper action according based on the study survey design (the author).

The statistical results provide significant results focused on comprehensive potential risks register and updating forms and submittals as an official procedure used in operating execution communication for KFU campus ongoing projects for decision-maker and all project managers and their teams. Analysis and evaluation for questioners in the construction field is a practical method that supports all involved members to reply and explain all information about all potential risks that occurred through the project lifecycle, which is considered robust and realistic information. **Figure 2** shows the sequence of the study.

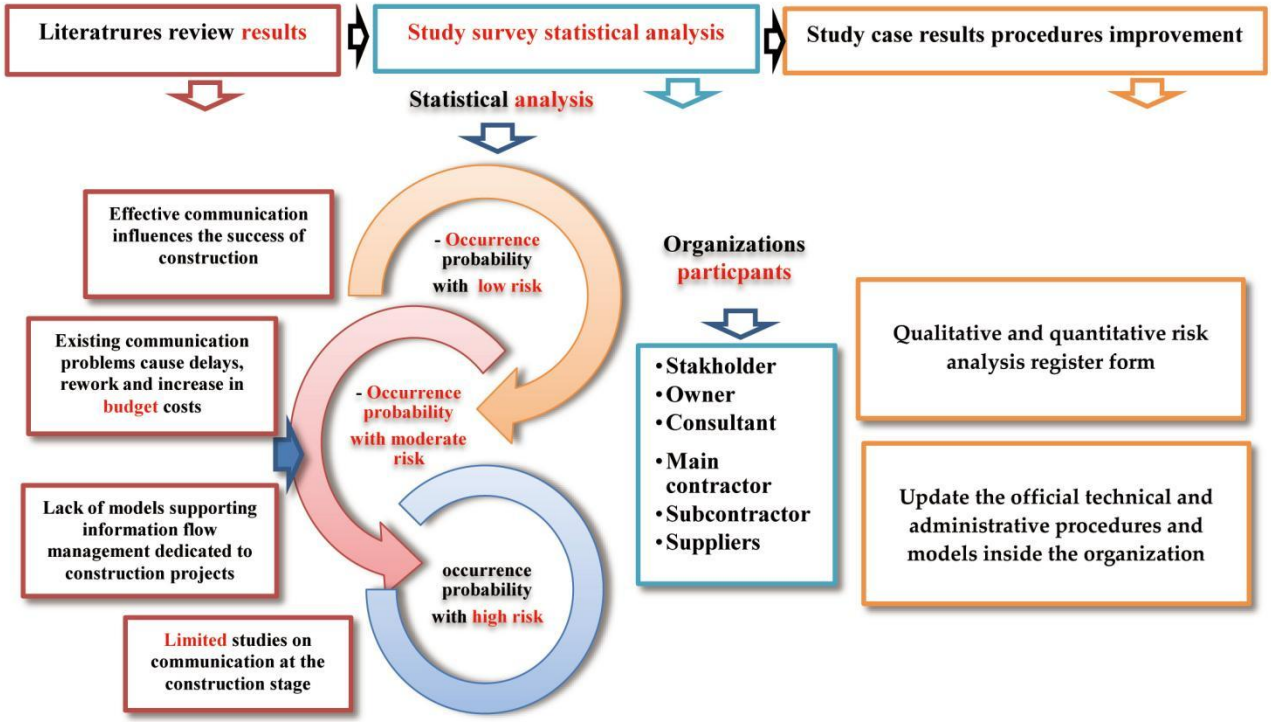

Figure 2. Sequence of the study methodology

The study survey concentrated on King Faisal University campus project KFUCP as mega project, which contained 72-construction project with 10 billion SAR cost from a comprehensive educational campus with all the facilities needed to achieve its goals, which has an area of about (4.5) million square meters, with a total capacity of (45,000) male and female students and average 15000 employees. According to project management and application science, the project stakeholders involved in all communication channels must be identified during the preparation of the project identification document, project feasibility document, project plan, and project communication plan. Tender documents for all projects in KFUCP include different mandatory types almost repeated for each project, and all members communicate around it to manage starting from the design process till handover process, as an example: complete specification for each item, clear bill of quantities BOQ as pricing list for each item, comprehensive drawings for all disciplines (architect-mechanical-electrical-civil), general and conditions, all Correspondences and forms owned to KFU organization.

All communication channel processes, which occur in both formal and informal procedures and scope, carry many risks in their natural effect on the communication Improvement approach in KFUCP. Implementing this educational campus as a mega project required building a robust and iterative communication management hierarchy between all teams involved in campus execution like design team, owner technical team, owner committees, stakeholders committees, contractor team, subcontractor team, suppliers, external firms, local organizations. All these communication departments or teams involved in KFUCP include:

- The owner team includes the contracts and finance affairs department, project management administrative, and technical teams.

- The execution team includes the design consultant, supervising consultant, main contractor teams, subcontractors' team, material and systems suppliers, and manufacturers list.
- Stakeholders committees include bidding analysis, rector and vices-rector, finance affairs, legal affairs, and maintenance and operation departments.
- External organizations committees include all government ministries related to engineering and academic and educational Affairs end-user requirements.

Figure 3 shows the intertwined relations for the communication channels in KFUCP among all teams involved in the execution of KFUCP within five construction stages (initiation, planning, execution, monitoring, and closing). The main core for these intertwined communication channels in KFUCP is the contractual documents called tender documents that contain all information and data of implementing all construction processes from the design phase till the handover phase.

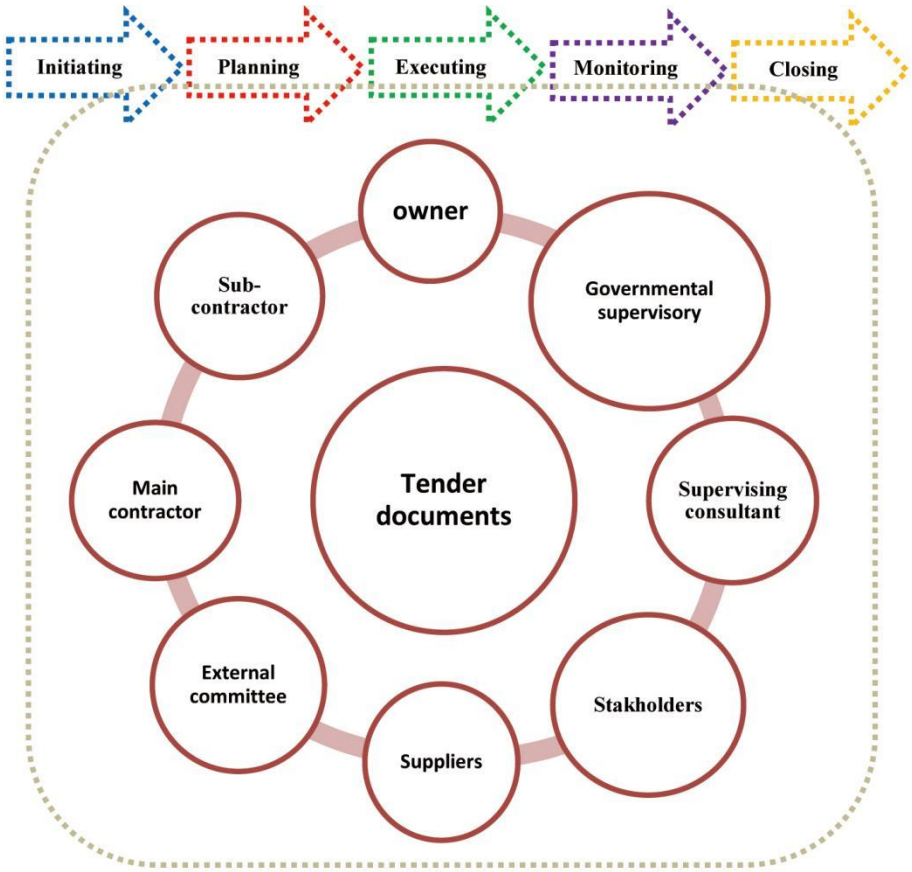

Figure 3. Intertwined relations for the communication channels in KFUCP [25]

The average amount of official contractual documents for execution until the project handover reaches about 3000 documents paper, including scheduled time, drawings, and official submittal forms to make all required technical and administrative procedures. There are additional approximately 2000 documents paper to complete the as-built document. The average communication channels essential needed for all technical and administrative procedures to support the successful status of the project reach about 30 channels continuously with different periods within the project lifecycle, **Table 1** shows the type and time of the communication procedures between the organization or teams involved essential in KFUCP communication processes over the daily working hours, which reach about 8 hours per day, and which can be summarized as follows: meetings (periodic - emergency) with all stakeholders' levels, reports (daily/monthly/yearly -

specialized), site execution forms and submittals for all disciplines of engineers, correspondence forms (paper - electronic (email) - telephone (by phone), field visits (periodic - emergency), social and business communication (email – WhatsApp), and official organization website.

Table 1. Type and time of the communication procedures in KFUCP [53]

Communication medium	Communication status	Communication time
Consultant with owner	Meetings - Field visits - Credits on approved paper forms - Official correspondence - Reports	every two weeks/daily
Consultant with the main contractor	Meetings - approved paper forms - official correspondence - field supervision	Weekly/daily
Consultant with sub-contractors / suppliers	Meetings - approved paper forms - reports - field supervision	Weekly/daily
Consultant with governmental and supervisory committees	Meetings - reports	Almost every two months
owner with governmental and supervisory committees	Meetings - official correspondence	Almost every two months
owner with the main contractor	Meetings - approved paper forms - official correspondence - field visits	every two weeks/daily
Owner with sub-contractors / suppliers	Meetings - accreditation by certified paper forms - official correspondence - field visits	Almost every month

All communication procedures among all teams member participating in the campus construction projects to facilitate all projects success; however, they encounter a range of risk effects ranking from high to low with different range of occurrence probability. All communication risks affect project progress negatively and encounter cost and time overrun. This study focus on identifying all potential communication risks that could occur in construction projects by using field survey to prove the list of communication risks occurs through the construction operations from initiation stage until handover stage. The study results proved the importance of avoiding and solving all potential communication risks in construction projects to facilitate high communication among all team members and achieve success considering project time, cost, and quality.

3. Results and discussions

3.1. Characteristics of respondents

The study survey was directed to a purposive sampling. It targets engineers and other related experts who work in all stages of construction projects in KFUCP, who also had many years of experience in construction projects. The respondents were asked to disclose whether: a) respondent position include project manager, site engineer, technical engineer, account, and administrative. The most group of participants were field engineer (41%), followed by project manager (19%) and technical engineer (10%) (See Appendix B, **Figure 1**). With regard to years of experience, the majority 52% have experience between 5 to 15 years, followed by those who have 15 to 25 years (23 %), and then those more than 25 years (13 %). Only 12 % of participants have less than 5 years experience as shown in in Appendix B (**Figure 2**). Regarding number of communication risks solved: from 1 to 5 (55%), from 6 to 10 (12 %), and more than 10 (33%) (Appendix B, **Figure 3**). With regard to the number of times have communicated with company: less than 5 times (4%), from 5 to 15 times (33%), from 15 to 25 times (39%), more than 25 times (24%) (Appendix B **Figure 4**). Respondents' successful percentage of success in project communication reached ratio of 100% (61%) as shown in in Appendix B, **Figure 5**).

3.2. Respondent's opinion about potential risks in the stakeholder category

The stakeholder category has 11 potential risk items. The inquiries in this section included; skills and procedures in communication, information and technical staff; impartiality; technical and financial matters

integration, and time for necessary decisions. In addition, obstacles encountered by stakeholders such as: relying only on the financial criterion, has not a particular timetable for fine-tuning the communication process between stakeholders teams, specialists' absence from meetings, and technical capacity to make the required adjustments to the project. Appendix B (**Table 1**) shows respondents' opinions regarding this issue with mean range between 2.2 and 2.5, and the standard deviation ranges between 0.62 and 0.72 indicating the values tend to be close to the mean.

3.3. Respondent's opinion about potential risks in the owner technical team category

The owner's technical team roles in construction projects impact essentially on the project's success status. The study survey was titled potential risk items in 8 inquiries for the respondent. The inquiries discussed scheduling regular meetings with project parties. The inquiries investigate sufficient reporting data and information; and analyse the report's results in corrective action; the monthly report contains a comparative analysis of approved submittals within the scheduled time. Furthermore, the inquiries asked about procedures to update project standard forms; coordination between engineering disciplines; updating job descriptions in all disciplines; and communications methods are centralized. The mean ranges between 2.2 and 2.4, and the standard deviation ranges between 0.56 and 0.69 indicating the values tend to be close to the mean. Appendix B (**Table 1**) shows all respondents' opinions.

3.4. Respondent's opinion about potential risks in the consultant category

The consultant organization by the owner inquiries in the study survey titled 16 items investigates the technical structure's effectiveness in communication processes. The inquiries include categories to discover the consultant's role in potential risks in communication. First: the experience in aligning between approved times and approved documents; coordination between departments to avoid common design errors; teams are or are not committed to routes and timings for approving procedures; relying on oral directions only; identification of technical and administrative responsibilities in communicating with other parties; governance standard of projects policies; periodic follow-up for change orders is not apparent. Second: transmission of confidential information; technical information development as technical problems solutions; quantity surveyor works often trusted; interpersonal communication skills influence; readiness in the specialization details during the communication process (field visits - meetings); a cohesiveness of communication procedures between technical and administrative teams; disciplines work Follow-up according to specific forms; using checklist procedure to follow-up after work; specific agenda for periodic meetings. The consultant communication has mean range between 2.0 and 2.5, and standard deviation ranges between 0.58 and 0.81 indicating the values tend to be close to the mean. Appendix B (**Table 1**) shows all respondents' opinions.

3.5. Respondent's opinion about potential risks in the main contractor category

The contractor inquiries in the study survey were titled in 12 items. The inquiries include categories to discover the main contractor role in potential risks in communication grouped in two categories: First: time to obtain the required data; standardization of references and governing policies; amendments and changes in items submission forms; standardization of communication language within the project; the control core of technical and administrative communication; adopted submittals with organization conditions; teams are not supported financially by the head office or banks; initial and final handover phase takes a long time. Second: all members' awareness of modern communication programs; financial support by the head office or banks for all members; the impact of quantities inventory forms before and during project implementation; all members must commit to specific paths of project communication submission. The contractor

communication has mean range between 2.1 and 2.5, and standard deviation ranges between 0.62 and 0.78 indicating the values tend to be close to the mean. Appendix B (**Table 1**) shows all respondents' opinions.

3.6. Respondent's opinion about potential risks in the subcontractor category

The sub-contractor is an organization that executes parts of a project under the main contract. The inquiries in the study survey were titled in 3 items. The inquiries include questions to discover the subcontractor's influence on communication process potential risks, a good understanding of approved submittal procedures, technical information content, and effectiveness in informal meetings. The subcontractor communication potential risks had reached a probability of 68.952% and a high-risk occurrence degree of 2.4 with an average range between 2.3 and 2.5, and standard deviation ranges between 0.59 and 0.71 indicating the values tend to be close to the mean. Appendix B (**Table 1**) shows all respondents' opinions.

3.7. Respondent's opinion about potential risks in supplier category

The supplier's firm is an organization that delivers all project materials and systems under the main contract. The inquiries in the study survey were titled in 3 items. The inquiries include discovering the supplier's influence on communication processes' potential risks; correct reading of project specifications, obtaining required certificates and guarantees for all materials and systems supplied; and commitment to the supply-approved materials procedures. The supplier communications potential risks had mean range between 2.3 and 2.5, and standard deviation ranges between 0.65 and 0.70 indicating the values tend to be close to the mean. Appendix B (**Table 1**) shows all respondents' opinions.

3.8. The stability of the study survey measures

The risks mentioned in the study survey for all teams of different organizations, their probability of occurrence reaches an overall rate of 72.1% with a moderate risk degree. Ensure the answers will be approximately the same if they are repeatedly applied to the same study sample. To measure the reliability of the study survey one, the authors used the stability factor (Cronbach's Alpha) to ensure the stability of the study tool, which reached a value of (0.745). This indicates that the general stability factor of the study is high, which indicates also that the study survey has a high degree of stability that can be relied upon in the application field of the study, where the statistically acceptable value in this test is 60%, which is an acceptable percentage that is suitable for researches in the business field[71].

Figure 4 shows the potential communications risks average in case study KFUCP based on study survey respondents about the five organizations and firms working in the study case KFUCP stakeholder 80.94% with moderate risk degree, owner team 68.09% with high-risk degree, consultant 69.25% with moderate risk degree, main contractor 74.38% with high-risk degree, subcontractor 68.95% with high risk degree, suppliers 68.23% with moderate risk degree, and average agree for total 72.10% with moderate risk degree.

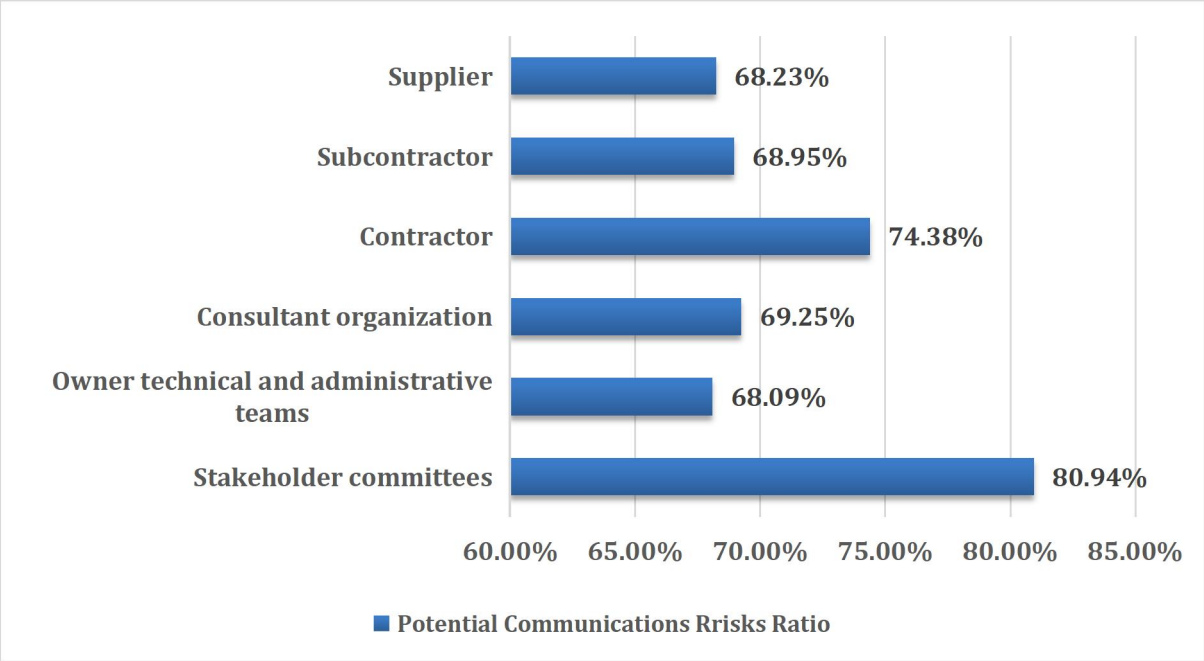

Figure 4. Potential communications risk average in KFUCP relating the six categories

According to communications risks monitored, deduced, and analysed through the study survey distributed to approximately 125 engineers, administrators, and technicians involved in KFUCP, there were significant evidences and results in communication processes to support officials' decision-makers to build the project's success status with its main constraints. As the literature review presented, within the period 1986 - 2020, more than 103 studies related to communication in construction projects in relation to five main factors: effectiveness in project success; negative application of the procedure for time, cost, and quality; influence in project delays; effect in the redesign and rework; influence in workstation health and safety. Nevertheless, limited studies addressed the issue of communication in construction phase. The number of research that addressed communication in the construction context is limited [70]. The review of earlier studies []see for examples, 1,2,7,11,13,14,17,19,25,26,31,45,46,48,52,55,57,62[] showed a gap in analysis of communication potential risks and how to deal with them during the project lifecycle focuses on how to make an assessment study for potential risks in communications management processes topic inside ongoing projects inside public campus and support construction project successful and investments status by KFU. Therefore, Statistical analysis was performed to make an assessment for all potential risks of all types of communications through conducting and distributing a robust and iterative study survey among a chosen sample from experts, representatives, and technical members involved to achieve the improvement approach proposal. Based on the knowledge from literature review work and study results. This study investigates how to handle all potential risks for KFU project management through partnerships between several agencies (such as the university's team, the projects management experts, private organizations firms, and municipal governments). This study addressed the gap in global research by presenting a survey study for a specific construction project performed in Saudi Arabia on a group of 120 construction project participants from 5 leading organization practitioners. Based on the study survey and literature review results, the authors analysed the need to develop procedures to support effective communication between all organization construction project participants in the study case.

The results showed valuable information on potential communication risks and its information flow procedures and submittals in the construction execution phase. The owner should have full awareness about manipulating the risks inside communication processes and submit significant potential risks spreadsheet

register in communication processes, which enables to register the proper corrective and preventive action towards any potential communication risks and draw risk indicators for each submittal belonging to the execution construction phase procedures. Therefore, a dynamic mutual analysis manner was built through the project lifecycle based on 53 communication risks most likely to occur and 66 proper actions, consequently improving 15 official corresponding and submittals as official communication procedures.

4. Conclusion

Construction projects contain numerous communication processes between all organization's working teams in construction project, which generally contain potential risk aspects that affect project success.

Evaluation of all potential risks found in communication processes using statistical analysis and expert opinion is a practical and applicable approach to support crisis reduction and project success status. Overcoming potential risks registered to encounter the communication processes within the project lifecycle facilitates and supports all organizations working on construction projects to success status. This study addressed a gap in literature review and presented the results of a survey study for a specific construction project performed in Saudi Arabia on a group of 120 participants from 5 leading organization practitioners. Therefore, a dynamic mutual analysis was built through the project lifecycle based on 53 communication risks that were most likely to occur and 66 proper actions, consequently improving 15 official correspondence and submittals as official communication procedures.

5. Limitations of the Study

This research achieved significant results on communication risks in specific construction projects using statistical analysis for experts' opinions in construction fields for public education campus projects as a case study. However, the results are limited to other public construction projects in the same context and identifying the risks list encounter the organizations through projects execution. Additionally, despite the study tool's quality in collecting experts' opinions, the method used in the study survey is influenced by some issues such as self-reporting. The data could be subjective. The study opens the door for future studies on public organizations' construction projects concerning controlling risks in communication processes like commercial and healthcare projects. Additionally, the design processes phase and execution phase impacts can be another approach area of research.

Author contributions

Conceptualization, EMHI, HZA and AEES; methodology, EMHI; software, EMHI; validation, EMHI and AEES; formal analysis, EMHI; investigation, EMHI; resources, EMHI and AEES; data curation, EMHI; writing—original draft preparation, EMHI, HZA and AEES; writing—review and editing, EMHI and AEES; visualization, EMHI and AEES; supervision, EMHI and AEES; project administration, EMHI; funding acquisition, EMHI and AEES. All authors have read and agreed to the published version of the manuscript.

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Conflict of interest

The authors declare no conflict of interest.

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Appendix A:

Table 1. Study survey categories content

Potential risks items	Impact			Occurrence probability				
	High	**Medium**	**low**	**Strongly Disagree**	**Disagree**	**neutral**	**agree**	**Strongly agree**
Stackholders								
Poor communication skills of the decision maker.								
Slow procedures from decision-making.								
Lack of information required for the decision-maker.								
There is a degree of impartiality in the decision-maker.								
Poor ability to match the technical and financial parameters of the decision-maker.								
Lack of technical staff among decision-makers.								
Consuming a long time in communication to complete the documents necessary to make a decision.								
Rely only on the financial criterion in making a decision.								
There is no special timetable for fine-tuning the communication process between stakeholders.								
Absence of some specialists and stakeholders from meetings.								
Lack of technical capacity of some decision-making bodies in making the required adjustments to the project.								
The technical tam of the owner								
No regular meetings with project parties.								
Inadequate and inadequate reporting.								
Failure to analyze the results of the reports and not take corrective action after them.								
Failure to update the standard forms used in the project.								
The monthly report does not contain a comparative analysis of the path of crediting models with the schedule.								
Poor coordination of the course of credits between engineering departments.								
Lack of updating of job descriptions in disciplines with natural engineering overlap.								
Centralization of communication with the length of the chain of credits.								
Consultants								

Appendix A Table 1 *(Continue)*

Potential risks items	Impact			Occurrence probability				
	High	**Medium**	**low**	**Strongly Disagree**	**Disagree**	**neutral**	**agree**	**Strongly agree**
Lack of experience in aligning crediting times and lack of crediting documents.								
Poor coordination between departments to avoid common design errors.								
Lack of identification of technical and administrative responsibilities in communicating with other parties								
Failure to adhere to the established routes and timings for accreditation.								
Rely on oral directions only.								
Poor transmission of confidential information.								
Poor technical information Development leads to poor solutions to technical problems.								
Inaccuracies in the work of technical inventory.								
Poor interpersonal skills in communication and the sphere of positive influence.								
Lack of readiness in the details of the specialization during the communication process (field visits - meetings -...).								
Confusion between technical and administrative communication circles.								
Lack of standardization of references and policies governing projects.								
Poor method of periodic follow-up of realistic purchase orders.								
Poor follow-up is required for work according to established models.								
Poor follow-up after adopting the forms with the checklist (l el) for each item.								
Poor tribal and remote arrangement of periodic meetings.								
Main contractor								
It takes a long time to obtain the required data.								
Lack of standardization of references and governing policies								
Frequent amendments and changes in submission forms for items.								
Lack of standardization of communication language within the project								
Non-adoption of the use of some modern communication programs.								
Centralization of decision-making in technical and administrative communication.								
Lack of total inventory before and during project implementation which affects effective communication procedures.								

Appendix A Table 1 *(Continue)*

Potential risks items	Impact			Occurrence probability				
	High	Medium	low	Strongly Disagree	Disagree	neutral	agree	Strongly agree
Poor presentation of works, materials, or plans to be adopted.								
Poor course of financial support from the head office or banks.								
Weak technical and administrative support from the main office of the project crews.								
Failure to adhere to specific paths of communication.								
Poor submission of the project closure and initial delivery phase.								
Subcontractors								
Lack of good understanding of credit model trading								
Incomplete technical submissions for completion of works.								
Poor effectiveness in formal meetings.								
Suppliers								
Incorrect reading of project specifications.								
Not to bring the required certificates and guarantees for the materials and systems supplied.								
Failure to follow the approved procedures when supplying materials to the project.								

Appendix A Table 1 *(Continue)*

Table 2. Qualitative and quantitative risk analysis register form.

Category	Potential Risks Items	Evaluation Committee with project manager		Duration time		Date .. /.. / 20.. Repres. Eng./ ……		
		the occurrence probability of 70% with occurrence degree (moderate or high)	Proper action (corrective or preventive)	Adopted with project base schedule			Submittal form	Rev
				Daily	weekly	Monthly		
Stakeholder	Poor communication skills of the decision maker.							
	Slow procedures from the decision-making.							
	Lack of information required for the decision-maker.							
	There is a degree of impartiality in the decision-maker.							
	Poor ability to match the technical and financial parameters of the decision-maker.							
	Lack of technical staff among decision-makers.							

Appendix A Table 2 *(Continue)*

Category	Potential Risks Items	Evaluation Committee with project manager		Duration time		Date .. /.. / 20.. Repres. Eng./ …….		
		the occurrence probability of 70% with occurrence degree (moderate or high)	Proper action (corrective or preventive)	Adopted with project base schedule			Submittal form	Rev
				Daily	weekly	Monthly		
	Consuming a long time in communication to complete the documents necessary to make a decision.							
	Rely only on the financial criterion in making a decision.							
	There is no special timetable for fine-tuning the communication process between stakeholders.							
	Absence of some specialists and stakeholders from meetings.							
	Lack of technical capacity of some decision-making in making the required adjustments to the project.							
The technical team of the owner	No regular meetings with Project parties.							
	Inadequate and inadequate reporting.							
	Failure to analyze the results of the reports and not take corrective action after them.							
	Failure to update the standard forms used in the project.							
	The monthly report does not contain a comparative analysis of the path of crediting models with the schedule.							
	Poor coordination of the course of credits between engineering departments.							
	Lack of updating of job descriptions in disciplines with natural engineering overlap.							
	Centralization of communication with the length of the chain of credits.							
Consultant	Lack of experience in aligning crediting times and lack of crediting documents.							
	Poor coordination between departments to avoid common design errors.							
	Lack of identification of technical and administrative responsibilities in communicating with other parties							
	Failure to adhere to the established routes and timings for accreditation.							
	Rely on oral directions only.							
	Poor transmission of confidential information.							
	Poor technical information Development leads to poor solutions to technical problems.							
	Inaccuracies in the work of technical inventory.							

Appendix A Table 2 *(Continue)*

Category	Potential Risks Items	Evaluation Committee with project manager		Duration time		Date .. /.. / 20.. Repres. Eng./ …….		
		the occurrence probability of 70% with occurrence degree (moderate or high)	Proper action (corrective or preventive)	Adopted with project base schedule			Submittal form	Rev
				Daily	weekly	Monthly		
	Poor interpersonal skills in communication and the sphere of positive influence.							
	Lack of readiness in the details of the specialization during the communication process (field visits - meetings -...).							
	Confusion between technical and administrative communication circles.							
	Lack of standardization of references and policies governing projects.							
	Poor method of periodic follow-up of realistic purchase orders.							
	Poor follow-up is required for work according to established models.							
	Poor follow-up after adopting the forms with the checklist (l el) for each item.							
	Poor tribal and remote arrangement of periodic meetings.							
Main contractor	It takes a long time to obtain the required data.							
	Lack of standardization of references and governing policies							
	Frequent amendments and changes in submission forms for items.							
	Lack of standardization of communication language within the project							
	Non-adoption of the use of some modern communication programs.							
	Centralization of decision-making in technical and administrative communication.							
	Lack of total inventory before and during project implementation which affects effective communication procedures.							
	Poor presentation of works, materials, or plans to be adopted.							
	Poor course of financial support from the head office or banks.							
	Weak technical and administrative support from the main office of the project crews.							
	Failure to adhere to specific paths of communication.							
	Poor submission of the project closure and initial delivery phase.							
Sub-Contractor	Lack of good understanding of credit model trading							
	Incomplete technical submissions for completion of works.							

Appendix A Table 2 *(Continue)*

Category	Potential Risks Items	Evaluation Committee with project manager		Duration time		Date .. /.. / 20.. Repres. Eng./ …….		
		the occurrence probability of 70% with occurrence degree (moderate or high)	Proper action (corrective or preventive)	Adopted with project base schedule			Submittal form	Rev
				Daily	weekly	Monthly		
	Poor effectiveness in formal meetings.							
Suppliers	Incorrect reading of project specifications.							
	Not to bring the required certificates and guarantees for the materials and systems supplied.							
	Failure to follow the approved procedures when supplying materials to the project.							

Appendix A Table 2 *(Continue)*

Appendix B. Characteristics of respondents

Figure 1. Respondent Position

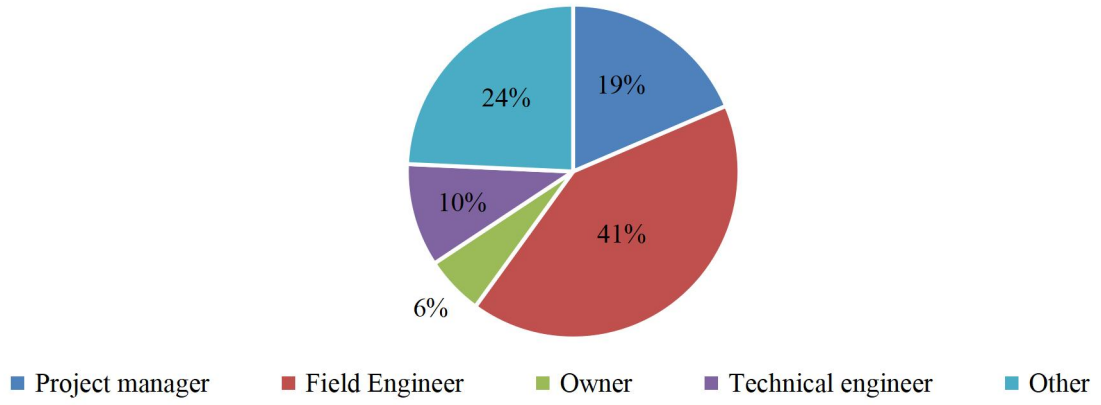

Figure 2. Years of experience

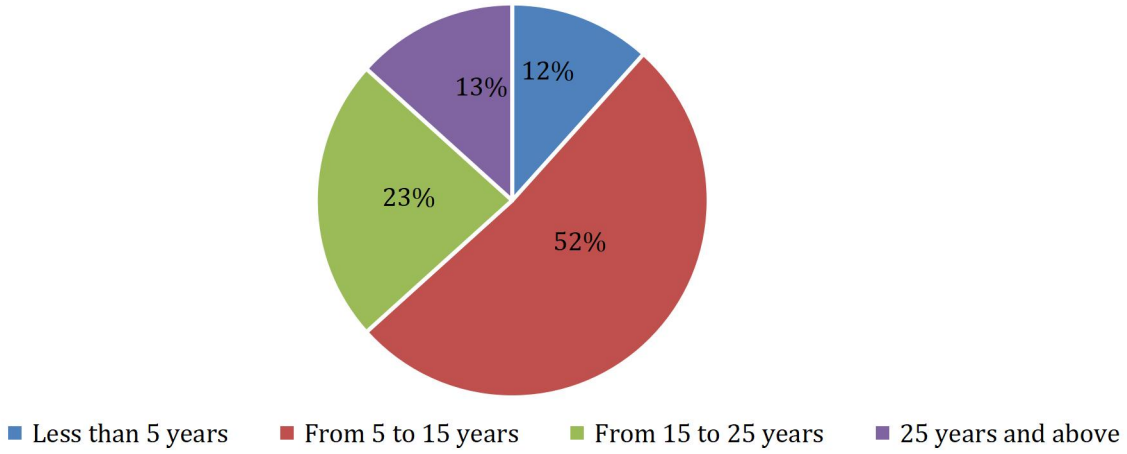

Figure 3. Number of communication risks solved

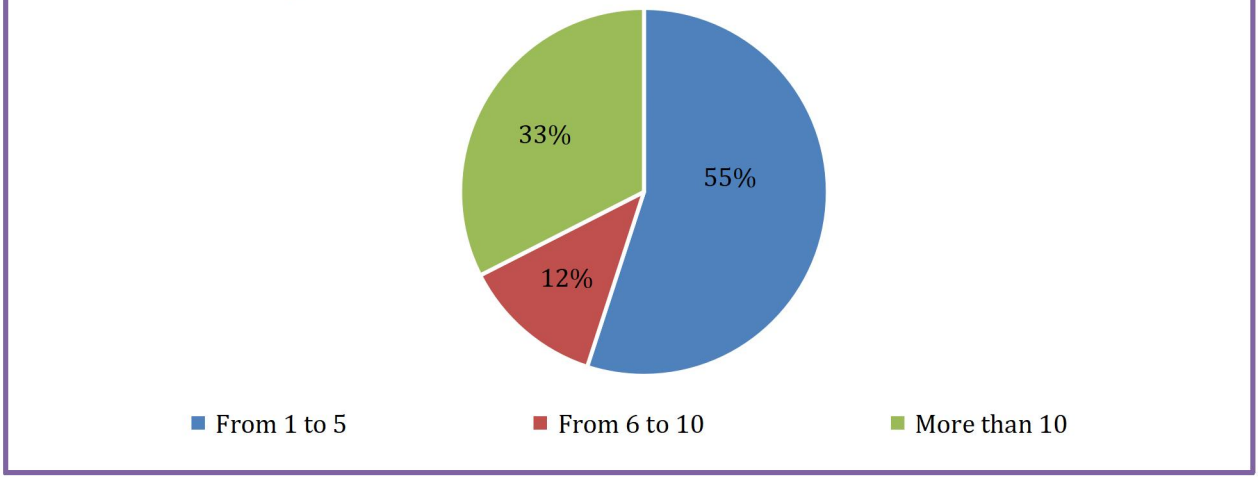

Figure 5. Percentage of success in project communication

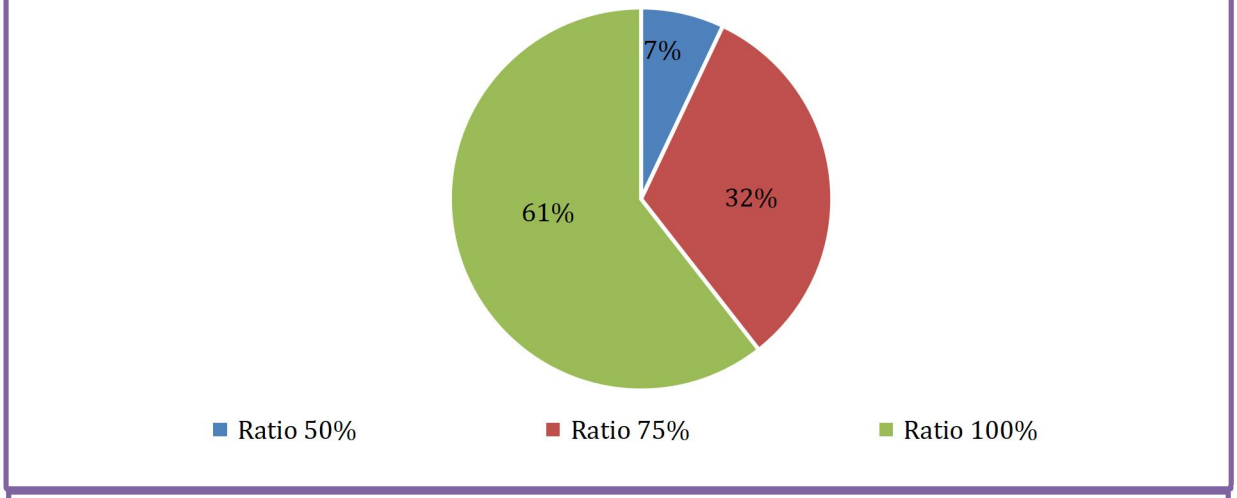

Figure 4. Number of times have communicated with company

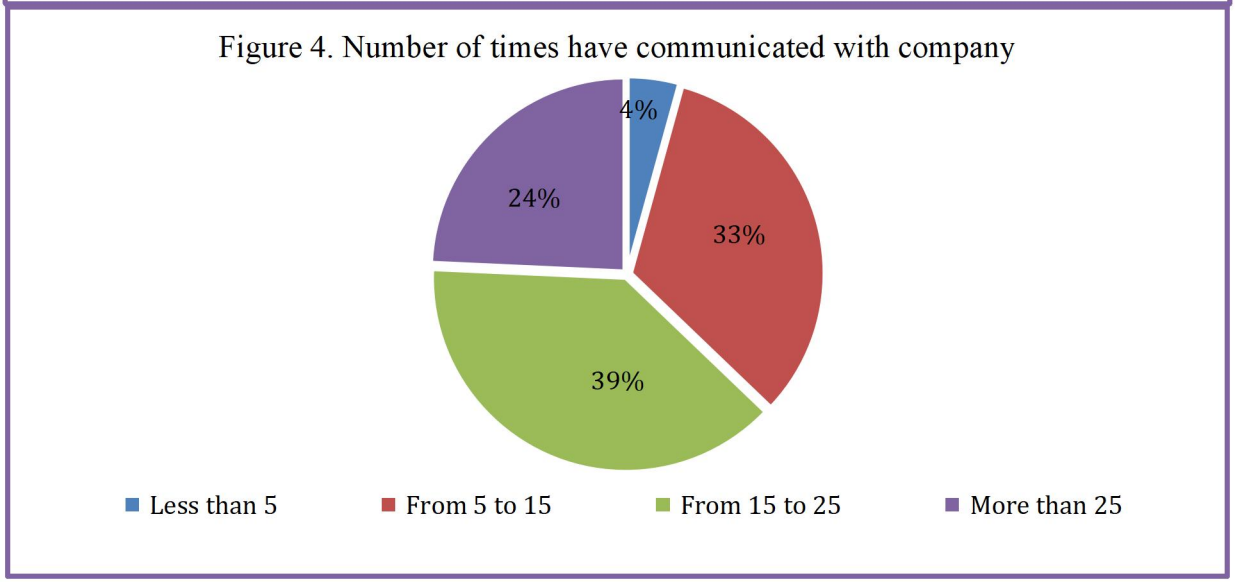

Table 1. Results of respondents.

Potential Risks Items	**Mean**	**SD**
Stakeholder	2.420	0.670
Poor communication skills of the decision maker.	2.371	0.700
Slow procedures from the decision-making.	2.386	0.661
Lack of information required for the decision-maker.	2.429	0.623
There is a degree of impartiality in the decision-maker.	2.514	0.649
Poor ability to match the technical and financial parameters of the decision-maker.	2.457	0.690
Lack of technical staff among decision-makers.	2.414	0.727
Consuming a long time in communication to complete the documents necessary to make a decision.	2.514	0.712
Rely only on the financial criterion in making a decision.	2.429	0.645
There is no special timetable for fine-tuning the communication process between stakeholders.	2.457	0.711
Absence of some specialists and stakeholders from meetings.	2.386	0.682

Potential Risks Items	**Mean**	**SD**
Lack of technical capacity of some decision-making in making the required adjustments to the project.	2.271	0.608
The technical team of the owner	2.310	0.650
No regular meetings with project parties.	2.200	0.646
Inadequate and inadequate reporting.	2.371	0.636
Failure to analyze the results of the reports and not take corrective action after them.	2.443	0.647
Failure to update the standard forms used in the project.	2.242	0.685
The monthly report does not contain a comparative analysis of the path of crediting models with the schedule.	2.314	0.687
Poor coordination of the course of credits between engineering departments.	2.343	0.695
Lack of updating of job descriptions in disciplines with natural engineering overlap.	2.229	0.565
Centralization of communication with the length of the chain of credits.	2.314	0.645
Consultant	2.290	0.670
Lack of experience in aligning crediting times and lack of crediting documents.	2.271	0.631
Poor coordination between departments to avoid common design errors.	2.4	0.641
Lack of identification of technical and administrative responsibilities in communicating with other parties	2.343	0.652
Failure to adhere to the established routes and timings for accreditation.	2.300	0.594
Rely on oral directions only.	2.514	0.671
Poor transmission of confidential information.	2.357	0.757
Poor technical information Development leads to poor solutions to technical problems.	2.343	0.607
Inaccuracies in the work of technical inventory.	2.271	0.631
Poor interpersonal skills in communication and the sphere of positive influence.	2.271	0.653
Lack of readiness in the details of the specialization during the communication process (field visits - meetings -...).	2.343	0.583
Confusion between technical and administrative communication circles.	2.271	0.608
Lack of standardization of references and policies governing projects.	2.171	0.717
Poor method of periodic follow-up of realistic purchase orders.	2.357	0.633
Poor follow-up is required for work according to established models.	2.214	0.773
Poor follow-up after adopting the forms with the checklist (l el) for each item.	2.200	0.689
Poor tribal and remote arrangement of periodic meetings.	2.071	0.816
Main contractor	2.300	0.700
It takes a long time to obtain the required data.	2.500	0.649
Lack of standardization of references and governing policies	2.157	0.710
Frequent amendments and changes in submission forms for items.	2.214	0.674
Lack of standardization of communication language within the project	2.314	0.687
Non-adoption of the use of some modern communication programs.	2.257	0.648
Centralization of decision-making in technical and administrative communication.	2.429	0.709
Lack of total inventory before and during project implementation, which affects effective communication procedures.	2.457	0.625
Poor presentation of works, materials, or plans to be adopted.	2.257	0.690
Poor course of financial support from the head office or banks.	2.357	0.655

Appendix B Table 1 *(Continue)*

Potential Risks Items	**Mean**	**SD**
Weak technical and administrative support from the main office of the project crews.	2.200	0.786
Failure to adhere to specific paths of communication.	2.157	0.786
Poor submission of the project closure and initial delivery phase.	2.342	0.754
Sub-Contractor	2.400	0.650
Lack of good understanding of credit model trading	2.342	0.715
Incomplete technical submissions for completion of works.	2.300	0.640
Poor effectiveness in formal meetings.	2.571	0.599
Suppliers	2.320	0.690
Incorrect reading of project specifications.	2.371	0.700
Not to bring the required certificates and guarantees for the materials and systems supplied.	2.343	0.652
Failure to follow the approved procedures when supplying materials to the project.	2.243	0.706

Appendix B Table 1 *(Continue)*