CRITICAL FACTORS FOR MANAGING PROJECT COMMUNICATION AMONG PARTICIPANTS AT THE CONSTRUCTION STAGE

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Critical Factors for Managing Project Communication among Participants at the Construction Stage

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DECLARATION

I hereby declare that this thesis is my own work and that, to the best of my knowledge and belief, it reproduces no material previously published or written, nor material that has been accepted for the award of any other degree or diploma, except where due acknowledgement has been made in the text.

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ABSTRACT

Technically complex construction projects often involve interests-competing and task interrelated organisations to execute and manage projects during the construction process. The construction process has therefore become a collaborative activity which requires inputs from different organisations. Project team communication, which is the transmission and interchange of project related information among building participants, is a vital process to effectively accomplish and coordinate construction work. This research examines the critical factors for managing project team communication at the construction stage. These factors could impact project team communication performance and are called communication factors in this study.. The research started by identifying these critical factors through comprehensive literature reviews. A pilot questionnaire survey to investigate construction professional opinions was then conducted to examine the significance and comprehensions of the identified factors. A framework of critical factors for managing project team communication has been built up from both theoretical and practical points of view in this study. The understanding of the identified communication factors provides a framework for project participants to develop strategies for improving communication effectiveness at the construction stage. An empirical questionnaire survey was further carried out to investigate the impacts of the communication factors on communication performance. Understanding the impacts of these factors can help to improve the communication

performance indicators by applying needed actions to the related predicting factors. Therefore, effectively managing these factors in practice can improve the communication performance and further benefit both individual project team members and the objectives of the whole project.

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CHAPTER 1. INTRODUCTION

1.1 BACKGROUND

Implementing building projects is a complex activity which is conducted by many specialised organisations. During the last few decades, the construction industry has been experiencing increased demands from building projects clients with respect to a wider set of use functions (Luiten and Tolman, 1997). To meet these demands, building projects have become more large and sophisticated with complex activities which require multiple inputs from different specialised organisations (Anumba and Evbuomwan, 1999; Pietroforte, 1997; Shohet and Frydman, 2003; Thomas *et al*., 1998; Walker and Peansupap, 2004b). These organisations then form a task based project team to implement design, construction, and management activities in order to accomplish a building project (Pietroforte, 1997; Thomas *et al*., 1998). Typically, a project team includes the participation of clients, architects, consultants, engineers, main contractors, sub-contractors, and suppliers.

The building process is the coordination of activities among the task oriented project team members, which highly depends on the communication of information between them (Anumba and Evbuomwan 1999; Dawood *et al*., 2002; Thomas *et al*., 1998; Walker and Peansupap, 2004b). Each participant in the project team is typically in charge of a particular functional task during the design and construction process. To implement a building project, these independent participants need accurate and timely information from others so that they can make decisions appropriately and accomplish their work (Pietroforte 1997). Therefore, large amounts of complex information (for example design drawings, project programmes and change orders) are communicated between these participants for task implementation (Thomas *et al*. 1998). This importance of communication in building projects can be illustrated using Guevara and Boyer's (1981) statement "communication systems are the central nervous systems which make it possible for hundreds of people to do dozens of tasks in an integrated and orderly manner, and to coordinate their efforts and skills towards a common goal."

Effective communication between project participants has a critical influence on the performance of a building project. Numerous studies have highlighted the importance of effective communication for project success (Emmett & Gorse, 2003; Guevara & Boyer, 1981; Shen, 1992; Thamhain and Wilemon, 1986; Thomas *et al*. 1998). According to Thomas *et al*. (1998), "statistical analysis revealed that 41% of the variation in perceptions of project success can be attributable to the variation in communications effectiveness." If there is effective communication between project participants, accurate information will be quickly communicated and consensus decisions easily achieved among the project team members. Subsequently, it will improve team work, reduce conflicts and rework, and contribute to project success. Therefore, managing project team communication and achieving communication effectiveness is important for project success.

However, communication between building project participants is a complex activity and its effectiveness is difficult to achieve. Communication problems are always reported e.g. not enough information, information lately received from others, or having difficulties to access information providers in other participants. Poor communication performance may be due to the complex characteristic elements of team communication, such as communicators with different backgrounds and multiple communication channels. As pointed out in the beginning, building projects have become more complex in terms of design and construction, presenting a complicated context for communication between the project participants. For example, fast-track construction is now used to implement projects quickly, in which design and construction stages overlap and a building process is compressed. In fast-track construction, many changes and redesigns happen at the construction stage. This requires designers to timely deliver fully coordinated, certain, and accurate design drawings to other participants. As well, the increasing numbers of specialist organisations from different companies are involved in a building project. These participants usually have competitive interests, pre-existing patterns of work activities, specialised work languages, different expectations and perceptions of quality and success, and different organisational constraints and priorities (Blyth, 2001; Sonnenwald, 1996). These diverse backgrounds of each participant hinder the development of effective communication (Pietroforte, 1997; Thomas *et al*., 1999).

Thus, effective management of the communication across interfaces between these organisations is required (Potter, 1995). In addition, in complex building projects, large amounts of information are produced by different organisations and communicated among them. This large and complex information often leads to many communication problems between participants (Dawood *et al*., 2002).

To achieve project team communication effectiveness, it is important to successfully manage team communication. Various factors impact project team communication effectiveness, for example, kinds of communication media used to support communication activities, document system to manage large amount of information, collaborative working relationships between participants. Therefore, for achieving team communication effectiveness in a project, it is important to identify critical factors for managing project team communication which could impact communication performance based on understanding the complex communication team communication in a building project.

To explore and understand these critical factors can help to manage team communication and improve its performance which benefits individual project team members and ensures the objectives of the whole project achieved. This understanding would also contribute to the further development of the methods for managing communication in a building project.

1.2 THE SCOPE OF THIS RESEARCH

Communication between building project participants is complex activities and its effectiveness is difficult to achieve. Whilst many exiting studies have addressed the importance of effective communication between project team members to building project success, it has been pointed out that there is little improvement in the effectiveness of project team communication (Thomas, *et al*. 1998). This leads to the formulation of a number of fundamental questions in this study. For example, what is the performance of project team communication that is typical communication problems in current building projects? What are critical factors for managing project team communication that are factors contribute to communication effectiveness? And what impacts do these factors have on communication performance? It has been found that little study has been conducted in the literature to address these important questions systematically, especially on the communication during the construction phase (Emmitt and Gorse, 2003).

Considering the dynamic composition of the project team and different works throughout the project's life cycle (Thomas, 1996), this study focuses on examining the communication between participants of the project team at the construction stage in a building project. In other words, the scope of this study is defined by building projects, the construction stage, and project team communication (inter-organisational communication). The data collected from practical surveys are from the construction industries in China Mainland and Hong Kong.

1.3 THE AIM AND OBJECTIVES OF THE RESEARCH

It is the major aim of this study to identify critical factors in managing communication between project participants, particularly at the construction stage. The current project team communication performance was also examined. Meanwhile, these examinations lead to an analysis of the impacts of the critical factors on communication performance.

In pursuit of its goal, more specific research objectives were developed below:

1. To conceptually understand the communication process between the project participants at the construction stage in a building project through literature review;
2. To identify communication performance indicators for assessing project team communication performance through literature reviews
3. To identify communication factors which are critical factors for managing project team communication through literature review, then to examine the significance of the identified communication factors and identify additional factors for building up a communication factor framework by conducting a pilot questionnaire survey
4. To further explore the communication factors in practice and investigate their impacts on communication performance by conducting an empirical questionnaire survey, as well as to examine communication problems and the effectiveness of the communication factors in practice.

1.4 RESEARCH METHOD

The research objectives set in this study will be achieved by adopting adequate research methods. These include a comprehensive review for understanding relevant literature in the discipline of communication on construction projects, a pilot survey for setting up the framework of communication factors, and an empirical questionnaire survey for further exploring the communication factors.

This study on exploring and interpreting communication factors uses quantitative and qualitative analysis to illustrate variable relationships. Lin and Liu (2004) pointed out that research on the social science have the two main kinds: theoretical research and application research. They further suggested that theoretical research is usually undertaken by using quantitative and qualitative analysis for illustrating the relationships between variables. It is considered that this study follows in the category of theoretical research on exploring and interpreting the critical factors in communication management. Quantitative methods such as the ranking method, significant test, regression analysis, correlation analysis, and qualitative methods such as content analysis, are used for conducting analysis in this research.

The general process of this research includes setting up the research objectives by literature review, establishing a communication factor framework by literature review and a pilot survey, and exploring communication factors in practice by an empirical questionnaire study. Sekaran (1992) has developed a generic research process. He illustrates the process that a researcher may follow in moving from a rather vague idea of a potential problem to a formulation of a theoretical framework through preliminary data gathering by observations, a review of the works of others, and a survey. The researcher then designs a scientific study, and collects and analyses data. The general process of this research is depicted by a flow chart, as shown in Figure 1.1.

By adopting this research framework, the research starts from conducting a preliminary literature review for the purpose of formulating the research scope and focuses. Then review focuses on understanding complex team communication in a building project. After having a conceptual comprehension of team communication, comprehensive literature reviews were conducted for identifying two types of communication variables. One group of communication variables are communication indicators for assessing project team communication performance. Another group of communication variables are the communication factors which are critical factors for managing project team communication. The significance of the identified communication factors were further examined through a pilot questionnaire survey. The framework of communication factors was set up after the pilot study. An empirical questionnaire survey was finally conducted to find the impacts of these critical factors on communication performance in practice. The survey is also for examining communication problems and the effectiveness of the communication factors in current projects. Through the application of the above research procedures, the objectives of the study are achieved.

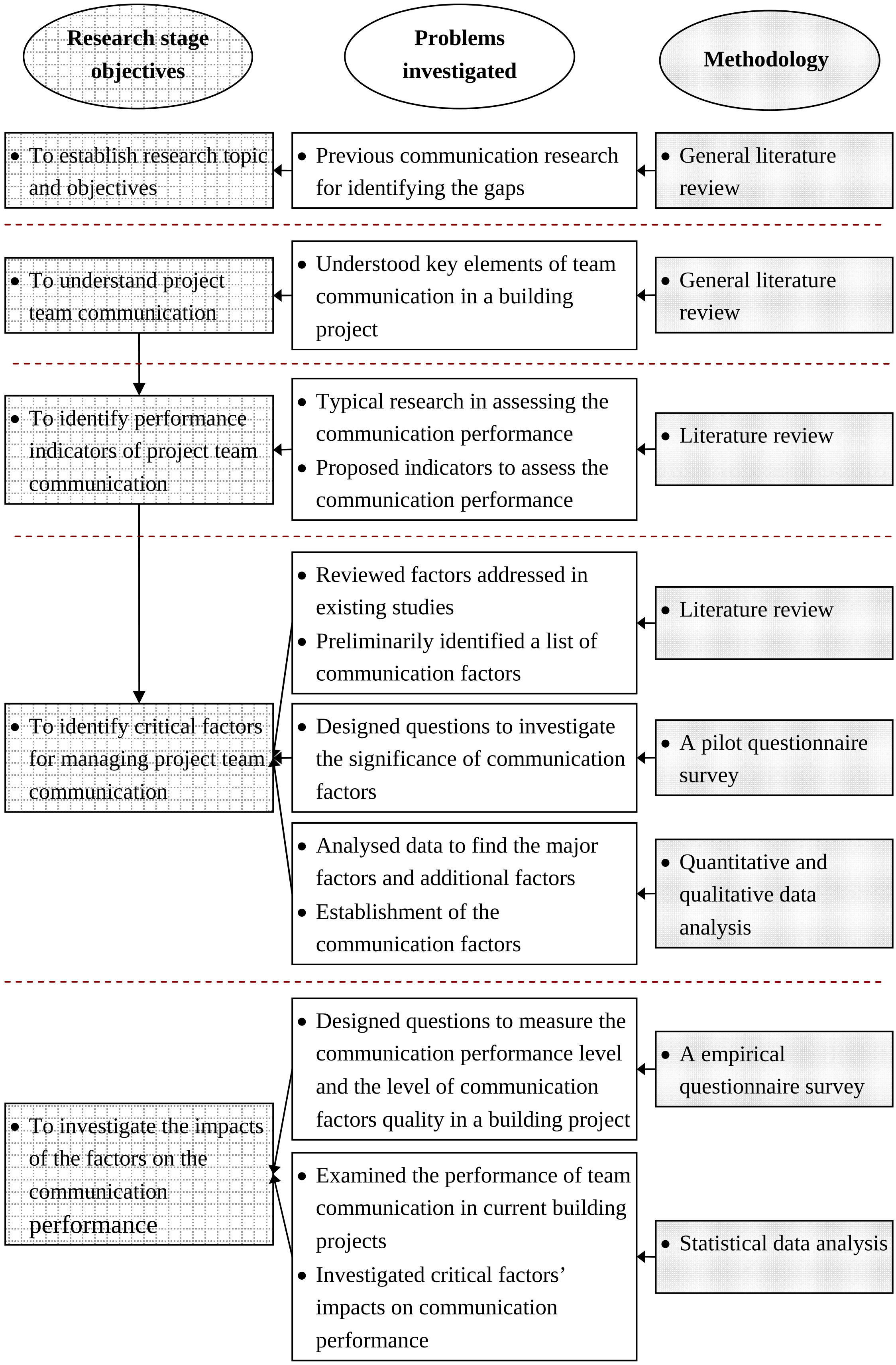

Figure 1.1 Research framework

1.5 THE CONTRIBUTION OF THIS STUDY

This study contributes to the knowledge in the discipline of communication between project participants for a building project. Through examining the key elements of the project team communication process and comprehensive literature review, a framework of critical factors for managing project team communication is found, and the impacts of these critical factors on communication performance are explored by conduction the survey.

The identified critical factors for managing team communication provide a framework to develop communication management strategies at the construction stage in a building project. The typical communication problems at the construction stage in current building projects were identified by using a communication performance assessment index. The variation of the effectiveness of the each factors accounting for the variation of the indicators of communication performance were acquired through analysing impacts of the factors on the indicators. Project managers could then put their efforts on the determining factors to each indicator to improve the performance of this indicator. These all can help to improve the communication effectiveness and further benefit both individual project team members and the objectives of the whole project.

1.6 THE OUTLINE OF THE THESIS

The thesis includes 10 chapters. Each chapter will address specific issues. The contents in the individual chapters are briefly described as follows.

This chapter introduces the background, objectives, proposition, research approach, and the contribution of this study.

Chapter 2 presents the understanding of team communication process in a building project. The concepts of communication and the elements of the communication process in implementing a project at construction stage are discussed.

Chapter 3 presents the comprehensive literature studies in the discipline of construction communication. These literature review leads to the formulation of the research originality for this study.

Chapter 4 proposes the indicators to assess communication performance between project participants by undertaking literature reviews. This review builds up the assessment method adopted in this study to assess project team communication.

Chapter 5 identifies a list of the critical factors for managing project team communication which include the factors of project characteristics and management measures. This research task is undertaken by brainstorming sections and comprehensive literature reviews.

Chapter 6 presents the research work based on the pilot survey which investigates the significance and comprehension of the communication factors. It presents the process of the pilot survey and data analysis. The analysis results in a framework of the communication factors. The results provide a basis for investigating the impacts of these communication factors on communication performance in the later stage.

Chapter 7 describes the methodology for conducting the empirical questionnaire survey. The empirical survey is very important for ensuring that quality data will be collected. Therefore, it is important to engage a proper survey methodology. This chapter therefore presents the questionnaire contents, the ways for distributing and collecting the questionnaires and the framework of the methods for analysing the data.

Chapter 8 presents the examination of communication performance and communication factors in the empirical survey. It identifies the typical problems of communication performance in practice. It also examines the effectiveness of the each individual communication factors in construction practice.

Chapter 9 presents the analysis results and discusses the impacts of the critical factors for managing project team communication on project team communication performance. The analysis is conducted through applying correlation analysis.

Chapter 10 presents the conclusion of this research. It discusses the implications of the study and makes recommendations for future studies

CHAPTER 2. CONCEPTUAL UNDERSTANDING ON COMMUNICATION IN CONSTRUCTION

2.1 INTRODUCTION

This chapter aims to provide a clear conceptual understanding of communication in construction. First, an understanding is gained about the concepts of communication. Second, the main elements of the communication process and their attributes are identified and discussed. Third, the project team communication environment which mainly concerns the process of a building project and the building project participants is presented. It is considered that this conceptual understanding is essential for building a foundation for examining communication variables in the following chapters.

2.2 CONCEPTS OF COMMUNICATION

It is well appreciated that project success and project objectives can be achieved through effective communication (Emmerson, 1962; Sonnenwald, 1996; Xie, 2002), but to do this requires an adequate understanding of communication. The concepts and implications of communication are reviewed in this section.

2.2.1 Definitions of communication

Communication is typically considered as a "complex process" (Sigband and Bell

1989). It is also considered as one of the most elusive organisational variables (Guevara and Boyer, 1981). In the WEBNOX dictionary, communication is simply defined as the activity of conveying information. However, the meaning of communication is much more comprehensive and all-embracing. The communication is defined in different way by different researchers according to their perspectives. The following definitions give some idea of the variety of meanings involved.

Some researchers emphasise media and channels used during the communication process. For example, Osgood *et al*. (1957) state that communication is one system which influences another by manipulation of alternative media over the channel connecting them. Hybels (2002, citied in Zhao, 2003) comments that communication includes not only oral language and the written documents but also symbols and body gesticulation.

Others consider communication as the skills for interaction. For example, Theodorson and Theodorson (1969) state that communication is a means for the transmission of ideas, attitudes, or emotions from one person or group to another (or others). Orlikowski (1994) considers communication in building projects and regards communication as a personal management skill. He states that communication is the basic means through which managers interact with their project counterparts.

However, according to the Project Management Institute (PMI) (2000), communication in a project context is subject to more meaning than communication skills, and the emphasis is given to information processing. Communication management is therefore defined by the institute as the process required to ensure timely and appropriate generation, collection, dissemination, storage, and ultimate implementation of project information. The institute further argues that the communication process provides the critical links among people, ideas, and information which are necessary for the project success.

Some researchers who examine the role of communication in construction embrace the meaning of knowledge and information integration. For example, Anumba and Evbuomwan (1999) regard communication as "the imparting, conveyance or exchange of ideas, knowledge or information." Fischer (1989) defines communication in building projects as "the continuous and interdisciplinary sharing of goals, knowledge, and information among all project participants."

Some other scholars, particularly in the management discipline, tend to emphasise the functions of communication. Communication is defined by them as a process of exchanging information, resulting in shared meaning and mutual understanding between two or more persons or groups (Flippo and Munsinger, 1975; Roger and Kincaid, 1981; Staley, 1992). Guevara and Boyer (1981) define communication as a process of one individual affecting the perceptions of another individual. Pietroforte (1997) states that the function of communication is to achieve and accomplish common goals, and defines communication as a channel of influence aimed at changing personal and work relationships. Pietroforte (1997) further views communication as a mechanism through which different ideas, perceptions and business goals are conciliated in order to achieve a common understanding of the meaning and an agreement on the purpose of information**.** Richmond and McCroskey (1992) suggest six functions that communication serves in the organisational context, which are to inform, regulate, integrate, manage, persuade, and socialise.

Project team communication, which is the concern of this study, has a more comprehensive meaning than basic human communication. Before explaining the meaning of project team communication in the building project context, communication types and organisational communication definitions will be presented. The definition and the functions of project team communication in this study will be introduced at the end of this section.

2.2.2 Communication types in a organisation

Understanding the concept and meaning of communication in an organisation is more difficult, as it covers communication happened in different interfaces, for example, inter-personal, inter-departmental and inter-organisational communication. Previous researchers have classified communication according to the communicators involved and the communication context.

Communication types

In the area of human communication, communication is classified in terms of the type of involved communicators. Kreps (1989) divides communication into four types: intrapersonal communication enables an individual to process information; interpersonal communication enables individuals to establish and maintain relationships; small-group communication enables members of work groups to coordinate activities; multi-group communication enables different work groups to coordinate their efforts. Emmitt and Gorse (2003) further provide an explanation of the different types of communication (Table 2.1).

Other researchers examine communication in organisations and generally classify communication, such as, internal or external communication, and independent of the organisation or within the organisation. In the context of communication in a project, PMI (2000) examines communication at a project level and classifies communication into two types: internal (within the project) and external (to the customer, the media, the public, the government etc.). Guevara (1979) provides a detailed description of three areas of communication encountered in an overview of communication in an organisation. The first area is independent of the organisation, for example, interpersonal communication, whose primary influences are cognitive phenomena and social roles and norms. The second area is within the organisation and includes interpersonal and inter-departmental communication. The primary influences of interpersonal communication are organisational roles and norms, plus applicable

Table 2.1 Types of human communication (Emmitt & Gorse, 2003)

Process	Number of people involved
Intrapersonal communication The internal communication process (cognition) includes the manifestation of information in the brain, which is understandable to us. Intrapersonal communication would also include the knowledge that another person is able to process information (relevance), which provides the initiator of communication with the knowledge that s/he can communicate with another person.	Only one person involved. It is the thought process of one person either when they are alone or communicating with others. Intra-communication may be used when one person makes a decision. As this is only one person involved some scholars do not view intrapersonal communication as a communication process
Interpersonal communication Communication directly between two people enables individuals to establish and maintain relationships. It involves the transfer of signals and messages that manifest themselves in both parties. Intrapersonal and interpersonal communication functions enable information to be processed and joint decisions to be made.	Generally two people – more than two people may be considered to be a group – the significant difference being that in interpersonal communication, between two people, the message is intended for only one receiver. Some scholars do not differentiate between interpersonal communication on a one-to-one basis and that of a small group, yet there can he many differences in the nature of interaction.
Group communication Messages are conveyed to a group. They may be presented in a way that addresses the whole group or individuals within the group. Messages may be interpreted and processed by individuals within the group in different ways. Terminology and language may be specific to the group. Each group will have its own culture and norms.	More than two people but limited to a single group of people. Communicators may address the whole group or individuals within the group. Even when individuals communicate within a group this action will be communicated to the rest of the group.
Multi-group communication A person or group communicates a message to a number of different groups or sub-groups, the response to the message may be different depending on the group's motivations and norms.	Although communication of this nature targets a number of groups or sub-groups, there is an element that the messages are largely contained within the specific groups, e.g. departments within an organisation.
Mass communication Messages are sent through media – radio, television, and newspapers – or to large audiences. Individuals and groups of people receiving the message may attach different meanings to it depending on their culture and norms.	Although there is little control of who and how many receive the message, groups can be targeted, e. g. television viewing at a particular time. Professional journals are used to send information to their profession.

social norms. And the primary influences of inter-departmental communication are inter-departmental relations and the aggregate effect of the information exchanged. The third area of communication is external to the organisation and this can be broken down into inter-organisational and organisation-environmental communication. The primary influences of the former are the relations among organisations, those of the latter, environmental components.

In this study, organisational communication in a building project is deemed to happen in the three different types. The first is communication with in a company or a organisation, for example, communication within a main-contractor company. The second is communication with other participants, for example main-contractors communicate with architects. The third is communication with all stakeholders, for example, main-contractors communicate with government departments.

Project team communication

This study focuses on examining project team communication during the construction stage in a building project. According to Anumba and Evbuomwan (1999), project team communication relates to communication between the various members of a given project team, such as clients, architects, and main-contractors. This study concerns communication within a project team and does not include communication with other stakeholders, such as the public and the government. This communication between project participants at the construction stage is typically expressed in this study as inter-organisational communication which is communication external to a given participating organisation.

This inter-organisational communication concerns networks between involved organisations. The comprehension of organisational communication is different from that of human communication and places more emphasises on the maintenance of communication networks which tie together independent groups or organisations (Eisenberg *et al*., 1985; Goldhaber, 1990 cited in Mead, 1999). Goldhaber (1990, cited in Mead, 1999) defines organisational communication as "the process of creating and exchanging messages within a network of interdependent relationships".

Eisenberg *et al*. (1985) further state that an inter-organisational communication system is a network where entire organisations take the place of the individual roles found in single organisational networks. To implement inter-organisational communication, Eisenberg *et al*. (1985) introduce three used linkages: institutional linkages, representative linkages, and personal linkages. At the construction stage, these three kinds of communication actually happen at the same time, which implies characteristics of organisation and individual, and linkages between organisations or between individuals, may influence project team communication.

2.2.3 The definition and functions of project team communication in this study

Having examined various concepts and definitions of communication, communication between building project participants at the construction stage is defined in this study as "*the transmission and interchange of project related information among project participants in order to coordinate and accomplish construction work, and to achieve the common project goals.*" In this context, the process of communication is not simply the transfer of information, as it also aims at reaching mutual understanding, conducting corresponding actions, and finally achieving integrated coordination and project objectives.

Furthermore, functions of communication will be different when different problems or communication contexts are considered. In line with the above communication definition given in this study, the functions of project team communication at the construction stage include information transmission, work coordination and relationship maintenance.

Information transmission

In the project team communication process, a great amount of information is generated and exchanged between independent organisations, mostly along the institutional linkages which tie together these organisations. This kind of communication focuses on information exchange which sometimes can be realised by a computer and automation. The transmitted information is usually quantitative and definite technical information including design information, schedule and programme information, and others.

Work coordination

Project team communication at the construction stage is used mainly for planning, managing, executing, and coordinating the activities to be undertaken for completing a project. During the construction stage, a great deal of dynamic and non-routine information about the performance of the project and the changes of project conditions is generated and communicated among the participants. This type of information is often communicated between participants along organisation representative linkages and personal linkages.

Relationship maintaining

In the team work context, project team members are from different organisations and have different focuses of work and profit. One participant should use various means of communication to influence others and maintain good work relationships (Borcherding, 1978 in Pietroforte, 1999). This kind of communication is usually through organisation representative and personal interaction.

The classification of the three communication functions is echoed to some extent with the argument in the study by Eisenberg *et al*. (1985), which states that inter-organisational communication focuses on forging and maintaining information, material, and social linkages.

2.3 KEY ELEMENTS IN COMMUNICATION PROCESS

Communication is a complex process (Sigband and Bell, 1989). Researchers have tried different ways to describe and investigate communication activities. To understand communication in a building project, basic theories about communication and their applications in construction are described in this section.

2.3.1 Communication process model

Researchers have tried to use a model to describe the human communication process. McQuail and Windahl (1993) summarised and discussed a number of basic models from the previous studies which described the communication process from different perspectives. Among these models, the pilot one is the 'linear' model of the human communication process introduced by Shannon and Weaver (1949), as shown in Figure 2.1:

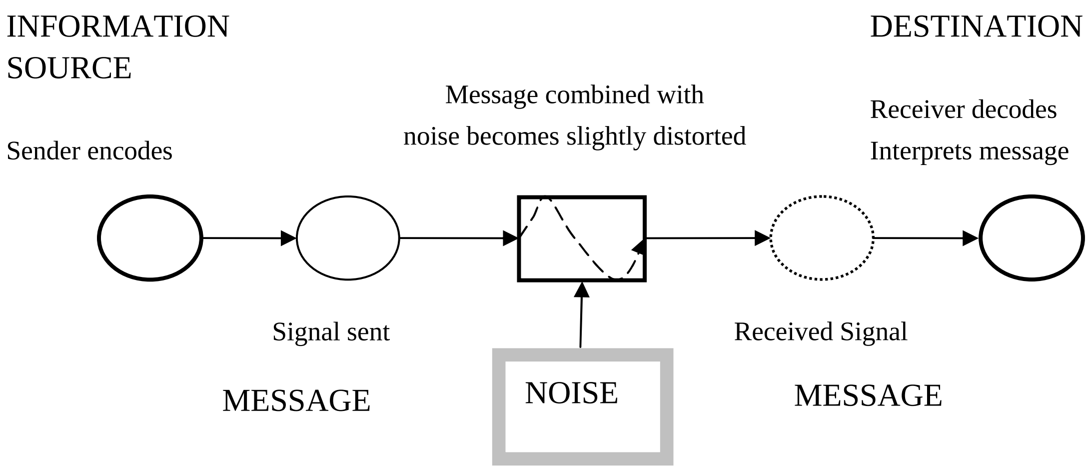

Figure 2.1 'Linear' model of the human communication process (Shannon and Weaver, 1949)

This linear model of communication process developed by Shannon and Weaver (1949) is a model supported by mathematical theory. However, human communication is more complex than it, for example, the feedback of communication process does not include in this model. Figure 2.2 depicts a typical model describing "human communication process" developed by Schermerhorn *et al*. (1994).

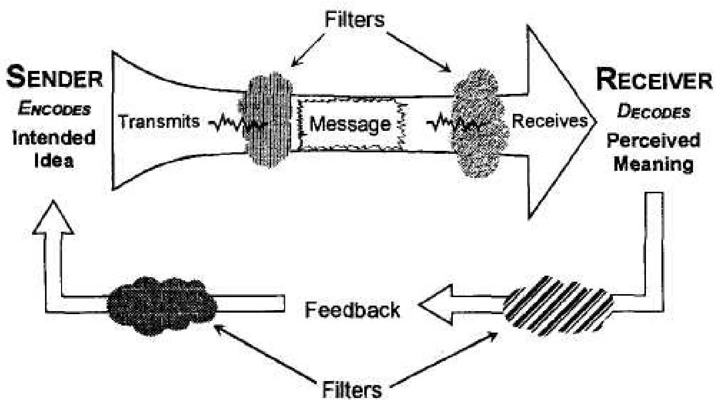

Figure 2.2 Human Communication Process (Schermerhorn *et al*., 1994)

These process models are drawn primarily from the fields of psychology and sociology. Emmitt & Gorse (2003) commented that this process model approach is more concerned with: how senders and receivers encode and decode messages; how channels and media are used to transmit messages; and how efficient and accurate the communication act is.

These models are considered limited for building project team communication because project team communication is a dynamic process and characterised by inter-organisational communication. In reality, the communication process is more complex than the representation of these models. Pietroforte (1999) argued the components in the communication process model may be multiple as in the case of project team communication in the building process. Moreover, communication in building process is dynamic. Throughout the projects' life cycle, as members join and leave the team, new channels are created and fade away. As participants are trained or gain experience, barriers are eliminated and filters are improved (Thomas, 1996).

The above analysis of the communication process reveals a common set of elements which are essential to an understanding of communication and its implications in construction. In this study, the main elements in communication are outlined instead of using these communication models. According to previous research works (Emmitt & Gorse, 2003; Guevara & Boyer, 1981; McQuail & Windahl, 1993), the key elements of communication can be regarded as follows: the communicators, the information and message, the channels and networks, the media for communication. A good understanding of these elements of communication, which will be presented in the following sections, is essential for examining communication variables in the following chapters.

2.3.2 The communicators: the sender and the receiver

The human communication process starts with the sender's need to transmit a message and completes when the message is understood by the receiver. The sender is the source initiating the communication (Done, 2004). The sender decides what message has to be sent, encodes that message (putting information in a transmittable form), selects the media of communication, and ensures information arrives at the receivers (Thomas *et al*., 1998). As the originator of communication, the sender knows the intentions and purposes must clearly encode into the message and information (Done, 2004; Thomas *et al*., 1998). This encoding process is by phrasing, graphs, and by his non-verbal communication such as appropriate emotional overtones. When choosing the media of communication, the sender should consider enabling the receiver to understand the message (Thomas *et al*., 1998). The sender should also make sure that all aimed receivers can be accessed and receive information. The way the sender conveys the message also demonstrates the significance of message and how urgently he wishes to inform (Hollingsworth, 1986).

The communication process is not completed until the message is accepted and understood by the receiver (Hollingsworth, 1986; Thomas, 1996). The message must be decoded by the receiver to achieve a mutual understanding between sender and receiver (Thomas *et al*., 1998). According to Gibson and Hodgetts (1990), comprehension and decoding of the message by the receiver depends on some factors including: the receiver’s receptivity to the message and how much he knows about the topic, the relationship and trust that exist between senders and receivers, and the receiver's understanding and perception of the information being conveyed. These factors influencing the decoding process were echoed by many other researchers (Guevara and Boyer, 1981; Pietroforte, 1997; Thomas, 1996). The receiver’s background including knowledge, abilities, and experience determines their receptivity. Social and organisation culture could also influence their perceptions on the message. The various attitudes, interests, and expectations between the sender and the receiver often result in a conflicting relationship and different perception which leads to an inconsistent process for decoding messages. Meanwhile, the media and environment of communication also impact the ability of the receivers to receive the message. As the target of the intended meaning is achieved, the receiver can then act on the message.

In the majority of cases, the receiver of the message has an opportunity to ask the sender for additional information or for clarification. This is usually referred to as feedback in communication models. The receiver's response to a message provides feedback to the sender. It can be verbal or non-verbal but it is essential for the accurate completion of the communication process. Without feedback, the sender does not know if the message has been received and understood.

In communication between building project participants, communication roles (senders and receivers) mainly involve professional organisations in a project, including the client, the architect, the engineering consultant, the main contractor, the sub-contractors, and others. These communication roles of building project participants will be discussed in details in the sections 2.4.2. Eisenberg *et al.* (1985) indicate three levels of linkages in inter-organisational communication which are institutional linkages, representative linkages, and personal linkages. In this situation, communicators could be individual, organisational representatives, or an entire organisation. In building projects, these communicators might be the construction job site foremen, the lead discipline engineers and managers, or entire professional firms (Thomas, 1996).

2.3.3 Information and message

The information or message is the encoded ideas or meaning being transmitted which could be in the form of static documents or dynamic processed data. Harrington (1991) says that information can be viewed in two ways. The classic "resource" view says that information can be created, transmitted, stored, and received by an organisation much like the production components on an assembly line. Here, information is static and unchanging. Unlike the resource view, the "perception" driven view sees information as more than processed data. Here, information is dynamic and constantly evolving and is often interpreted differently by different parties.

Some researchers classify information into several general types in terms of the functions of information. Functions of information refer to why messages are sent and received in organisations and the purposes of information transmission. Farace (1977) synthesised research on message content and developed three broad categories: production, innovation, and maintenance. Production information deals with getting work done, innovation messages deal with problem solving, while maintenance information is used to solve personal problems or for institutional control. Tichy and

Fombrun (1981) looked at the message content exchanged between parties and found four areas including information, goods and services, expressions of affect, and attempts to influence and control. Information messages most likely fall within Farace’s (1977) category of innovation messages. Goods and services messages approximate product messages. Messages of expressions of affect, and attempts to influence and control serve functions similar to maintenance messages. This classification of product and innovation information accords the two views on information which are “resources” and the “perceptions”. These three kind functions of information – product, innovation, and maintenance – also echo the three kinds of functions of communication described in Section 2.2.3, being transmitting information, coordinating works, and maintaining relationships.

To implement different functions of information, ideas and meanings are typically coded to a different structure. Production information is the solution which is more structured and tends to be more quantitative and unequivocal. This structured situation can be approached by systematic procedures and process of coding information (Pietroforte 1999). Innovation information for problem solving is qualitative and equivocal, i.e., it has multiple or conflicting interpretations (Daft and Macintosh, 1981). These unstructured problem solving processes use iterative and interactive solution procedures and a process of qualitative or uncodified information (Pietroforte, 1999). These two kinds of information processes are consistent with the formal and informal channels in that they communicate information between project participants as discussed in Section 2.3.4.

To effectively transmit the product information among the project participants, information and messages should be coded to different formats, for example, simple memos, formal letters, or graphical drawings. The appropriate form used to encapsulate the message and information depends on the structure, importance of message and the channel used to deliver it (Bowen and Edwards, 1996). The typical information formats include document, note, memo, letters, reports, sketches, drawings, graphical material, physical model, etc.

In building projects, there is a large amount of information transmitted among the project participants. The examples of information transmitted not only include contracts, change order approvals, project execution plans, but also some simple verbal exchanges during project meetings (Thomas, 1996). Different authors classify the construction information in different ways.

Pietroforte (1999) suggests two types of information communicated among the collaborative participants in a building project: information mainly used for representing the requirements of the building to be realised, and information coordinating the activities that lead to the above information realisation. He further illustrates that the realisation of the building process leaves a trail of written, graphic and numeric documents. The explicit examples of this kind of information are the drawings, specifications, calculations and schedules and the building itself, which also incorporate all the information that is processed during its construction. At the same time, these information records result from a process in which an even greater amount of information is generated and communicated in order to plan, implement and coordinate the activities that lead to these documents' generation. This type of information is not easily traceable because it is not recorded or hidden in project files in the form of meeting notes, submittals, correspondence, inspection results, etc. These two kinds of information seem similar to Farace's (1977) category of production and innovation messages.

The other study on construction information was conducted by the United Kingdom's Department of the Environment (BT, 1995). The construction information was classified in terms of three broad categories: technical information, commercial information, and management and control information (BT, 1995). Technical information includes designs and technical evaluations required to describe a building e.g. drawings, specifications, details, and design clarifications. Commercial information includes the contract details which establish responsibilities for the delivery of a project e.g. delivery schedules, costs and payment schedules, administration terms and conditions. Management information includes the project management information needed to control the project. This category includes information which is developed by the project manager e.g. meeting minutes, submittals and shop drawings, the change order status log, as-built drawings, requests for information, the contract status log, safety information, daily logs and project schedules.

Shen (1992) summarised typical information transmitted in construction projects in terms of three different forms: general information, project information and organisational information. This summary is displayed in Table 2.2.

The specific contents of information are not considered in this study. This study focuses on general communication functions served on a project level and exploring the procedures to support these functions. The important issues for information are to appropriately present and code information and ensure the high-quality content of information which could support the communication activities between the project participants.

Table 2.2 Typical information in construction projects (Shen, 1992)

General information - government, public, commercial etc.
Policy document,
Technical and political regulation and code,
Administration procedure,
Market document
Organisational information - specific professional instruction
Design document,
Estimating cost data,
Schedule and plan,
Procurement and material control document
Safety and quality assurance control
Accounting financial document
Construction technical document and scheme,
Management information - progress, cost and quality performance about the project
Drawing Management
Variation Register
Material/Sample Control Schedule
Non Conformity Report
Site layout plan
Master program
Short term program
Daily/Progress report
Quality plan/manual/report
Safety plan/manual/report
Minutes of meetings
--Project / Coordination / Progress Meetings
--Safety / Safety Committee Meetings
Project Financial Reports
--Payments Schedule / Cash Flow Forecast
--Variation Orders / Cost Claims
Subcontract Documents
--Operational Bills of Quantities
--Works subletting
Request for Information and Documents Register
Claims Documents
Contract document change order

2.3.4 The communication channels and networks

Channels

Channels or linkages are the conduits through which the message flows (Thomas, 1996; Thomas *et al*., 1998). They can be formal, following organisational structure using written means, or informal with virtually any lines using verbal face-to-face or electronic means (Thomas *et al*., 1996; Shohet and Frydman, 2003).

Formal channels usually flow along a defined organisational hierarchy and tend to deliver directives and involve the submission of reports (Sigband and Bell, 1989). Transmitting messages through formal channels is explicitly recognised as official by the organisation (Xie, 2002). They are more likely to deliver downward instructions and directives in a written form (Rogers and Agarwala-Rogers, 1976), for example, the contract, the drawing, the specification, the schedules, change orders, policies, and others. These channels also can be used in keeping participants informed by transmitting performance data. Project progress and required inputs are passed upward through these channels from contractors to consultants and clients (Thomas *et al*., 1998).

If adequate communication does not take place in formal channels, it will surely take place by means of informal ones (Sigband and Bell 1989). When formal channels fail to satisfy an individual's information requirements (Sigband and Bell 1989), informal channels will be used by communicators. These informal channels of communication typically form a “grapevine” (Hunter, 1993 cited in Xie, 2002). Different authors have different views about the functions and effectiveness of informal channels. Some researchers consider that they are more effective (Mead, 1999; Rogers and

Agarwala-Rogers, 1976; Sigband and Bell, 1989). Communication through informal channel often contributes towards an organisation's effectiveness in reaching its goals (Rogers and Agarwala-Rogers, 1976). Wofford *et al*. (1977) consider informal channels normally evolve on projects and may prove to be of equal or greater value than formal channels. However, they further argue informal channels of communications are often the least efficient even though these channels carry many messages vital to project success.

In the construction industry, formal communication channels between project participants are defined and established by contracts. The contract usually defines hierarchical relations between the project participants. It establishes formal communication linkages between participants and a linear chain of command for information flows during the course of the project (Mead, 1999). The typical types of contract arrangement and their established project organisation structure are discussed in detail in Section 2.4.

Building project participants often resort to some informal channel to get required information and solve problems. The project team communication and information diffusion process are generally slow through the contract-driven, linear communication channels. In dynamic and uncertain construction processes, project participants often need using informal channels, for example face to face discussion and telephone conversations, to solve contingent problems immediately and reduce uncertainty. Parker (1980) studied communication channels and showed that the role of informal communications in building projects is crucial to the effectiveness of construction. Mead (1999) further pointed out that anecdotal evidence shows informal transmissions are where real communication occurs during the course of a building project.

In a nutshell, the transmission of information on building projects often follows two related tracks. Firstly, the formal channel where quantitative and formal information is used for evaluating contract performance. Secondly, the informal channel where individuals exchange and process information through undocumented conversations and face to face discussion in order to clarify the inherent ambiguity in the system.

Communication networks

In the organisation context, the linkages between communicators could build up communication networks. The organisational communication process is more complex than the human communication process. Organisations are composed of a series of people or groups, each of whom occupy a specific role. Communication among these people takes place over a set of linkages between them. A communication network is therefore formed by a set of communication channels linking communicators. With regard to inter-organisational communication, entire organisations take the place of the individual roles found in single organisational networks (Eisenberg *et al*., 1985).

Communication networks are formed by several basic communication models. These main basic communication models developed by psychologists are wheel, chain and comcon (Figure 2.3) (Emmitt and Gorse, 2003).

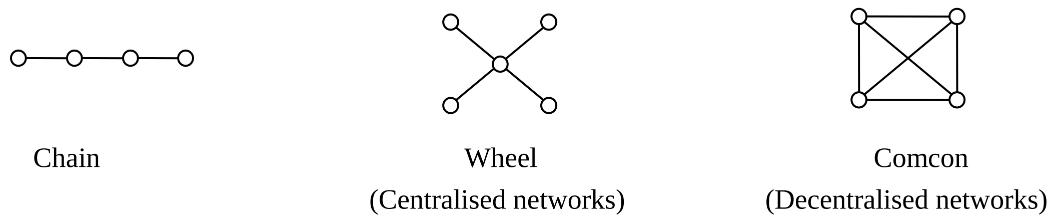

Figure 2.3 Basic communication models (Emmitt & Gorse, 2003)

A combination of these basic models can develop on building projects. Emmitt & Gorse (2003) described two models to describe typical communication networks in different situations at the construction stage on building projects. One is a revised wheel model as a formal communication network in traditional contract arrangement at the construction stage (Figure 2.4). The architect and main-contractor are the two centres in the formal communication network. Much of the formal communication during the construction phase will flow through either the architect or the contractor. An advantage of this centralised communication network is that the formal lines of communication are clear and those on the periphery are aware of whom to contact for information and decisions (Emmitt & Gorse, 2003). Another is a comcon model as a communication network in a typical project meeting (Figure 2.5). Figure 2.5 demonstrates the number of possible interactions in a meeting. In this decentralised network, there is potential for open interaction with all members attending the meeting, but this interaction can become uncontrolled.

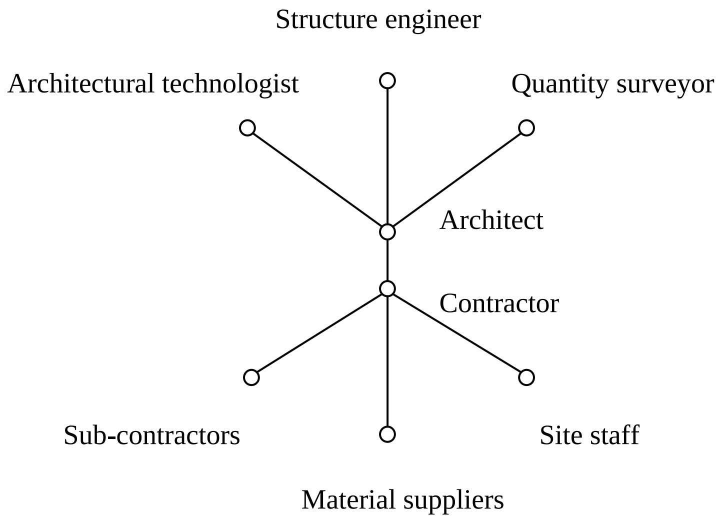

Figure 2.4 Model of centralised network occurring during the construction phase (Emmitt & Gorse, 2003)

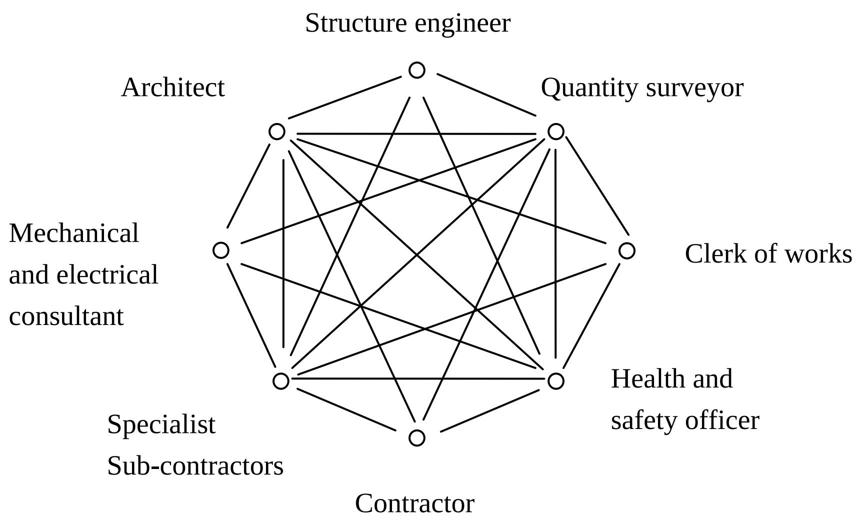

Figure 2.5 Schematic of possible interactions in a meeting (Emmitt & Gorse, 2003)

However, the relations between communicators in communication networks are more complex than the above patterns. Different frequencies of interaction exist between different people and organisations. Each communicator plays a different role in a communication network. Social network analysis techniques are usually used to determine the communication structure between people and organisations within a social system. It is a method to map the communication networks, analyse the frequency of communication between individuals, and identify the different roles of each communicator. Through analysis of relational data, high level descriptions of a communication network are represented graphically by a sociogram. This analysis method can be supported by some computer programs. For example UCINET IV and Krackplot are used widely in sociology and communication science (Garton, *et al*., 1997). However, this method does not effectively address changes in the network over time and over different situations (Rogers & Kincaid, 1981). Furthermore, there is a problem with the data collection, which is the discrepancy between the communication links reported by the respondent and the ones actually occur in practice (Emmitt & Gorse, 2003; Mead, 1999).

Excluding the above discussed density and roles, other properties of communication networks and linkages have been explored in previous research. Tichy and Fombrun (1981) used four variables of size, centrality, density, and reachability to describe a network and its participants. Size refers to the number of people to which a person is linked, or at the network level the total number of linkages in the network. Centrality is a measure of the level of communication activity at a specific node of the network. Density has been defined as the ratio of actual to potential contacts within a network (Monge and Eisenberg, 1987). Reachability, at the individual level, is defined as the number of steps that it takes to reach another person in the network (Monge and

Eisenberg, 1987). Monge and Eisenberg (1987) defined four additional properties of linkages: centrality, symmetricality, reciprocity, and multiplexity. The strength or centrality of a linkage corresponds to the amount of information that flows through a network linkage. The symmetry of a link explores the degree to which individuals have similar status or relationships within the organisation. Reciprocity is used to measure the intensity and direction of specific communications between individuals. Multiplexity analyses the extent to which individuals communicate beyond their topic area or area of influence.

Temporary and varied relations and communications between participants in projects make it difficult to effectively describe communication networks and information flow between them. It is important to identify the main communicator and their relationships for managing communication channels and networks in a building project. The focus of this study is management procedures that help to set up clear communication channels. The formal channel and network are established clearly identify each project team member and define their roles, responsibilities, and relationships between them. Roles in an organisation dictate who occupies what specific position or job, either formally or informally prescribed. The specific articulation of the participants and their associated roles in the project team will be discussed in the Section 2.4.2. The formal role influences to whom one communicates in the course of coordinating a job. Besides communicating with others through formal channels, one may also talk about job-related and non-job-related issues with others via informal channels. Informal networks and channels are formed by good professional relationships.

2.3.5 The media for communication

The medium for communication is the tool or technology used to transmit the requisite information (Anumba and Evbuomwan, 1999; PMI, 2000; Xie, 2002). The myriad kinds of media have been identified and classified in previous studies (Anumba and Evbuomwan, 1999; Emmitt and Gorse, 2003; PMI, 2000; Zhao, 2003), for example postal letter, telephone, fax, face to face conversation, meetings, electronic mail, and videoconference.

In order to easily manage these kinds of media, some research classified these media into several groups in terms of their forms. Robbins (2004 cited in Zhao, 2003) classified the communication media into three basic methods which are oral (speeches, formal one-on-one and group discussions, informal rumour mill or grapevine), written (memos, letters, electronic mail, fax transmissions, organisational periodicals, notices placed on bulletin boards etc.) and non-verbal communication (face expression, tone and stress of speaking, body language, etc.). Shan (2003) and Zhao (2003) regarded communication through electronic means as an independent group. Hunter (1993 cited in Xie, 2002) reviewed the means of communication in the construction industry and divided media into traditional and electronic. Based on these previous studies, communication media have been summarised and grouped by the author into the categories shown in Table 2.3.

Table 2.3 Communication media type

Original non-verbal media	**Oral media**	**Written media (paper based)**	**Electronic media**
• Body language • Face expression • Speaking tone and stress	• Face to face conversation • Via telephone • Meeting	• Fax • Post • Bulletin	• Email • Voice mail • Video conferencing • Internet and intranet (networked electronic databases)

Traditional media are non-electronic means which include original non-verbal media, oral media and written media (paper based). As information technology (IT) develops, more communication uses electronic media. Electronic communication is the transmission of oral and written message from one electronic device to another in such a manner that the message is heard, read or viewed and remains in the electronic form (Hunter, 1993, cited in Xie, 2002). This category of media classification is by no means exhaustive because of the myriad of existing communication media.

To ensure that communication achieves its desired effects, it is essential that suitable media are used to transfer information and support the communication process. The different kinds of media have the different attributes. The choice of media depends on the inherent characteristics of the media themselves and the nature of the situation in the communication process. Emmitt and Gorse (2003) state that the benefits of one medium over another will depend upon the message being conveyed and the channel through which it will pass. Some previous studies examined the different characteristics of media in terms of the message it conveys and the channel it passes through.

Pietroforte (1997) classified communication media as lean and rich in terms of the kinds of information that the media support. Communication media vary in richness, with different capacities to process equivocal information (Daft and Lengel, 1984). *Lean communication media* are generally impersonal and asynchronous, and rely on rules, forms, procedures or databases. They are used effectively in well-defined situations, such as routine tasks. The less ambiguous and more certain the issue or the information to be exchanged, the leaner the medium required. *Rich communication media* refers to the complexity of language supported, the flexibility of the format, the number of simultaneous channels of communication, and the degree to which the message is personalised. Communication about ambiguous or ill-defined situations requires the use of rich and iterative media such as meetings or direct personal contact.

Thomas *et al*. (1998) and Xie (2002) stated that the media for communications is often dictated by the channel and is sometimes correspondingly categorised as "hard" or "soft". Hard and soft media refer to communication through formal and informal channels respectively. This classification puts focus on the communication channel rather than the media, even though the media and channel are closely related and often discussed together in the communication management.

To examine the characteristics of each individual medium easily, the communication media are grouped in this study as lean and rich media, referring to Pietroforte's (1997) study (Table 2.4). Lean media usually include post, fax, bulletin, email, internet and intranet which are always text based communication. Rich media usually include meetings, face to face conversations, and video conferencing, which are always oral based communication.

Table 2.4 Communication media characteristics

	Lean media	**Rich and iterative media**
Kinds of media	Post, fax, bulletin, email, Internet and intranet	Meeting, face to face conversation, video conferencing
Time	Asynchronous	Synchronous, provide feedback immediately, a number of simultaneous channels of communication
Message	Impersonal message and rely on rules, forms, procedures or databases	Personalised message, the complexity of language, the flexibility of format
Context	In well-defined situations, less ambiguous and more certain issues such as routine tasks.	In ambiguous or ill-defined situations

The following part will discuss several kinds of media which are often used in project communication and their characteristics.

1. Written media

Written media are the paper-based communication media. Important written media include post and fax which are described as follows.

Post

Post is the traditional media used in building projects to keep the project team members informed by sending copies of design drawings, progress reports, calculations, correspondence, and other important project documentation (Howard and Petersen, 2001; Sievert, 1986). It is the way to distribute printed documents with legal significance and give parties enough attention (Gorse *et al*., 1999; Howard and Petersen, 2001). Project team members may quickly and frequently communicate through telephone or fax. However, important verbal messages must be followed up in writing e.g. meeting minutes to assure documentation of important information and be distributed by post to each project team member (Sievert, 1986). At the same time, if the changes have been made to related project documents, original project documentation must be updated and distributed by post delivering system to relevant parties (Gorse *et al*., 1999). Printed documents with fine details are often difficult to read and may cause misunderstanding and confusion (Gorse *et al*., 1999). Especially, the communication needs of teams are poorly served by written documentation since it could not provide the dialectic necessary to resolve misunderstandings about requirements or decisions among project members (Curtis *et al*., 1988). Therefore, additional information and interaction is required by phone (verbally) or fax for forging a common understanding of these issues (Curtis *et al*., 1988; Gorse *et al*., 1999). Because post has limited speed and costs of post are more compared with email, it is not used as frequently as in previous years (Howard and Petersen, 2001)

Fax

It is commonplace to use faxes to transfer last minute information, provide details, and confirm verbal instructions in building projects (Gorse *et al*., 1999). Faxes are fast when communicating immediate printed information which would otherwise be supported by post. However, it only provides poor quality in A4 width to one recipient at a time and cannot be edited (Gorse *et al*., 1999; Howard and Petersen, 2001). Whilst little time is required to send a fax, important information should be followed up by sending the formal written documents by the post distribution system. Gorse *et al*. (1999) argue problems may arise when faxes were used as a major method of updating and amending many of the changes to project documents. It is impossible to update all related project documents and distribute to all relevant parties by fax (Gorse *et al*., 1999).

2. Oral media

Typical oral media include telephone, face to face discussions and meetings. These are discussed as follows.

Telephone

Oral talking and discussion among the team members is always needed to clarify confusion about the written documents and to communicate the needs and requirements of each other (Curtis *et al*., 1988; Gorse *et al*., 1999). This is because these oral media provide the dialectic necessary to resolve misunderstandings and achieve common decisions among project members (Curtis *et al.*, 1988). These oral media include telephone, project meetings and face to face discussions.

Telephones, especially cellular mobile phones, are frequently used in the construction industry for their wide availability and time saving potential (Howard and Petersen, 2001; Sievert, 1986). In the construction industry, where time is always at a premium, this is particularly beneficial (Sievert, 1986). The project manager can now easily communicate to the architect with a mobile phone even when he is on the project site. The quick exchange of information and handling of inquires can be realised through telephone. However, sometimes telephones are not effective for discussing complex technical issues. The professional language difference between project team members brings about difficulties when they talk to each other by telephone. It is difficult for project team members to understand without face-to-face talking aided by drawings and visiting sites (Xie, 2002).

Face to face discussion

Face to face discussion can be used in uncertain and complex situations. Murray *et al.* (2000) reported face-to-face discussions between two co-operating organisations occur with a high frequency in situations of uncertainty. The building project is characteristic of uncertainty and interdependence (BICR, 1966). Project team members often rely on face to face communication to quickly obtain required information from others and remove uncertainty. The building project design drawings and construction site situations are usually complex. The inherent fuzziness of drawings can lead to ambiguous interpretations which require face to face communication to clarify the confusions (Pietrofer, 1997). Complex construction situations need face to face communication and sometimes site visits to discuss and resolve the problems.

Previous studies have proved face to face discussion is the most effective method of communicating in the construction industry (Di Salvo, 1980; Gorse *et al*., 1999; Xie, 2002). It can effectively remove uncertainty and confusion, and at last enhance the communication effectiveness (Xie, 2002). Gorse *et al*. (1999) firstly stated face to face communication can provide meta-communication to clarify confusion. Messages may be misinterpreted by communicators. Individuals may have different understandings of why another person communicated and what was meant by the content (Gorse *et al*., 1999). The person can understand the information and the senders' intentions with explicit verbal explanations and statements in face to face discussion. Gorse *et al*. (1999) also stated that during face to face communication, misunderstandings can be quickly recognised by visual and verbal expression. Explaining this, he describes how if one specialist is trying to explain a problem, he may be able to see that the other person does not understand due to their facial expression. The verbal questioning can also provide instant feedback and further identify communication problems quickly. This explanation reflected Goleman's (1997) statement: the advantage of face to face communication is that we can constantly calibrate our understanding, adjust our interpretations (mental model) to what is being said. Whilst the effectiveness of face to face discussion is well known, Gorse *et al*. (1999) observed construction professionals always neglected to use it in practice.

Meeting

By its nature of uncertainty, interdependence, and complexity, a building project requires many meetings to coordinate participants' activities, resolve problems, and make congruent decisions (Sievert, 1986). The design and construction process are complex activities which need coordinated inputs from different participants all through the process. However, working separately from different project team members decreases the quantity and effectiveness of communications in the coordination of activities (Xie, 2002). Professionals always neglected to use informal face to face discussion in practice (Gorse *et al*., 1999). Therefore, effective meetings must be held frequently between the project team.

Well-arranged project meetings can increase the intensity and effectiveness of the communication and finally make well co-ordinated design and construction activities (Xie, 2002). To resolve conflicts, meetings offer a sure way to describe the exact nature of the problem and to share information and understanding among a group (Gorse *et al*., 1999; Sievert, 1986; Xie, 2002). They provide instant two-way communication in which every participant obtains an immediate response to unclear points (Sievert, 1986). Clarification of these unclear points can also be supported with other media such as textual and graphical documents, verbal explanations, or personally visiting sites (Gorse *et al*., 1999).

Successful meetings do not just happen; they must be planned. Meetings should be held only when necessary, kept short, and planned to achieve specific project objectives. Active participation and open discussion aimed at resolving problems should be encouraged. These kinds of project meetings are held regularly in building projects (Sievert, 1986). Project progress meetings can provide a complete but brief report of project performance and update the progress to each participant. Project orientation meetings enable different participants' to cooperate with their work. Decision-making meetings may solve specific problems and prescribe the future actions of each participant.

3. IT development in communication

New information technology, namely the internet, has been applied to construction communication and has gradually changed the way the project team communicate (CRC CI, 2005; Mead, 1999; Nitithamyong and Skibniewski, 2006; Pietroforte, 1997, Shohet and Frydman, 2003; Walker and Betts, 1997). Project team members can now communicate information by e-mail, audio and video conference, and use networked project databases because of the capability offered by IT of processing significant amounts of information and overcoming the space and time limitations.

E-mail

E-mail is used to report, inform and transmit project related information among the participants. Project documents can also be sent by email as attachments. By e-mail, messages and documents can be instantly sent to all receivers at different locations. All that is needed are computers with access to the internet. Therefore, Shohet and Frydman (2003) stated that communications may increase by expanding the use of e-mails for communications between project participants. However email is not widespread throughout the construction industry (Gorse *et al*., 1999). Gorse *et al*. (1999) stated that a weakness of email application in building projects is that many sites do not have online computer terminals, and many of the professionals are not experienced in the use of this type of equipment due to the industry's late adoption of information technology.

E-conference

During the implementation of the building project, project team members should gather from different working locations to attend the project meeting. Sometimes, these project team members work in different cities, even in different countries. Now with the supports of new information techniques, e-conferences (audio and video) can be held which do not require physical attendance for communication. E-conferences may save time and costs for travelling to meetings (Gorse *et al*., 1999). However, it is still necessary to hold certain meetings because e-conferences are not as effective as face to face meetings (Gorse *et al*., 1999; Xie, 2002). Behaviours differ when sitting together compared to seeing each other through screens (Xie, 2002).

Project intranet

An intranet is a restricted internet network which uses a series of linked web pages to distribute information to individuals within an organisation or to inter-organisational members of a project team (Nitithamyong and Skibniewski, 2006). A project intranet is essentially a shared web-based electronic database system used on the project level whose goal is the access and sharing of information between the participants.

The project intranet is an advanced technique which has the following advantages. The project intranet is an easy to use and low cost technique which has significant storage powers and distance-transmission capabilities (Mead, 1999). By allowing project participants timely access to project related information, the use of project intranets can improve the speed of information flow among the project participants (Xie, 2002).

By allowing each member of the project team to access accurate project information, the project intran*et al*so creates a virtual communication network among the project team members (Mead, 1999). It gives project team members an effective means of re-engineering traditional project communication networks. Unlike the traditional rigid linear communication pathway, the use of the project intranet changes the direction and geographical range of information flows among the project participants.

The project intranet works as the central document management platform in this "virtual communication network." It puts the information needed at the hub of a wheel whose spokes are the members of any specific project team. This organic model allows project team members to access and share information in real time.

The project intranet can increase the effectiveness of a project's communications by developing this virtual communications network. This virtual communication network should improve the communication effectiveness by increasing the frequency of information exchange and the accessibility of project information, while reducing communication barriers such as gatekeeping, distortion, and particularly information overload (Mead, 1999). It can visualise and streamline review cycles and information flow which can reduce administrative and delivery costs.

However, the application of project intranets is still in its initial stage. The improvement of the speed and usability of techniques need to be improved. Pietroforte (1997) stated that several factors hindered the practical application of database systems on the project level in the construction industry. First, a large part of the knowledge used in a building project is too complex to express and cannot be easily stored and reproduced. Second, a large amount of information is created dynamically through the interaction of project participants and hasn't been recorded. Third, the construction industry is composed of independent and specialised firms which, for competitive reasons, are interested in applying information technology only to their internal operations. They are unwilling to take on the significant development costs of these integrated systems. As well as this, they are reluctant to lose the managerial control over information flows to the sharing of data between the participants. Howard *et al*. (1989) argued the construction industry tended to create islands of automation which reinforce the communication barriers between firms. This situation has not changed too much even recently. Shohet and Frydman (2003) examined project team communication and pointed out that the potential of electronic means for project team communications has not materialised in the current construction industry.

Apart from the described elements of the communication process, context is another aspect of communication to which attention should be paid because project team communication activities happen in a building project for implementing complex construction activities. The organisation settings determine the requirement and the objectives of communication.

2.4 ENVIRONMENT OF COMMUNICATION IN BUILDING PROJECTS

This study explores project team communication at the construction stage. The communication environment is very important to this inter-organisation construction. Therefore, the process of developing projects, the project team composition and their relationships are introduced in this section. These are all important to managing project team communication.

2.4.1 Project process

A framework of a building process is useful in identifying the main stages in developing projects and understanding the construction communication environment. The development process starts with the realisation and identification of a need by the project client. The client then chooses appropriate consultants and organisations to assist with the design and construction operations. Invariably it leads to the impletion and completion of the project. Various research works have described the process in the different ways.

In the study by Pietrofete (1999), a building project comprises of six stages as illustrated in Figure 2.6. Pietrofete (1999) specify these stages as follows: The project starts with a client who needs a building. He hires an architect and briefs him on his needs and budget. The architect interprets and transforms these needs into a set of design plans with the progressive participation of other design consultants. The plans go through several stages of definition and approvals by the client. In the last part of this process the architect develops the necessary documentation of the project needs so that it can be priced and contracted by a general contractor. After a successful bidding process and the selection of a contractor, construction operations start. The contractor prepares a construction plan, chooses the techniques and means of construction and hires specialised subcontractors who perform parts of his work. Orders of materials and parts are issued. During the construction process, the architect, acting on behalf of the client in the traditional contract arrangement, makes sure that the quality of construction operations reflects the agreed upon original design plans.

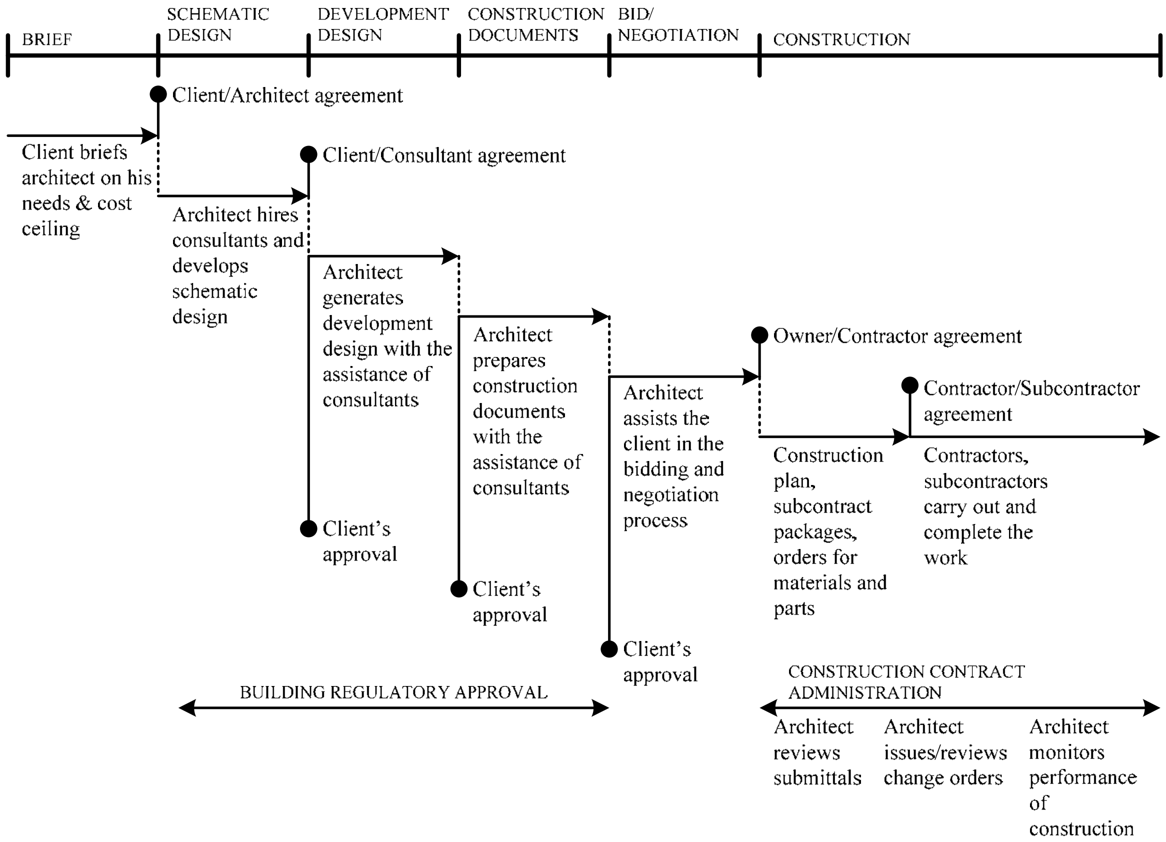

Figure 2.6 The six phase building process (Pietrofete, 1999)

In another study, He (1999) divided the building process in three stages with reference to the Chinese construction industry as shown in Figure 2. 7.

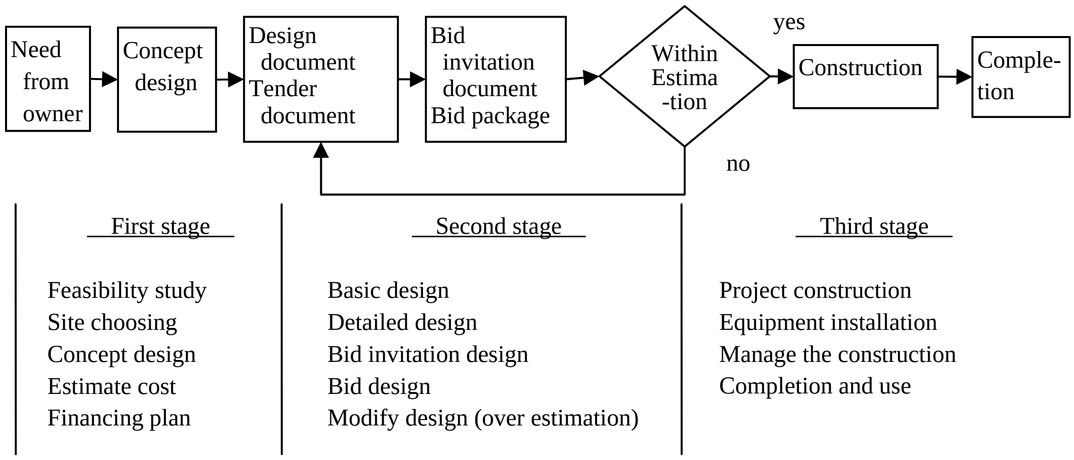

Figure 2.7 Traditional management implementing process (He, 1999)

These different models to describe the building process reflect the complex activities involved in developing projects. The above typical models for describing the complex building process imply three major phases: briefing, design, and construction. The examination of communication between project participants in this study will be at the construction stage.

It is necessary to gain an understanding about the general activities at the construction stage for a typical building project. The Handbook of Architectural Practice and Management (RIBA, 1980) has outlined the main management activities and the responsibility of each participant for these works at the construction stage in the traditional contract arrangement (Table 2.5). This description not outlines the specific construction activities at the construction stage. Complex and interdependent construction activities are out of the scope that this research studies.

Table 2.5 The main management activities at the construction stage (RIBA, 1980)

1. Client hands over site to contractor
✧ Client: Hand over site to Contractor.
✧ Contractor: takes possession of site from client and preparation for construction.
2. Site meeting
✧ Architect: Holds regular site meetings.
✧ QS, C & S and M & E, Site Inspectorate, Contractor: Attend site meetings.
3. Construction methods and programme
✧ Contractor: Advise engineer C & S of methods of construction and obtain approval. Discuss setting out with architect and check soil conditions with engineer.
✧ C & S and M & E: Check soil conditions with contractor and site inspectorate. Agree methods of construction with contractor, consider proposals for alternative, and adjust details if required.
✧ Site Inspectorate: Check setting out with contractor and check soil conditions with contractor and engineer C & S
4. Production meeting
✧ Contractor: Hold regular production meetings.
✧ Architect, nominated sub-contractors and suppliers: Attend contractor's production meetings as required.

5. General supervision

- Architect: Continue general supervision of project. Administer the terms and provisions of the contract, e.g.
  - (a) Issue architect's instructions and drawings from time to time.
  - (b) Issue certificates & notify sub-contractors of amounts included.
  - (c) Nominate any outstanding sub-contractors & suppliers, & notify them of nomination.
  - (d) Receive claims and adjudicate.
  - (e) Ensure that rights and duties of both client and contractor are fulfilled.
  - (f) Authorise day works if required etc.
- Client: (b) Honour certificate within period stated in Contract appendix.
- C&S: Provide overall supervision C & S work through resident engineer, or inspection through clerk of works.
- M & E: Supervise sub-contractors' work or implement visits of inspection (as agreed).
- Site inspectorate: Make regular inspection and supervise quality control, and submit weekly reports to architect, check drawings in advance of requirements. Co-ordinate progress photographs.
- Contractor: Notify architect of any claim for extension of time, and for reimbursable costs etc. as they occur.
- QS: (a) Advise architect on financial implications of his administration of the contract and on any claims presented.
  (b) Prepare valuations for interim certificates.

6. Progress

- Architect: (a) Keep client informed of progress.
  (b) Keep client furnished with running financial statements.
  (c) Obtain client’s approval to any increased costs.
- Contractor: (a) Maintain programme and progressing action: adjust programme as necessary.
  (b) Provide OS promptly with all necessary information for interim accounting procedures.
- Site inspectorate: (c) Authenticate day work records as regards quantities of labour, plant and materials only.
- Client: Note progress and financial statements and approve justified increased costs.
- QS: (b) Maintain running financial statements to facilitate control of cost.
  (c) Maintain accounting procedures.
- C&S: (b) Contribute to control of cost procedures.
- M & E: (b) Implement and maintain quality control and control of cost procedures and advise on interim payment and other cost claims.
- Nominated sub-contractors and suppliers: Provide contractor promptly with all necessary information for accounting.

7. Commissioning and testing

7-1.

- Architect: Initiate action for commissioning and testing at appropriate time.
- Nominated sub-contractors and suppliers: Carry out commissioning and testing procedures.
- Site inspectorate: Collaborate in commissioning and testing.
- Contractor: Co-ordinate commissioning and testing.
- M&E: Finalise testing and commissioning requirements.

7-2

- Nominated Sub-contractors and Suppliers: Carryout commissioning and testing procedures.
- M&E: Witness acceptance tests and arrange for client to be represented directly if required.
- Client: Witness M & E acceptance tests if desired.

7-3

- Nominated sub-contractors and suppliers: Carry out commissioning and testing procedures.
- M&E: Make arrangements for training of client's operating and maintenance staff.
- Client: Appoint operating and maintenance staff in good time.

8. Prepare for completion

- Architect: Make progress on preparation of Building Owner's Manual and record drawings, to be ready for practical completion.
- C & S and M & E: Make progress on section for Building Owner's Manual and record drawings.
- Nominated sub-contractors and suppliers: Prepare material for Building Owner's Manual and record drawings.

Nowadays, many projects operate under fast-track methods of design and construction where some elements of design and construction run concurrently. The large size of projects and the desire to shorten the duration of the delivery process require simultaneous procurement of several project activities (Shohet and Frydman, 2003). Therefore, many projects operate under fast-track methods of design and construction. Construction work is commenced before the design is completed (Pietroforte, 1997). Events occurred usually unpredictable during the construction of the project in the fast-track process (Pietroforte, 1999). This feature introduces dynamic and uncertain circumstances in the construction phases (Cohenca *et al*., 1994; Cohenca-Zall, 1997; Hummel and Yi, 1994; Laufer, 1991; Laufer and Howell, 1993; Sweet, 1992).

In fast-track construction contextual, timely and accurate information communicated between the participants is essential to the project's success. Pietroforte (1999) argued that the timing and contents of the several construction packages which developed after construction procurement are very important issues to ensure smooth construction site work. He further discussed that a large part of the information is created through group and personal interaction to deal with the uncertain and unexpected issues in this context. Therefore, major efforts in terms of the coordination and communication between the participants are required in current building projects (Shohet and Frydman, 2003).

2.4.2 Project participants

Project team communication depends very much on the pattern of roles involved and the relationships existing between them (Higgin and Jessop, 1965). The project team composition and their relationships are therefore introduced and discussed in this part.

The project team members

The completion of the construction project depends on project team members devoting to the integration of specialised knowledge and work (Cleland, 1995). Different kinds of project have different participants. For example, typical civil engineering projects and building projects have different participants and different relationships among them (Figure2.8 and Figure 2.9).

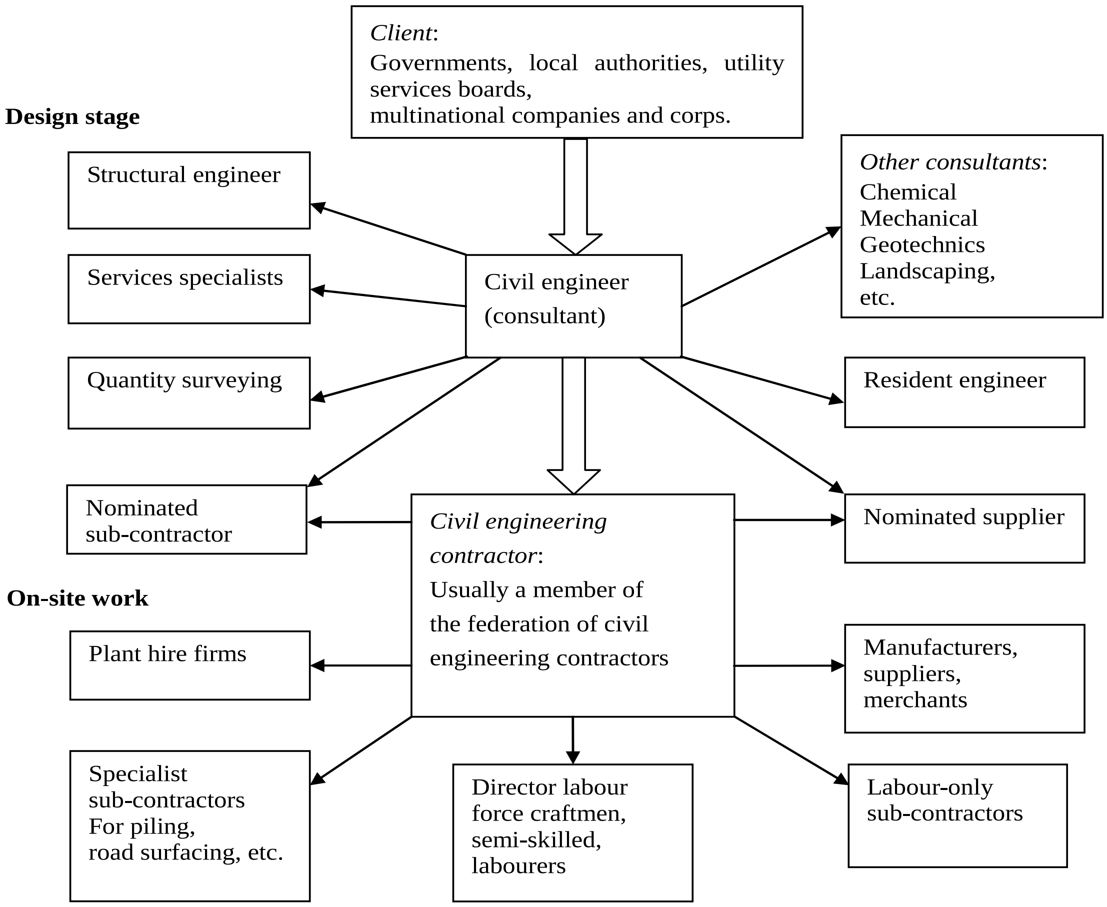

Figure 2.8 Civil engineering structure (Forster, 1986)

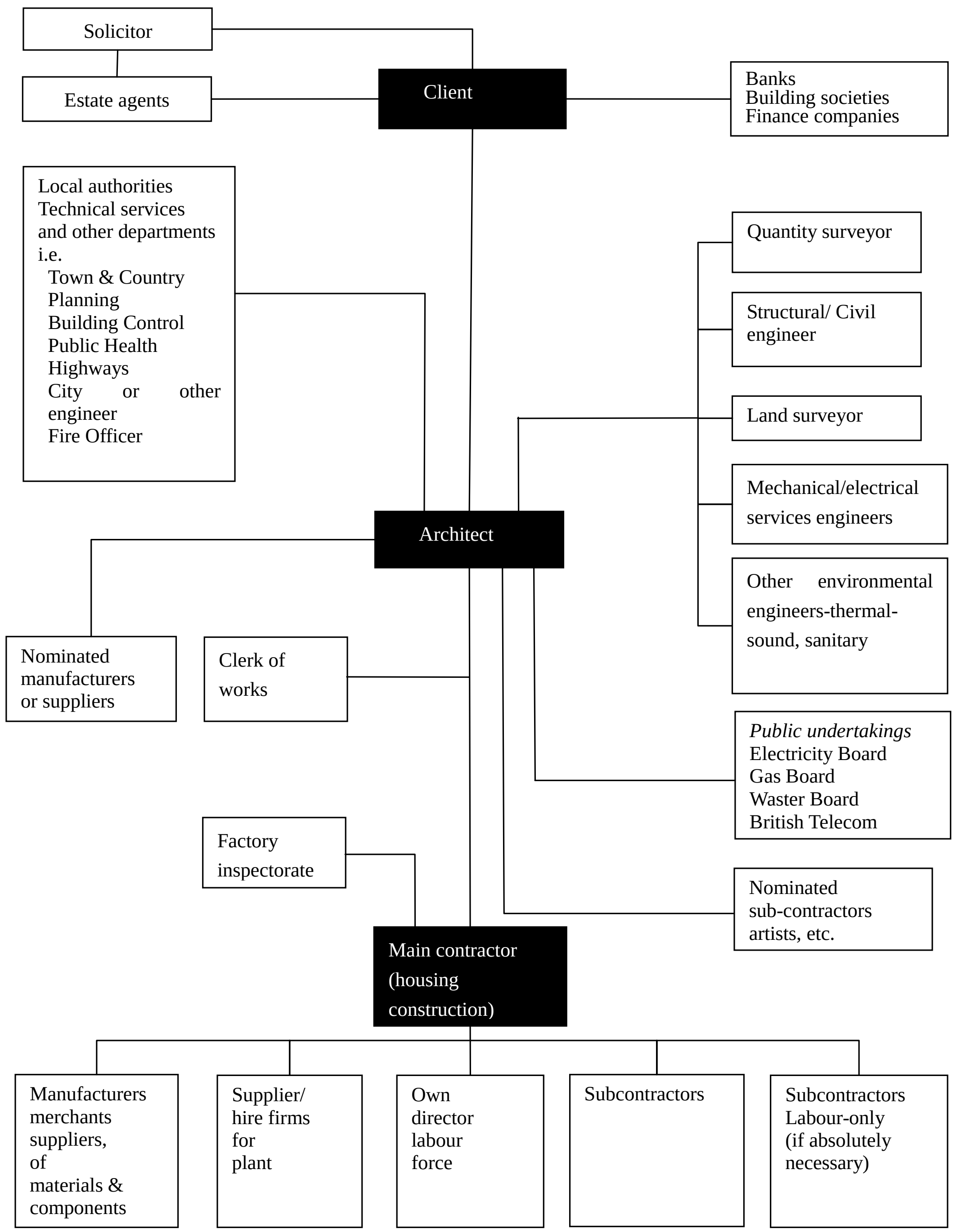

Figure 2.9 Building project associates (Forster, 1986)

Foster's (1986) model helps us to identify the main participants and the status of major participants in projects. The focus of this study is on building projects. The major building project team members include the client, the architect, the main-contractor and others, as identified from the building project associates model

(Figure 2.9). The typical project participants and other involved stakeholders in building projects are identified from Figure 2.9 and summarised in Table 2.6 below.

Table 2.6 The typical participants and other stakeholders in building projects (based on Foster, 1986)

Developers ♦ Private ♦ Government ♦ Other types of the developer participants: consultant, lawyer, banks, building societies, finance companies)	**Architects** ♦ Architects ♦ Land surveyor & landscaping
Designer engineers ♦ Quantity surveyor ♦ Structural/civil engineer, geotechnics ♦ Mechanical/electrical services engineers ♦ Other environmental engineers: thermal, sound, sanitary ♦ Chemical and other professional engineer	**Main-Contractor** ♦ Management staff ♦ Director labour force craftsmen and semi-skilled labourers
Sub-contractor ♦ Specialist sub-contractors for piling, road surfacing, transportation etc. ♦ Labour-only sub-contractors	**Suppliers** ♦ Materials and components supplier ♦ Equipments and plants hire suppliers
Governments ♦ Local authorities and management departments ♦ Technical services and other departments: Departments of town & country planning, building control, public health, health and safety, fire officer, quality supervision, transportation, environmental, revenue, engineer, etc.	**The other third parties** ♦ International engineering company, ♦ Neighbour company ♦ Insurance company, etc.

The responsibility of each party needs a clear description and authorisation (He, 1999). The major team members and their general responsibilities in the traditional contract arrangement are depicted in Table 2.7 which was provided by Thomas (1996). Team composition, and thus their responsibilities vary as a project progresses through its life cycle from business planning to facility operation.

Table 2.7 Major team members and responsibilities (Thomas 1996)

	Team member			
	Owner	**Designer**	**Contractor**	**Other****
Responsibility	Project Management	Project Management	Project Management	Supply
	Business Planning	Engineering	Cost Control	Prefab.
	Operations & Maint.	Design	Schedule Control	Specialty Work
	Safety	Contract Admin.	Estimating	Regulatory
	Legal	QA/QC	Construction	Prof. Services
	Finance	Environmental	Safety	
	Procurement	Estimating	QA/QC	
	Engineering	Approvals	Procurement	
	Environmental		Transportation	
	Construction Mgmt.		Administration	
	Contract Admin.		Payroll/Accounting	
	R&D/Process		Submittals	
	QA/QC		Shop Drawings	
	Real Estate Acquis.			

*** Vendors, Government Agencies, Unions, Subcontractors, Consultants*

The relationships among participants

Project team communication depends very much on the pattern of roles involved and the relationships existing between the team members (Higgin and Jessop 1965). Contractual obligations in building projects often establish communication linkages between parties and outline who will control critical information flows (Mead 1999). Additionally, the type of procurement system used will influence the manner in which the design and construction phase are organised, and how participants communicate through various communication channels (Emmitt and Gorse, 2003; Xie, 2002).

Projects in different procurement systems have different participants according to the contract arrangement. One participant has different responsibilities in different types of procurement system (He, 1999). So, when we begin to examine the communication between the project participants, we should identify the general contract type used in recent years. Sometimes, procurement system and contractual arrangement have the same meaning (He, 1999) and will be used interchangeably in this study. The forms of procurements usually used are traditional, design and build, and management contracting.

The project organisational structure in the traditional contract arrangement is depicted in Figure 2.10, which helps to identify the main participants and relations between them. In the traditional contract arrangement, three main participants are involved: the client, the designer and the main-contractor. The client has a direct contractual relationship with the designer and the main-contractor (Shohet and Frydman, 2003). The communication or interaction is limited to the observance of contractual requirements (Pietroforte, 1997). Pietroforte (1997) further stated this communication and interaction in the traditional contract arrangement is characteristic of the impersonal and bureaucratic nature of contractual relationships which are described in the following paragraph.

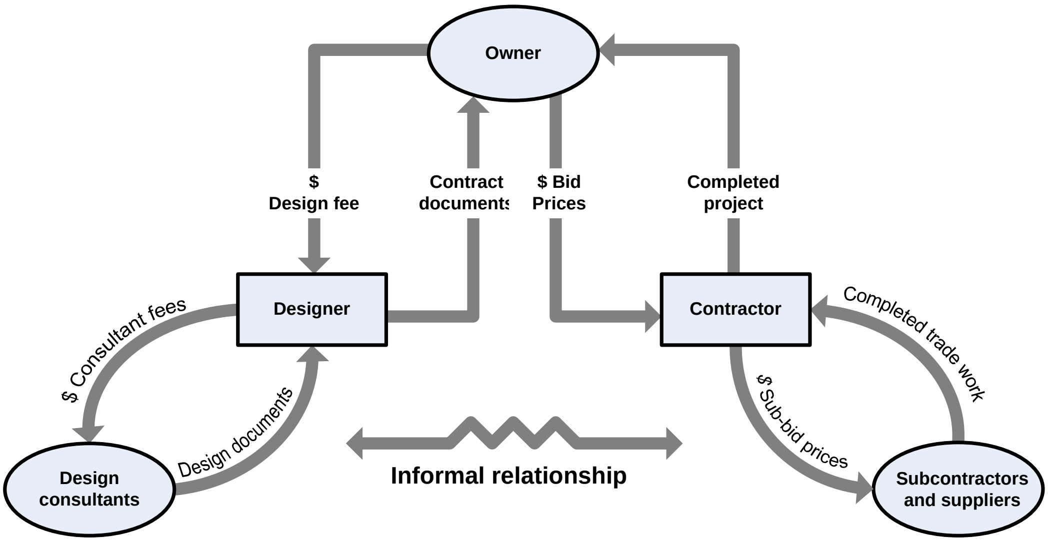

Figure 2.10 Traditional approach (Gould and Joyce, 2003)

The owner hires, on a fee basis, an architect who then hires consultants. The main contractor engages in a contractual agreement with the owner on the basis of the documentation prepared by the architect and an agreed upon fixed price. The main contractor subcontracts parts of his work to trade subcontractors on a competitive basis. In their turn, sub-subcontract portions of their work to other entities such as sub-subcontractors and suppliers. (Pietroforte, 1999)

During the administration of the construction contract at the construction stage, the main responsibilities of the architect are discharged as follows: interpreting the contract requirements, reviewing and approving submittals from the contractor and subcontractors, observing the progress and quality status of construction and reporting to the client, judging the performance of the contractor in terms of compliance with the contract documents, initiating or reviewing change orders from the contractor, verifying and approving the contractor's requests for payment.

The responsibility of the main-contractor at the construction stage is to control the construction work. The organisation is responsible for the choice of the methods, sequence, procedures and coordination for completing the work. The architect becomes the mediator of the client and the main-contractor. This function may induce an antagonistic relationship between architect and contractor. However, the architect cannot interfere with the direction and control of the construction work by the contractor.

Contractors generally subcontract a significant portion of their work to specialised contractors on a competitive basis. When this type of agreement is executed, the subcontractor becomes directly responsible to the contractor for the quality and timely completion of his work.

Another two important procurement methods, Design-Build (Figure 2.11) and Construction Management (Figure 2.12), have gradually been used in the construction industry to deal with the complex environment and relationships. According to the contract documents in a Design-Build arrangement, the main-contractor becomes the most important participants and undertakes full or partial responsibility in the design and construction stages. The increasing complexity of projects has also led to the development of the Construction Management procurement protocol, in which there is no main-contractor between the owner and the various specialist subcontractors. The construction manager becomes the principal consultant coordinating the entire

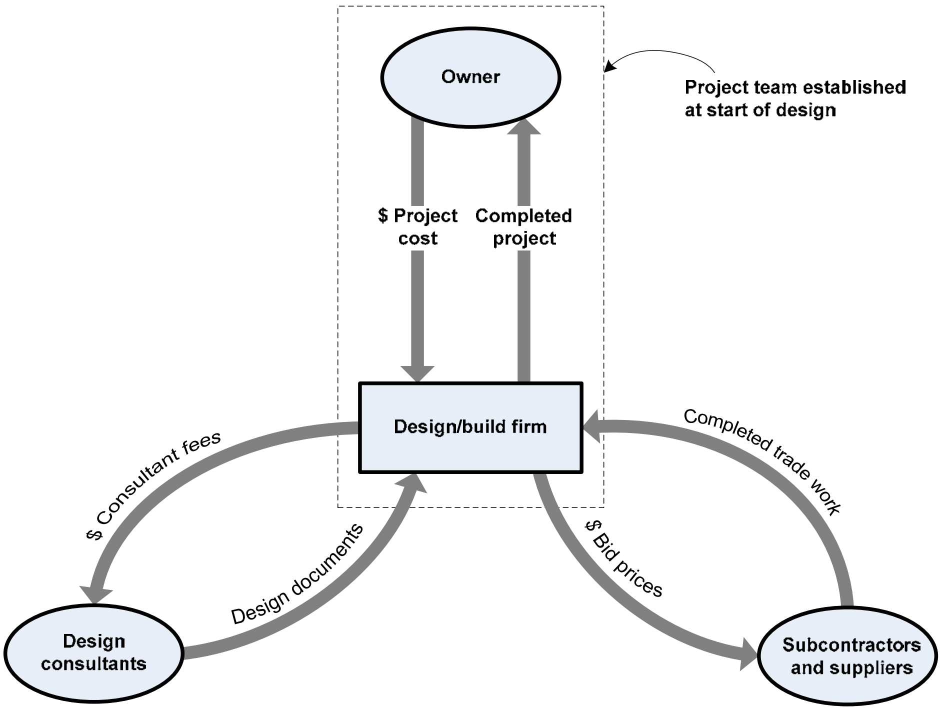

Figure 2.11 Design and build approach (Gould and Joyce, 2003)

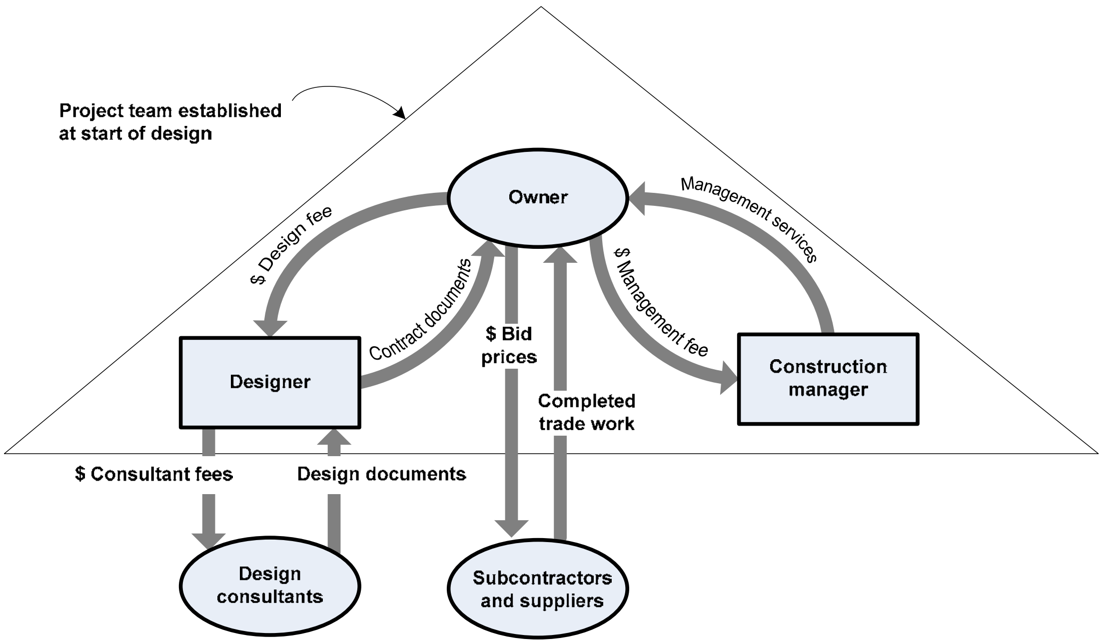

Figure 2.12 Construction management approach (Gould and Joyce, 2003)

building process, from the conceptual design through the commissioning of the project. Construction management firms do not perform any design or construction activities, but rather act as the owner's representative, controlling and managing the flow of information during the life cycle of the project (Shohet and Frydman, 2003).

In this study, the building project and traditional contract arrangement are the basic settings for analysis, but the new building process and role patterns, for example fast-track process and construction management, are also discussed.

2.5 SUMMARY OF THE CHAPTER

This chapter provides a clear understanding of communication in construction. The basic theoretical understanding and the implications to the definition, the functions and key elements of communication (communicators, information and message, media, channels and network) are discussed. Then, the communication environment – the building project process and the project team composition – is presented. These are the important and basic understandings about project team communication from which communication variables (communication indicators and factors) will be examined in the following chapters.

CHAPTER 3. IDENTIFICATION OF RESEARCH GAPS IN THIS STUDY

3.1 INTRODUCTION

The previous chapter presents a conceptual understanding of the definitions, the elements, and the environment of communication in construction. This chapter examines the major research developments in construction communication. This examination will lead to the identification of the research gaps which provides the basis of the originality in this study. First, an overview of the development of research on construction communication is presented. Second, pervious studies for improving communication performance are reviewed. Then, a special focus is given to research studying communication performance indicators and communication factors in construction. Finally, research gaps are identified and an outline of this study is presented.

3.2 RESEARCH DEVELOPMENT ON COMMUNICATION IN CONSTRUCTION

Much and fragment research have conducted on the subject of communication. The construction industry has also gradually recognised the importance of communication. But there is little research on communication in the construction industry (Xie, 2002). Emmitt and Gorse (2003) gave a brief overview of research on communication in the construction industry which is presented in this section.

3.2.1 Early research on communication

The pilot study on communication in the building industry is “Communication in the Building Industry” conducted by Higgin & Jessop in 1965 which is often referred by other researchers. This study, and the other “Interdependence and Uncertainty” (Building Industry Communication, 1966) were both published by the Tavistock Institute in the 1960s. They are the first specific examinations on communication in construction.

Higgin and Jessop (1965) investigated poor communication performance between members of the building project team. They examined and detailed the communication process in the construction projects in their study. Then, they drew their conclusion that the nature of relationships was the main factor behind poor communication. This was a result of the historical development and fragmentation of trades, professions and responsibilities in building projects. They also suggested that an attempt at improvement was unlikely to yield any degree of success in the absence of more information. Although Emmitt and Gorse (2003) argued that the frequent citing of this report may be that little other research was conducted. Higgin and Jessop’s (1965) research into the communication process and problems in the construction industry is a good start and provides a platform for further research.

Higgin and Jessop's (1965) pilot study led to a more detailed publication, “Interdependence and Uncertainty” by Building Industry Communications (1966)

(Higgin and Jessop were members of the committee). This work made an attempt to unravel the complexity of organisational relationships in the industry by conducting several interviews and 13 case studies. The report described an industry in which abortive work, misunderstanding and delays resulted from failures in communication and division of responsibilities. Uncertainty and interdependence were regarded as key characteristics of communication and information flow. Interdependence was the relevance of different streams of information to each other. However, each participant brought their own experiences and prejudices to bear on the problem, with decisions being taken on an individual level, rather than an industry-wide level. They also recognised that organisations are not static, and, when communication flow is blocked, different organisational groupings develop. The need for an appropriate scale to measure whether one form of procurement was better than others was also highlighted. Their conclusion was that construction required collaborative leadership. They further proposed seven measures to ensure ideal communication. These are listed below:

- Careful assembly of a multi-skilled team with managerial, technological and analytical abilities;
- Removal (or reduction) of artificial barriers. Thus designers become part of the site management team;
- Considered use of management tools to ensure programming and progress data is continually revised and available to all parties;
- Abolition of conflicting interests, through incentives to minimise defensive action;

- Adequate resources for obtaining information held off site;
- Limit disruption brought about by other projects, i.e. work on one project at a time;
- Record all events and actions for later analysis and feedback into future projects.

These two pilot research studies on communication highlighted the fragmented nature of building projects, the separation of design and construction activities, a lack of coordination, a lack of trust, and the prevalence of adversarial relationships. They also identified factors that hindered effective communication. In essence their conclusions were a call for greater cooperation, integration and teamwork in building projects. Although neither report led to much improvement in communication in the construction industry, “a natural assumption would be that the Tavistock publications formed the catalyst for further research and led to improvements” (Emmitt & Gorse, 2003).

3.2.2 New circumstances and the development of construction communication research

The findings and recommendations of the Tavistock reports are still relevant, even though the situation for communication has become much more complex. Since the 1960s, building technologies have become more complex, the number of specialists has increased, the construction industry has becoming fragmented further, the use of specialist languages (codification) has increased significantly, and the amount of information required to construct a building has increased (Emmitt & Gorse, 2003). Emmitt & Gorse (2003) stated that pressures on time and profit could be greater determining factors than they were in the 1960s. At the same time, the application of new procurement systems and the rapid developments in information technology (IT) systems have helped to improved organisational relationships, and the transferring of resources, the storage of information and the tracking of decisions.

According to Emmitt & Gorse (2003), some publications on communication emerged from the 1970s. There has been some interest in communication research within the International Council for Research and Innovation in Building and Construction (CIB). For example, Working Group 96 'Architectural Management' has witnessed several studies attempting to deal with communication, both explicitly and implicitly, and Working Group 102 'Information and Knowledge Management in Building' has carried out some important work in the area of communication. Additionally, the papers published in the proceedings of the Association of Researchers in Construction Management (ARCOM) conferences which focus on communication, have steadily increased (e.g. Dainty & Moore, 2000; Gorse *et al*., 2000; Xie *et al*., 2000).

The above publications and previous research work explored communication in construction from different aspects and tried to investigate methods to improve communication in the construction industry. Their focuses and methods given on how to improve communication in the previous studies will be discussed in the following section.

3.2.3 Discussion on the nature of construction communication research

Based on the overview of research on construction communication, some kinds of studies on construction communication are discussed in the flowing paragraph.

Difficult communication research

Communication is a difficult thing to measure and it is difficult describe its components (Emmitt and Gorse, 2003; Guevara, 1979; Mead, 1999). As indicated in chapter two, communication has a comprehensive meaning and multiple elements, including roles, information, channels, networks, media, and barriers. Each of these elements can be broken down further into multiple variables. Each variable is abstract and dynamic. All of these variables mean that human communication is complicated and difficult to grasp in its entirety (Mead, 1999). Hill (1995) and Guevara (1979) also stated that the diversity and dynamics of communication processes do not readily fit with any recognised organisational models.

Team communication is more complicated to study due to the constraints and conflicts upon practitioners (Marshall-Ponting and Aouad, 2005; Thomas, 1996). Various organisations represented by the team, competitive interests of team members, different epistemological backgrounds and methods, and the individual requirements and agendas of other members all serve to complicate team communications (Marshall-Ponting and Aouad, 2005; Thomas, 1996;). Meanwhile, modelling and analysing communication in building projects is particularly difficult (Emmitt and Gorse 2003).

Extensive and fragmented communication literature

The literature surrounding communication is rich and fragmented (Mead, 1999). Communication has been studied by business researchers, computer scientists, psychologists, anthropologists and sociologists. Communication research areas cover human communication, mass communication, management communication, business communication and most recently the field of organisational communication (Mead, 1999). Therefore, Hunter (1993 cited in Xie, 2002) stated the study of communication is an inexhaustible one.

Little research on communication in the construction industry

Many textbooks and much literature studied the subject of communication in general, but little studied communication in the construction industry. As stated by Emmitt and Gorse (2003) construction management research can be traced back to the early 1960s with initial studies focusing on hard issues. It was not until the mid-1990s that the softer social sciences came to be applied to the construction management field. During the evolution of construction management research, few publications have dealt with communication, even though the industry has recognised the importance of communication across organisational boundaries to implement building projects (Emmitt and Gorse, 2003; Xie, 2002;).

From the above discussion, it is clear that communication is complex, but fundamental to the construction process. However, research on communication in the construction industry is scarce. Emmitt and Gorse (2003) pointed out “clearly construction communication research is in its infancy, and we should seek to learn from those social scientists and industrialists, from other sectors, who have recognised the importance of communication for some time.”

3.3 METHODS FOR IMPROVING COMMUNICATION

3.3.1 Importance and necessity for improving communication

Many studies highlighted the importance of communication to project success. For example, Thamhain and Wilemon (1986) listed "communicating effectively among task groups" the third most significant factor contributing to project success. Emmerson (1962) highlighted the vital importance of effective communication of information amongst the various participants of a building project. CII (1986) argued that "the single most important factor that contributes to successful project management is communications". Sonnenwald (1996) suggested that communication is a vital process for collaboration during design.

Others further proved this significance of communication using different methods.

Curties *et al*. (1988) studied the importance of communication and communication breakdowns using structured interviews. Hassan (1996) confirmed the importance of communication to the design process through interviewing designers. Thomas *et al*. (1998) analysed the relationship between project success and effective communication based on the data collected from 72 projects conducted by CII (Construction Industry Institute) organisations. They proved that effective communication is essential to the success of a project from the result of their multi-regression analysis.

Previous studies have also explored the impacts of communication on specific aspects of projects. For example, Olson (1982) studied the impacts of poor communication on productivity at the crew level in building projects. Coble and Snow (1996) and Mackanzie *et al*. (1999) stated that good communication has a significant impact on the safety records of projects. Jergeas and Hartman (1994) concluded that good communication and record keeping could avoid claims and disputes in building projects.

Even though effective communication is significant to project success, communication is a complex activity and its effectiveness is difficult to achieve. There are many explicit and implicit arguments regarding poor communication in the construction industry. Communication problems are always reported on industry bulletins, newspapers and academic articles. Successive governmental reports (Banwell, 1964; Egan, 1998; Egan, 2002; Emmerson, 1962; Latham, 1994) have consistently drawn our attention to the apparent lack of effective communication within the construction sector. Guevara & Boyer (1981) studied communication problems within construction companies and confirmed their prevalence in practice. Dawood *et al*. (2002) stated that increased communication problems arose as a result of the increased number of organisations involved and the large amount of information produced in building projects. Xie *et al*. (2000) examined communication problems about design in building projects and detected that communication problems appeared frequently in both internal and external communication processes and occurred more often at the design and construction stages. Some specialists have obvious advantages in this ineffective communication environment (Emmitt & Gorse, 2003; Xie *et al*., 2000). But if many individual groups are not coordinated properly, the construction work remains fragmented, resulting in bad performance in terms of quality, cost and time. Thus, Thomas *et al*. (1998) drew the conclusion that the lack of effective communication is a major obstacle to project success.

3.3.2 Approaches for improving communication performance

Different approaches to improving communication performance have been proposed and explored in previous research work. Marshall-Ponting and Aouad (2005) stated that there are two main theories for communication improvement, being technical tools and social action or human management approaches. Technical determinists believe technology is the single most important factor; but who apply the social action or human management approach proposes technology is enabling rather than deterministic. Marshall-Ponting and Aouad (2005) further argued that a mixture of both technology and human management approaches bring about changes, for example the method, Groupware, combined technology and strategic decision-making management methods. Other researchers (Emmitt and Gorse, 2003; Pietroforte, 1997) agreed with this statement and proposed that communication performance improvement is assumed to be caused by organisation management methods combined technique tools.

3.3.2.1 IT applications

New and emerging Information Technologies (IT), such as email, internet, multimedia, and virtual reality, have changed communication activities and played an important role in improving communication performance in the construction industry (Anumba and Evbuomwan, 1999; Nitithamyong and Skibniewski, 2004; Shen, 1992; Rojas and Songer, 1999). IT development and applications in construction communication are discussed in this section.

Mead (1999) summarised three broad stages of the development of information technology (IT) in construction. In the first stage, prior to 1980, computers were used to help streamline manual tasks like bookkeeping, typing, and number crunching. The second phase was the early 1980s, with the advent of the personal computer. During this era, construction computing became more application focused, and the period saw the development of stand-alone programmes for estimating, scheduling, and design. In the third phase, which dates from 1990, IT developed as a communication medium capable of establishing favourable supply chain relationships.

The communication environment has changed a lot by applying IT in the current construction industry. Considerable research has explored and developed information technologies, aiming to improve communication in building projects. They explored IT for improving communication through automatic information handling and expression, reengineering the communication network, and widening the available communication media. The typical work of which is described below.

IT has changed the media used for communication in construction. Pietroforte (1997) and Anumba and Evbuomwan (1999) suggested there is a need to provide for an appropriate medium infrastructure for communications supported by IT that will facilitate multilateral and flexible communication for project participants. According to Shohet and Frydman (2003), the potential of electronic means of communications is especially important for communication between project participants. They further suggested that the expanding use of emails may significantly increase project team communications performance. Mead (1999) examined the intranet-based communication process in building projects to determine the intranet’s effect on project communication effectiveness. The results indicated that by allowing each member of the project team timely access to key project information, an intranet creates a virtual communication network and benefits project communication performance.

Some researchers investigated and developed techniques to code and present information to facilitate communication between the participants from different professions. Generic methods have been developed and applied to aid information exchange between project participants in the construction industry. These include IDEF0 based modelling of information processes, the design structure matrix analysis, ApePT multi-objective-multi-criteria methods, IFO and STEP Information exchange standards (Austin *et al*., 1997). These product-modelling approaches such as industrial foundation classes IFC and aecXML enable the internet can overcome the in compatibilities of data formats, information can be real time shared without any transformation (Nitithamyong and Skibniewski, 2006; Wix and See 1999). Other enhanced visualisation tools based on the "what you see is what I see" (WYSIWIS) philosophy were also developed to present information and improve understanding in the communication process e.g. 3-dimensional drawing, 4-dimensional simulation (Anumba and Evbuomwan, 1999).

Other research has also been done to model information flow and the communication process in a building project. For example, Dawood *et al*. (2002) developed the automated communication system for a site document management system to facilitate the exchange of data and information between the building project team members. Caldas and Soibelman (2003) presented a prototype document classification system for managing information systems to aid information communication between the project participants.

Some information technologies to improve communication performance are by providing a computer-aided collaborative environment (Mead, 1999; Abduh and Skibniewski, 2004). Mead (1999) stated that computer supported collaborative work is a broad field that studies how people use technology to collaborate. Mead (1999) explained that the specific enabling technologies of computer supported collaborative work are often referred to as "groupware" which make use of multi-media technologies such as email, newsgroups, workflow systems, group calendars, collaborative writing systems, shared whiteboards, video communications, chat systems, and decision support systems. Perry and Sanderson (1998) suggested groupware systems have the potential to be useful for communication between participants in the construction industry and they stated that this system is now used more frequently that it did previously. Perry and Sanderson (1998) also suggested to use the method of concurrent engineering as a collaborative environment to improve communication between participants. Anumba and Evbuomwan (1999) studied the process of concurrent engineering in building projects and proposed an integrated framework for concurrent engineering in order to improve the effectiveness of the communication of project information at all stages in a building project’s life cycle.

According to Castro-Lacouture and Skibniewski (2003), computer supported collaborative work, usually realised by electronic network, is for communications-supported operations and the exchange of project information among highly distributed organisations such as contractors, designers, and suppliers. It also investigates fundamental design principles for the effectiveness of these activities (Nof, 2000). In terms of this principle, network based project management technologies as communication and information retrieval tools have made a rapid development by using internet-based technologies.

Abduh and Skibniewski (2004) reviewed academic research work to develop web-based collaborative work system for project management and information exchange. The WWW Coach project at Stanford University provides a mechanism to collect, organize and share information and service from the Web (Fruchter and Reiner, 1997). The Field Inspection Reporting System (FIRS), developed at the University of Colorado, is a system to collect, deliver, process, and manage the information produced in the inspection processes by taking advantage of state-of-the-art technologies such as pen-based computers, digital cameras, and the Web (Rojas and Songer, 1997). The SCHEREC project has as its objective to develop a web-based project management system by combining the power of an existing project management system with the Web, making the project schedule available to anyone from anywhere (Pena-Mora and Chen, 1996). A joint research between the University of Illinois at Urbana-Champaign and the U.S. Army Corps of Engineers at the Construction Engineering Research Laboratory (CERL) established the

WWW-QC project. This project is intended to demonstrate the possibility of multimedia information management through the use of a called “digital hard hat”, and the Web as the mode of information exchange and retrieval (Liu *et al*., 1996). An assessment model to measure the utility of ENT services to support activities in a particular project delivery system is needed (Skibniewski and Abduh, 2000).

In practice, a number of construction companies adopted these web-based project mangement technologies (Doherty, 1999; Nitithamyong and Skibniewski 2006). Nitithamyong and Skibniewski (2006) introduced that the most popular web-based project management systems used in construction industry are developed and offered by application service providers. They listed some examples of leading products, such as Buzzsaw by Autodesk, ProjectTalk by Meridian Project Systems, PrimeContract by Primavera, Viecon by Bentley, and VISTA 2020 by Market Street Technologies.

Research studies indicate that when firms embrace IT they can improve information flows and optimise the way a team communicates (Back and Bell, 1994; Basu, 1996; Betts *et al*., 1991; Brochner, 1990; Hammer and Champy, 1993). However, IT has been reported as being under-developed and less effective in the construction industry (Brandon, 2000; Pietroforte 1997; Seneviratne and Schexnayder, 1999). Information technologies haven’t been applied and used well in the real workshop. It was also reported that IT increased information overload and caused the loss of managerial control on information flows (Mead, 1999), which led to the IT applications in construction industry left relatively behind in their development.

3.3.2.2 Organisation management approaches

Technological 'solutions' are not only tools assisting the communication process. Communication should also concern the soft aspects, the people issues. Managing the background of communicators, the relationships between senders and receivers, and the organisational context will impact the performance of communication in construction. In the construction industry, the most important impact on communication is the way the project and team are organised. Previous studies put a lot of effort into exploring management approaches to improving communication performance, and typical examples of these approaches are introduced in this section.

The main important management approach in managing and improving project team communication performance is ensuring the appropriate contract arrangement sets up lines of communication and information flow among project team members (Mead, 1999; Pietroforte, 1997). Pietroforte (1997) studied communication and information between participants in different types of organisation transactions in building projects. He advocated that the organisational context and the nature of the information should be taken into account when trying to improve communication. Then he proposed a framework to interpret the impacts of different transactional organisations on information and communication. Pietroforte (1997) concluded that federative mechanisms supported by contract arrangement and technique infrastructure are key to improving project team communication effectiveness. The importance of the contract arrangement for project team communication is also manifested by many other research studies. Banwell (1964) studied contracts and communication, especially on issues of formal relationships. Shohet and Frydman (2003) argued the fast-track construction environment promoted the adoption of Construction Management procurement, in which contract arrangement is deemed to improve the effectiveness of project team communication. They further explored the communication characteristics in this procurement system.

According to Mead (1999), substantial evidence from previous studies e.g. CII, 1991; Eubanks & Bruno, 1995; Larson & Gray, 1995; William, 1992 proved that some organisation management approaches, such as partnering agreements and formal teambuilding, result in improved communication within the project team. Partnering is a management approach used by two or more organisations to achieve specific business objectives by maximising the effectiveness of each participant’s resources. The approach is based on mutual objectives, an agreed method of problem resolution and an active search for continuous measurable improvement (Bennett and Jayes, 1995, cited in Xie,2002). Through a partnering arrangement, the relationships between team members and their appreciation of eachother could be improved (Xie, 2002). This improvement helps build a friendly environment and improves the performance of project team communication.

3.3.3 Discussion on improvement methods

The consistent theme is the call for improvements to communication performance. But how this should be achieved is harder to find. The focus of this study is based on the following discussion of the improved methods.

Even though IT and organisation management approaches can help to improve communication, improved communication performance is still harder to achieve. Emmitt and Gorse (2003) led our attention to the following suggestions, which are some key themes but may be misleading in some areas.

Less attention paid to people issues than IT applications

Emmitt and Gorse (2003) commented that that the view that information technology will transform the way we work is rather optimistic. They further argued that transformation takes more than the implementation of hardware; it also requires more attention to the people issues.

Unclear organisational relationships and barriers to communication are more important than contract arrangement

New forms of contract and new procurement routes that attempt to improve organisational communications and so promote better teamwork have been introduced. Emmitt and Gorse (2003) argued that although a few exceptions do exist, the situation is more complex than it was 50 years ago. They further suggested that underneath the complexity of contract and procurement routes lie the same fundamental organisational relationships and potential barriers to communication.

According to Emmitt and Gorse (2003), to improve communication performance more emphasis should be placed on understanding factors impacting communication activities such as transacted tasks, the fundamental organisational relationships, and potential barriers to communication. Therefore, more efforts are needed to investigate factors that are essential to communication effectiveness. Therefore, previous studies examining the communication factors are reviewed in the next section.

3.4 STUDIES ON EXAMINING COMMUNICATION

Systematic studies on exploring factors influencing communication performance are difficult, but essential to improving communication effectiveness. Because of the complexity of communication, few researchers have systematically investigated factors influencing communication performance in the construction industry. These studies explored communication factors from different perspectives (e.g. Guevara, 1979; Wong *et al*.; 2004; Xie, 2002). Wong *et al*. (2004) explored the factors of project, organisation, individual, and communication variables as the sources of poor communication performance. Xie (2002) investigated factors of management strategies which could improve communication performance. Guevara (1979) conducted the study at the level of interpersonal communication within a company, but Wong *et al*. (2004) and Xie (2002) at the level of inter-organisational communication in a project. These systematic studies will be discussed in the following section, and detailed reviews of these studies are presented in the next chapter.

Quantitative analysis of communication and individual variables as the causes of communication problems in a construction company (Guevara and Boyer, 1981)

Guevara and Boyer (1981) investigated the communication factors of the organisation and individual characteristics and their influences on communication performance at the interpersonal level within nine construction companies. They applied the technique designed by Roberts and O'Reilly (1974) which investigated variables measuring communication across organisations. The multiple regression method was employed to find out which communication or individual variables affected the communication problems and to what extent. This was perhaps the first time that a quantitative method has been used to examine construction communications.

Qualitative analysis of impacts of factors of management strategies on communication problems for design communication within a project team (Xie et al., 2002)

Xie (2002) examined communication related to design issues between project participants at the design and construction stages. Case studies were carried out to gain insights into communication problems and explore why and how they are caused. Through the interviews conducted in case studies, a model was developed, consisting of the factors of management strategies, and their impacted communication problems.

Key factors for improving project team communication in Construction Management procurement projects (Shohet and Frydman, 2003)

Shohet and Frydman (2003) studied project team communication in the organisation context of Construction Management procurement. By examining the performance of communication in some effective projects by case studies, they identified several key factors for improved project communication in the construction management procurement context.

Factors influencing communication of safety information between main-contractors and sub-contractors (Wong et al., 2004)

Wong *et al*. (2004) identified the factors affecting communication of safety-related information between the main-contractor and sub-contractor in building projects. By conducting a post questionnaire survey and employing factor analysis methods, they set up a framework of the factors.

Factors causing communication problems on construction sites (Carter, 1993 cited in Xie, 2002)

Carter (1993 cited in Xie, 2002) investigated the communication problems identified by staff on an actual building site through structured interviews. This investigation lead to the development of four categorised factors which were communication problem happened environments.

3.5 IDENTIFICATION OF RESEARCH GAPS IN THIS STUDY

After the discussion of the importance of communication, communication performance improving methods, and the reviews of communication factors, the identified gaps are discussed in this section.

There has been little progress in improving and measuring communication effectiveness

Numerous studies have highlighted the importance of effective communications for project success and many publications identified communication problems in the construction industry, however little progress has been achieved in improving project team communications effectiveness in the construction industry (Thomas *et al*., 1998; Xie, 2002)

There has been little research into communication at the construction stage

Many studies about communication have been done in the fields of psychology and management studies. However, with a few exceptions, communication in the construction industry, particularly on site level, has rarely been studied (Thomas *et al*., 1999; Wong, *et al*., 200). Emmitt and Gorse (2003) concluded that the studies are predominantly design orientated. Only a few of the studies addressed issues that occur during the construction phases. For example, Pietroforte's (1992) research addresses the relationship between communication behaviour and the contractual conditions in the USA. A study commissioned by the Construction Industry Institute into the effectiveness of communication within project teams concludes that the major obstacle to project success is the lack of effective communication (Thomas *et al*., 1998).

Little research considering communication in specific organisation settings

There are no comprehensive and fully adequate theories or conceptual systems for explaining the nature of communication in organisational settings. Research should be developed to study communication performance within an industry like construction which has specific management and work contexts. The research should include cases of certain procurement, techniques and stages, or set the constraints on these requirements.

Little research has been undertaken to explore the factors influencing communication performance

Research tends to be focused on one particular event or one aspect of communication. According to Guevara (1979) and Emmitt and Gorse (2003), the variables relating to communication in construction have been studied at one point in time or another. Some give primary attention to the interactive process to which other elements are bound. Some examine group coherence in team meetings. Some look at a single aspect such as the impacts of a project intranet, or the client-quantity surveyor relationship. Hastings (1998) suggested that complex projects require an overall communication strategy. In order to understand and develop comprehensive theories of communication, these phenomena need to be simultaneously considered in future conceptual and empirical work, not separately as has been done but rather in a matrix which would show the relationships among these variables. However, few studies systematically explored the influence of factors on communication performance, only the studies of Wong *et al*. (2004) and Xie (2002) discussed in the above section.

Little work on the interaction of communication factors and communication performance

According to Mead (1999), some factors such as project team structure, the level of teamwork, contract form, scheduling requirements, and interpersonal relationships all seem to contribute to the success or failure of project communications. He further argued that there has unfortunately been little formal research that has explored the correlations between these variables and project communication performance (Mead 1999). Therefore, there is a need to look at these variables and to find out how communication performance is affected by the factors of the organisation and the project.

Few quantitative studies to examine the impacts of factors on communication performance

Xie (2002) examined the communication problems and investigated influenced factors in construction design. However, she only included three projects in the sample. This obviously limits inferences based on the study. Quantitative studies are needed to identify effects and to determine the relative strengths and extents of these factors on communication performance across a broad spectrum in construction.

3.6 RESEARCH FOCUS OF THIS STUDY

Based on the above discussion, the focuses of this study is established. This study focuses on setting up a conceptual framework of factors for managing project team communication at the construction stage. The first effort is put into considering how to examine communication performance at the construction stage by conducting a literature review. Then, the next major effort is put into finding out what factors are important to communication management and impact communication performance by conducting a literature and pilot survey. Finally, the impacts of the factors on communication performance are investigated by conducting an empirical questionnaire survey.

3.7 SUMMARY OF THE CHAPTER

This chapter reviews the major research in construction communication. This examination leads to the identification of the research gaps and outlines the focus of this study. Much research has been conducted on the subject of communication in general, but little focuses on communication in the construction industry. Previous studies were conducted for improving communication effectiveness, but little progress has been achieved. The focus of this study is set up: identifying critical factors for managing inter-organisational communication at the construction stage and analysing their impacts on communication performance. The next chapter will investigate how to examine communication performance by conducting a literature review, which will set up the basis for analysing the communication factors’ significance and impacts.

CHAPTER 4. ASSESSMENT TOOLS FOR COMMUNICATION PERFORMANCE

4.1 INTRODUCTION

To explore the impact of factors on project communication performance, communication performance should first be defined. However, little development has been made on assessing communication performance in the construction industry. In this chapter, the previous research on examining communication performance is reviewed. Following the literature review, an assessment tool used in this study is found to measure and compare the performance of project team communication. This assessment tool forms the basic means for analysing the impacts of factors on project team communication performance in this study. It can also be used to identify communication problems and evaluate the team communication performance of a project in the next stage of the study.

4.2 THE MEANING OF COMMUNICATION PERFORMANCE INDICATORS AND COMMUNICATION FACTORS

In this section, the meanings of interested variables, communication performance indicators and communication factors, as well as the rationale of the relationship between them, are defined.

Relationships among variables in social studies are usually complex, having multiple and intricate levels. Social variables are found to be highly related to each other and to have complex relationships (Miller and Salkind, 2002). Regarding to a research object, different researchers have their own perspectives, own settings, and own interested part of a object consisting of multiple levels. Thus, the same variables are termed and grouped in different ways by different authors. In these complex relationships, some variables could be viewed as causes in one study, but as effects in another study.

One important thing is to carefully define the meaning of variables and the relationship rationale between them in the study. Two terms, *communication factors* and *communication performance indictors,* label the variables that are to be studied here. Factors and indicators are terms which usually refer to variables of predictors and results respectively. Factors are variables of predictors which influence the performance of an object. Indicators are variables of results which indicate the performance of an object.

The primary investigated variables in this study are critical factors for managing project communication. These *factors are critical factors for managing project team communication at the construction stage and could impact the effectiveness of team communication in a building project*. These critical factors are called '*communication factors*' in this study and include factors of project characteristics, for example project complexity and project client experience, and factors of management measures, for example project information technology (IT) applications, project organisation management approaches, project communication media infrastructure, project information documentation, arrangement of organisational structure, schedule for communication and information distribution, information with high-quality content, social and informal mechanisms for cooperative working environment, and capable project manager. These factors will be discussed in detail in the next chapter.

To explore the communication factors' impacts on project team communication performance, the project team communication performance should be assessed first. In this study, *variables* which are *used to assess the performance of team communication on a project* are called *communication performance indicators,* for example communication inaccuracy and information underload. Through these communication performance indicators, the communication factors' impacts on the performance of project team communication can be examined. These communication indicators can also be used to identify communication problems and to evaluate the performance of project team communication in an individual sample project. These performance indictors are identified and discussed in the following sections of this chapter.

4.3 PREVIOUS STUDIES ON ASSESSING COMMUNICATION PERFORMANCE

To set up a list of communication performance indicators to assess communication performance, a comprehensive review of previous research in this area was conducted and is presented in this section. The assessment of project team communication performance is the primary work for further analysis on the impacts of factors on communication performance.

4.3.1 Necessity of assessing communication performance

To investigate the impact of factors on project team communication performance, the performance of project team communication should be defined and evaluated first. Also, to improve project team communication, an important step is to measure communication performance. Tomas *et al*. (1998) indicated that "consistent with the supposition 'what gets measured, gets done', a necessary step for improving project communications is the development of a means for measuring communications effectiveness".

However, communication performance has remained ambiguously defined and evaluated in the construction industry. Communication is abstract and dynamic in nature (Guevara, 1979). Communication performance is something more complex to describe and measure. Little development has been made on assessing and comparing communication performance in the construction industry. In addition, effective communication performance means different things to different people. While some writers consider information timeliness, accuracy and completeness as predominant criteria, others suggest satisfaction with coordination could be one important criterion.

4.3.2 The aims and performance of communication

It is crucial to describe the functions and aims of communication in order to define and assess communication performance. Effectiveness of communication is how well the functions of communication are implemented or the degree to which the aims of communication are met. Communication between project participants at the construction stage is used to facilitate the transmittance of information among project participants, the coordination of technical work, and the maintenance of their social relationship. To effectively implement these functions, some specific aims of communication are expected to be achieved. Guevara and Boyer (1981) stated that the primary aim of communication in organisations is to provide accurate information to all members who need the information. This assumes that neither too much nor too little information is in the system, and that it is clear from the outset who can utilise the available information (Guevara and Boyer, 1981). PMI (2000) said that the aim of project communication is that each member of the project team should timely access to key project information and information should be quickly and appropriately transmitted among project participants. Mead (1999) echoed the above aims and further advocated that good communication should also achieve work collaboration among project participants. Thus, communication performance may be indicated by the degree of these communication objectives achievements.

However, communication is complex activities and its effectiveness is difficult to achieve. The prevalence of communication problems in construction projects is often reported in industry bulletins, newspapers and academic articles.

Guevara & Boyer (1981) studied communication problems within construction companies and confirmed their prevalence in practice. They further revealed communication overload (having too much information), gatekeeping (the withholding of information), and the distortion of information were severe problems. On the other hand, underload (not having sufficient information) was not a severe problem.

Other researchers studied communication problems in construction projects. Dawood *et al*. (2002) stated that communication problems increased with the number of organisations involved and the amount of information produced in construction projects. He further pointed out inconsistency and ambiguity as common problems in information produced and exchanged. Xie *et al*. (2000) examined communication problems relating to design within construction projects and detected that communication problems appeared frequently in both internal and external communication processes and occurred more often in the design and construction processes. They further elaborated that inaccurate information, late information, and information underload were prevalent in construction design. Communication barriers, information overload, information distortion, and information misunderstanding were not major issues. They also argued that different views existed between their survey respondents and those in previous studies with respect to an understanding of the information. Previous researchers claimed misunderstandings are a main communication problem in multi-team construction process, especially shared understandings between participants, however their respondents did not regard it as a major issue.

Watkinson (1992) and Shen (1992) studied deficiencies in construction project information, some of which indicated communication problems, for example, information underload in decision making or action taking due to information not produced or not distributed to sites, information overload hindering the effective utilisation of information, documents and instructions conflicting with each other, information irrelevant to its purpose due to misunderstanding the requirements or incorrect transmission, information arriving too late to plan the work or order the materials due to untimely collection or distribution, and inaccessible information due to poor presentation or hierarchy barriers.

Many researchers have discussed the aims of communication and some communication problems; however, little work has been done on assessing communication performance in the construction industry. The two valuable works in this area are introduced in the next section.

4.3.3 Models assessing construction communication performance

With the exception of Guevara & Boyer (1981) and CII (1997) there have been few studies which have actually developed a tool to assess communication performance in construction.

Four communication problems indicating communication performance in a construction company (Guevara and Boyer, 1981)

Guevara and Boyer (1981) used the frequency of four communication problems - distortion, gatekeeping, overload, and underload to initially measure inter-personal communication performance in construction companies. These typical communication problems are listed in Table 4.1. Also they investigated the causes of poor communication performance in construction companies which is introduced in the next chapter.

Table 4.1 Four communication problems as the indicators of communication performance (Guevara and Boyer, 1981)

Category	Definition and meaning
Overload	A situation in which an employee has more information than can be uti1ised
Underload	A situation in which an employee does not have sufficient information to make decisions
Distortion	Message distortion occurs when the nature of the message is changed by adding or deleting bits of information.
Gatekeeping	The act of withholding information

Project communication performance assessment tool - COMPASS (CII, 1997)

Given the importance of measuring communication performance and the lack of available research, the Construction Industry Institute (CII) achieved this vital step by identifying six critical communication variables to assess communication effectiveness on construction projects (CII, 1997). The result of the research is a diagnostic software tool for project team communication called COMPASS (the Communications Project Assessment Tool) (CII, 1997)

COMPASS is the result of a three-year study completed by the University of Texas in conjunction with the Construction Industry Institute. 38 CII member organisations contributed data on 72 projects which had a variety of project types. These projects were widely distributed geographically, and the project sizes were greater than $5 million dollars. 608 questionnaires were completed and returned form 740 distributed questionnaires during the course of data collection.

Using this data, the research team developed a set of variables which were proved to adequately measure communication effectiveness. These variables were consolidated into six manageable categories: accuracy, timeliness, completeness, understanding, barriers, and procedures. These six variables and their descriptions are illustrated in Table 4.2 (listed in the following table by order of relative importance). The weighting factor applied to each category was developed as a means to reflect the relative importance for effective communication (Thomas *et al*., 1998)

Table 4.2 Critical communication variables for assessing project communication performance (Thomas *et al*., 1998)

Category	**Description**
Accuracy	The accuracy of information received as indicated by the frequency of conflicting instructions, poor communication, and lack of coordination.
Procedures	The existence, use, and effectiveness of formally defined procedures outlining scope, methods, etc.
Barriers	The presence of barriers (interpersonal, accessibility, logistical, or other) interfering with communication between supervisors or other groups.
Understanding	An understanding of information expectations with supervisors and others
Timeliness	The timeliness of information received including design and schedule changes.
Completeness	The amount of relevant information received.

To enhance the usability of this result, the research team used these communication variables to develop a Windows-compatible software application called COMPASS (The Communications Project Assessment Tool). COMPASS is a software-based diagnostic tool which can be used to collect data on the communication variables, assess the communication effectiveness of the project, and report the performance as a communication score.

Thomas *et al*. (1998) suggest that their study of developing COMPASS is a milestone for the improvement of project team communication by measuring communication effectiveness. COMPASS is designed for use by project managers in assessing team communication performance during the design and construction phases of engineering, procurement, and construction projects (Thomas *et al*., 1998). Through the use of this diagnostic tool, project communication effectiveness could be both measured and monitored, with specific problems identified. Additionally, a benchmark of the performance of project communication effectiveness was established by an average score from the 72 CII projects that were used to develop the tool. This enables users to compare and evaluate their communication scores with the established benchmark.

4.4 SETTING UP AN ASSESSMENT TOOL FOR COMMUNICATION PERFORMANCE

Based on reviewing previous research work that examined communication performance, it is possible to set up an assessment tool to evaluate project team communication performance in this study.

4.4.1 Discussion of previous work for assessing the performance of project team communication

From the literature review, even though some researchers provided indicators of communication performance in construction, only Guevara and Boyer (1981) and CII (1997) developed tools to reliably measure communication performance and assess communication effectiveness. Table 4.3 summarises the communication performance indicators used in Guevara and Boyer (1981) and CII's (1997) assessment tools and the indicators provided by others.

Table 4.3 Communication performance indicators

Performance indicators	**Definition and statement**	CII (1998)	Guevara & Boyer (1981)	Mead (1999)	Murray (2003)	Xie (2002)	Watkinson, (1992)	Shen, (1992)
Understanding	An understanding of information expectations with supervisors and other groups (COMPASS)	√		○	○	○		
Accuracy	Poor communications and a lack of coordination (COMPASS)	√		○	○	○	√	√
	Conflicting instructions (COMPASS)	√		○	○	○		
Timeliness	The timeliness of information received including design and schedule changes. (COMPASS)	√		○	○	○	√	√
Barriers	The presence of barriers: interpersonal, accessibility, logistic or other-factors (COMPASS)	√		○	○	○		√
Procedures	The existence, use and effectiveness of formally defined procedures outlining scope, methods, etc. (COMPASS)	√		○	○	○		
Underload /Completeness	Completeness: The amount of relevant information received. (COMPASS) Underload: A situation where an employee does not have sufficient information to make decisions. (Guevara, 1979)	√	√	○	○	○		√
Overload	Overload: A situation has more information than can be efficiently uti1ised. (Guevara, 1979)		√			○		√
Distortion	Message distortion occurs when the nature of the message is changed by adding or deleting bits of information. (Guevara, 1979)		√			○	√	
Gatekeeping	Gatekeeping : The act of withholding information (Guevara, 1979)		√			○		

√: Those who provided indicators
○: Those who used other's indicators

Comments on Guevara and Boyer's (1981) work

Guevara and Boyer's (1981) four communication problems measure the performance of inter-personal communication in an organisation. Their four variables of communication problems were used by Hunter (1993 cited in Xie, 2002) and Xie (2002) to measure communication performance in construction projects. Xie (2002) used these four variables to identify problems associated with information flow in construction projects. She concluded that these four variables could identify communication problems associated with information flow and indicate the effectiveness of communication in a particular construction project.

Comments on COMPASS

The development of COMPASS has received attention from other researchers (Xie, 2002, Mead, 1999, Murray, 2003). They all used COMPASS to assess the performance of communication effectiveness between project team members. Mead (1999) employed COMPASS to analyse the impacts of a project intranet on the communication effectiveness of a particular project. Xie (2002) used these six communication variables to investigate communication problems and issues in construction design. Murray (2003) applied COMPASS to seek the project participants' perceptions on communication effectiveness.

Mead (1999) considered that the COMPASS program developed by the CII has excellent potential for assessing and identifying communication problems on the project. He further argued that the program should be re-evaluated. He suggested that questions pertaining to the procedure variables may not be valid indicators of project communication performance for the anomalies of results. He further suggested that additional questions should be added that may help identify specific communication barriers including information overload and underload, gatekeeping, and distortion. Xie (2002) advocated a similar suggestion that additional questions should be added to identify specific communication problems with information flow, such as overload, distortion, accessibility etc., as identified by Guevara (1979).

4.4.2 Framework for assessing project team communication performance

Given that the features mentioned in the above section that COMPASS has excellent potential for assessing communication effectiveness, six communication variables in COMPASS identified by CII (1997) were used as the basic tool to assess the project team communication effectiveness in this study. The variable of procedure in COMPASS was excluded because Mead (1999) suggested that it is an anomaly in the COMPASS system. The four variables of communication problems identified by Guevara and Boyer (1981) were also included to assess communication performance. Therefore, a framework which incorporates eight variables can be formulated, as shown in Figure 4.1, for assessing communication performance in this study.

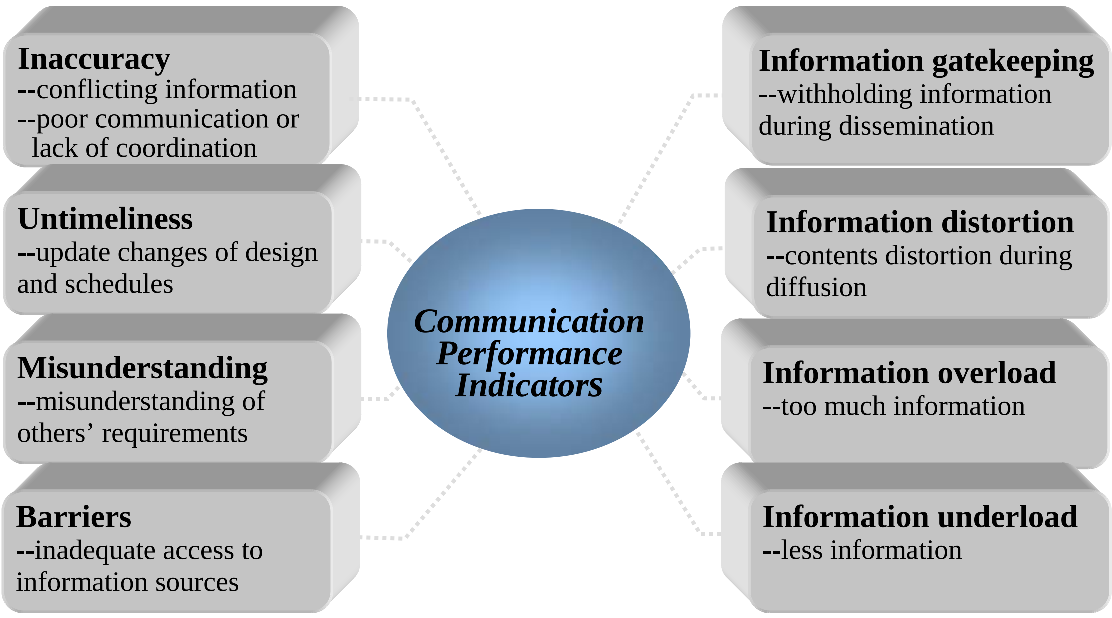

Figure 4.1 Consolidated framework for assessing communication performance

The communication performance indicators included in this framework are interpreted below. They are inaccuracy, misunderstanding, untimeliness, barriers, information underload, information overload, information distortion, and information gatekeeping.

Inaccuracy

Inaccuracy in COMPASS is indicated by the frequency of conflicting instructions, poor communication, and lack of coordination. Conflicting and inconsistent information and instructions have been reported as common communication problems by several researchers (Dawood *et al*., 2002; Watkinson, 1992; Xie, 2002; Newton, 1995). Communication between project participants is the best way to coordinate team work. Therefore, the inaccuracy of communication is also indicated by the frequency of poor communication and lack of coordination (Thomas *et al*., 1998; Mead 1999).

Misunderstanding

The indicator of misunderstanding means a misunderstanding of information expectations and requirements between each other (Thomas *et al*., 1998). Good communication should have information which fits the requirements and needs of receivers (Chris, 2000; Thomas *et al*., 1998). It requires the sender adequately understand the requirements of communication. However, Thomas *et al*. (1998) claimed an understanding of the information expectations of others is difficult to diagnose and remedy. He further claimed a lack of understanding may be present long before the symptoms are apparent (Thomas *et al*., 1998).

Untimeliness

Untimeliness is regarded as one of the communication performance indicators in this study. According to Thomas *et al*. (1998), at the construction stage, timeliness of information received includes updating changes in the design and schedule in COMPASS. PMI (2000) stated one of the aims of project communication management is the timeliness of information received. Each member of the project team should access and get the updated key project information on time (Mead, 1999; Watkinson, 1992; Thomas *et al*., 1998; Xie, 2000; Newton, 1995; Bocij and Chaffey, 2003; Shen, 1992).

Barriers

According to Thomas *et al*. (1998), in COMPASS, the meaning of barriers is the presence of interpersonal, accessibility, logistic, or other barriers that interfere with and restrict communication between project participants. Barriers are a typical communication problem in project team communication. In effective communication environment, it should be easy to contact the right persons in other participants and they should be able to provide the needed information and supports. Project documents should also be properly stored so that they can be easily accessed as needed (Shen, 1992).

Information overload and underload

In COMPASS, completeness is the amount of relevant information received which indicated by two aspects, overload or underload of information. If project participants are to effectively utilise the information, neither too much nor too little information should be presented (Guevara and Boyer, 1981; Shen, 1992). Information underload is a situation in which one does not have enough information to make decisions and implement their work (Guevara and Boyer, 1981; Hunter, 1993 cited in Xie, 2002; Mead, 1999; Xie, 2002). Overload is a situation in which the individual or system has more information than that can be utilised or processed (Guevara and Boyer, 1981; Thomas *et al*., 1998).

Information distortion

Information distortion occurs when the meaning of a message is changed or missed during diffusion, which is the communication problem related to information flow (Xie, 2002). According to previous studies, information is usually distorted or missed during its transmission in construction (Guevara and Boyer, 1981; Hunter, 1993 cited in Xie, 2002; Newton, 1995; Watkinson, 1992; Xie, 2002). This is a typical communication problem in construction.

Information gatekeeping

Gatekeeping is the act of withholding information (Guevara and Boyer, 1981). It is another problem related to information flow (Guevara and Boyer 1981; Hunter, 1993 cited in Xie, 2002; Xie, 2002). Information is often withheld by a gatekeeper intentionally or unconsciously during its communication process. An information gatekeeper is an individual so located as to control messages flowing through a communication channel, can control and withhold information (Xie, 2002). A good gatekeeper plays an important role in communication and should smooth and direct the information flow.

4.5 SUMMARY OF THE CHAPTER

This chapter has conducted a literature review on the tools used to assess communication performance. Comparative discussions have been conducted between two typical assessment tools. This leads to formulate a tool for assessing project team communication performance in this study. This assessment tool examines eight communication performance indicators which are inaccuracy, misunderstanding, untimeliness, barriers, information underload, information overload, information distortion, and information gatekeeping. These provide the basic means for analysing the impacts of communication factors on communication performance in this study. They can also be used to identify communication problems in the later stages of this work.

CHAPTER 5. IDENTIFICATION OF THE FACTORS FOR MANAGING PROJECT TEAM COMMUNICATION

5.1 INTRODUCTION

The previous chapter examines tools for assessing communication performance in construction. To improve the performance of project team communication, it is important to identify critical factors for managing project team communication. The purpose of this chapter is therefore to identify and formulate a list of the critical factors for managing project team communication at the construction stage which have an effect on the effectiveness of project team communication. These factors were investigated through a number of approaches, including specific literature reviews, a brainstorming session, and a synthesis of literature from a variety of sources. First, in order to generate preliminary data about the communication factors, specific investigation was given to several typical studies which presented various factors contributing to communication in construction. Then, the process for developing the list of communication factors in this study is described, followed by an illustration of the significance of the eleven critical factors and their implications for project team communication. This investigation leads to a formulation of a list of communication factors. These communication factors are further studied through a pilot survey in the next chapter.

5.2 PREVIOUS RESEARCH ON CONSTRUCTION COMMUNICATION FACTORS

Some researchers have investigated factors influencing communication in construction. In this section, in order to generate preliminary data about communication factors, a review was undertaken focusing on several typical studies of systematically exploring factors influencing construction communication. These studies explored various kinds of factors, for example, factors of individual and organisational variables as the sources of communication problems, factors of management and technical procedures for improving communication performance etc. (Guevara, 1979; Wong *et al*., 2004; Xie, 2002). Four typical studies are discussed as follows.

Factors influencing communication within a construction company (Guevara, 1979)

Guevara (1979) explored factors influencing communication performance within nine construction companies. He initially summarised the 27 most commonly used factors of inter-personal communication in an organisation and categorised them into three groups: communication, individual, and organisational variables (Table 5.1).

Table 5.1 Factors influencing interpersonal communication (Guevara, 1979)

Level of Analysis	**VARIABLES**		
	Communication	**Individua1**	**Organisation**
Interpersona1	-Message characteristics -Feedback -Overload and underload -Information processing -Source credibi1ity -Moda1ity choice -Gatekeeping -Distortion -Speed -Directiona1ity -Coding -Network a1ignment -Activity level -Accuracy	-Status authority -Inf1uence -Expectations -Mobi1ity aspirations -Satisfaction with communication -Trust -Interact ion	-Hierarchy: a) Number of levels b) Line-staff -Size: a) Total organisation b) Sub-units -Structure a) Tall vs flat b) Centra1ised/ decentralised -Performance criteria -Technology/work flow -Organisation rules, norms and goals

Having referred to Roberts and O'Reilly's work (1974) on organisational communication measurement and having studied further, Guevara (1979) identified 16 factors categorised into the three groups to analyse the impacts of these communication factors on four communication problems in construction companies:

- Communication variables: overload, underload, information processing, accuracy, media choice, distortion, directiona1ity, and gatekeeping;
- Individual variables: inf1uence, mobi1ity aspirations, satisfaction with communication, trust, and interaction;
- Organisation variables: type of work, size of organisation (total organisation).

The meanings and definitions of these factors were described in the work by Guevara (1979), as summarised in Table 5.2.

Table 5.2 Description and definitions of the major communication variables (Guevara, 1979)

Category	Description
Feedback	The information that is received and might be based on opinions that people may have.
Information processing	The modification of a message's content. This is done to summarise messages.
Accuracy	The quality or state that information has of being free from mistakes or errors.
Modality choice	Communication modalities are the different forms a message may take – written, oral, face-to-face, telephone, etc.
Directionality	Indicates whether information goes upward, downward or stays at the same level within the organisation.
Influence	The power of persons to affect others, seen only in its effects.
Mobility aspirations	The desire of an individual to change positions within the organisational structure.
Satisfaction with communication	Does the communication process fulfill the needs, expectations, wishes or desires that the individual has?
Trust	Willingness to be open with another individual.
Interaction	Reciprocal action between employees.
Size	Total organisation
Overload	A situation where an employee has more information than can be uti1ised.
Underload	A situation where an employee does not have sufficient information to make decisions.
Distortion	Message distortion occurs when the nature of the message is changed by adding or deleting bits of information.
Gatekeeping	The act of withholding information.

Guevara’s study (1979) is the first work to systematically examine factors in the construction industry. His study focuses on interpersonal communication within an individual construction company. However, project team communication concerns communications between various project participants from different organisations, which is the research scope of this study. Therefore, the communication factors investigated in Guevara’s study (1979) cannot be effectively applied to studying communication within a building project team, but give some indications for setting up the factor list in this study.

Factors affecting communication of safety information between main-contractor and sub-contractor (Wong et al., 2004)

In the project team communication area, Wong *et al*. (2004) explored factors influencing communication between main-contractors and sub-contractors. They focused on the communication of safety information. They identified a list of factors by using factor analysis methods to analyse the data collected from a questionnaire survey.

- Industry's physical nature
- Communication barriers
- Industry culture
- Communication means
- Organisation culture
- Content of information (messages)
- Client type and emphasis
- Values of communicators
- Organisational structure
- Provision of continuous training
- Relationship of main and sub-contractor
- Workers' attitudes

Wong *et al*.'s study (2004) is the important work that explores inter-organisational communication factors on construction sites, in which few investigations have been conducted. Their factors cover the major characteristics of projects and organisations which impact communication in construction projects. These factors have important implications for this study which focuses on team communication on construction sites.

Management strategies contributing to communication problems (Carter, 1993 cited in Xie, 2002)

In reviewing the studies on communication factors, Xie (2002) cited Carter's work (1993) in which the factors of the management areas contributing to communication problems were identified and classified under the following four categories:

- Computing or communication technology: problems associated with a computing or communication technology currently in use, or problems having the potential to be solved with such technologies
- The organisational structure: problems arising from information transfer and traditional communications within the organisational structure, typically those of omission, underload, overload and gatekeeping.
- Relationships: problems in relationships
- Management and others: problems resulting from the organisational structure, from management decisions, or those that are not classified into the above three categories.

The factors of management areas contributing to communication problems were identified through structured interviews on one construction site. Therefore, the validity of a generalisation based on these results is questionable. However, the categorised management areas for solving communication problems give valuable implications for this study which focuses on exploring critical factors for managing communication.

The factors influencing communication about design information in construction projects (Xie, 2002)

Xie (2002) investigated design communication in construction by conducting three case studies in building projects. These case studies were targeted at investigating communication problems, the factors influencing these communication problems and the corresponding management strategies. She set up a list of factors and management strategies for improving communication in construction design (Table 5.3).

The factors and management strategies in Xie's study (2002) presents a useful framework for studying factors influencing communication between building project participants. However, some of the factors and management strategies are not explained clearly enough and this framework needs to be reflected on improving its effectiveness. This model was established by a limited number of interviews in three case studies which impact its generalisation to other cases and consequently needs to be further developed. Meanwhile, Xie (2002) studied communication by examining design related issues in the implementation of a building project. Therefore, the application effectiveness of the framework developed by Xie (2002) is limited for this study, as this study's focus is project team communication at the construction stage.

Table 5.3 The key factors and management strategies for communication in design (Xie, 2002)

Key factors		**Management strategy**
Project management		
Procurement Method	Procurement method	Proper choice of procurement
Communication system	Communication strategies including the common protocols for IT use	Agreed communication strategy; common protocols for IT use;
Project support environment		
Information	Knowledge of client;	Well arranged programme; limited requirement changes; high quality brief ;
	Involvement of contractors and key subcontractors (specialists);	Early and adequate involvement of contractors and subcontractors
Quality and quantity of resource	Quality and quantity of the resource;	Well trained and sufficient resources;
Project coordination		
Social coordination	Communication environment	Good social environment
Technical coordination	Design team co-location.	Co-location design; regular face-to-face meetings
Key personnel		
Key personnel	Stability of key personnel and capability in communication	Key personnel stability and capability in communication.

The above literature review reveals that there are a number of factors influencing communication in construction. This specific literature investigation generated preliminary data about the communication factors. However, it can be seen that previous works present different groups of communication factors from various perspectives, with different focuses and scopes. Therefore, it is considered important to build up a comprehensive list of communication factors with the focus of this study on critical factors for managing communication between project participants at the construction stage. The list of communication factors identified in this study is discussed in the next section.

5.3 MAJOR COMMUNICATION FACTORS AFFECTING PROJECT TEAM COMMUNICATION

In this section, a list of identified communication factors, its logical development, and its significance to project team communication, is described. These factors have been proved their significance to project team communication from a theoretical perspective. This became the foundation for the following exploring work in this study.

5.3.1 Developing a list of communication factors from a theoretical perspective

A communication factor list in this study is a collection of relevant and significant factors, developed from a theoretical perspective. The process for developing this list of communication factors consists of several steps, including a preliminary specific literature review (Section 5.2), a brainstorming session, a more extensive literature review, and then a synthesis of reviews from the above variety of sources.

After the specific literature review, the development of a list of communication factors was then approached through a brainstorming session with two professors who are experts in construction management. The major critical factors for managing project team communication were elicited by examining the key elements in the communication process, such as communicators, information, communication channels and networks, communication media, and communication context etc.

A more extensive literature review was then conducted to further evaluate the significance of the factors and add other factors initially not included. Then, a list of significant factors was built up through a synthesis of reviews from the sources of the preliminary specific literature review, the brainstorming session and the more extensive literature review. As shown in Figure 5.1, the identified communication factors in this study include two groups that are project characteristics and management measures.

The significant impact to project team communication by these factors has been proved from a theoretical perspective. The significance of the factors is described and how they impact on the communication process of a building project is discussed in the next section. This forms the theoretical rational for the development of the communication factor list.

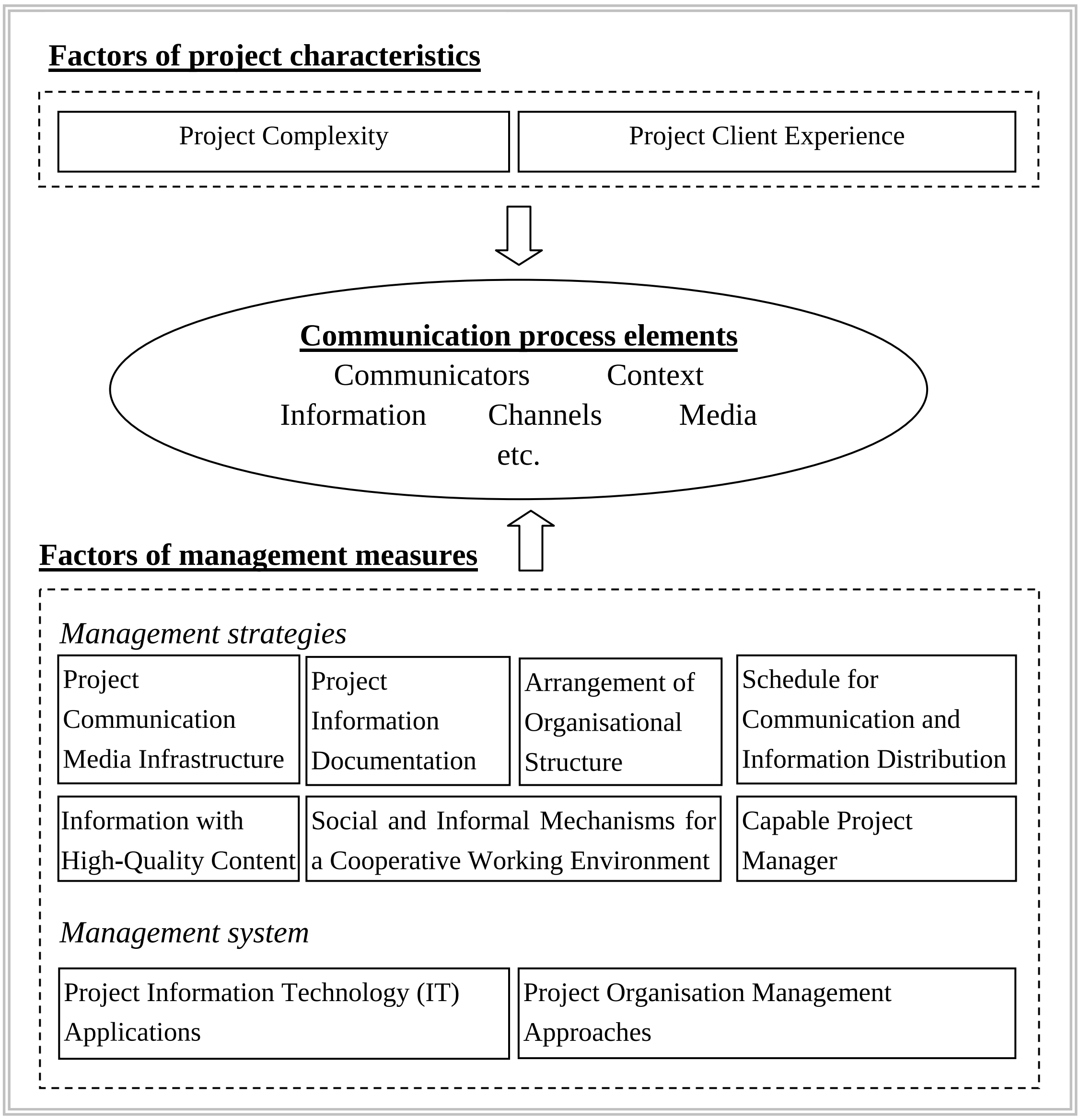

Figure 5.1 The project team communication factors

5.3.2 Major communication factors affecting project ream communication

11 critical factors for managing project team communication at the construction stage were found. These critical factors represent those managerial areas which impact the effectiveness of project team communication. These identified communication factors are classified under two groups: the factors of project characteristics and the factors of management measures:

A. Project-characteristics factors

- Project Complexity, such as project location, project size, project type, design complexity, construction complexity, the numbers of involved companies, and time constraints for design and construction work;
- Project Client Experience, such as client building experience, required completion time.

B. Management-measure factors

- Project Information Technology (IT) Applications, such as the IT application level, computer software applications, and computer hardware applications;
- Project Organisation Management Approaches, such as the type of procurement method and other measures controlling organisational relations of participants;
- Project Communication Media Infrastructure, i.e. established project communication media such as the email system, project meetings, and project intranet etc.;
- Project Information Documentation, such as the protocol for information format and description, and clear classified document storage system;
- Arrangement of Organisation Structure, such as the project organisational structure, participants' understanding of project organisational structure, the organisational structure for document distribution, and information dissemination coordinators;

- Schedule for Communication and Information Distribution, i.e. the timing of communication;
- Information with High-Quality Content, such as the high-quality design drawings and construction execution programs;
- Social and Informal Mechanisms for a Cooperative Working Environment, such as measures for maintaining inter-organisational collaborative working relationships, group culture ensuring committed attitudes of participants, policies for aligned objectives and working values among participants, and previous cooperation experience between participants;
- Capable Project Manager, i.e. project managers' capacity such as communication skills and professional knowledge.

The significance of the factors and how they impact on project team communication at the construction stage of building projects is discussed in the following section.

Project Complexity

Project complexity is one of the major factors affecting project team communication. The context of project team communication is communication for implementing a building project. Therefore, the characteristics and complexity of the building project can determine the complexity of the communication activities between project participants. Accordingly, Thomas (1996) stated that the variations in project characteristics and complexity can cause variations in a project's team communication performance.

The complexity of a building project, which has an impact on project communication, can be reflected by project location, project size, project type, design complexity, construction complexity, the numbers of involved companies, and time constraints for design and construction work.

Physical characteristics of a building project such as size and location can impact project team communication performance (Mead, 1999; PMI, 2000; Thomas *et al*., 1998). The size of the project determines the amount of information and the numbers of staff involved. Larger amounts of information need to be communicated and exchanged between project participants in larger projects. A small number of staff from different organisations can be quickly familiar with each other, and communication is much easier between them in a small project (Xie, 2002). Thomas *et al*. (1998) also claimed that excessively long communication channels, caused by remote project locations, further inhibited communication flow (however, while communication channels are impacted by the project location, they are not, physical barriers).

Complex design and construction activities can also determine the complexity of a building project and impact project team communication performance. To implement complex design and construction activities, a large amount of information is exchanged and communicated between project participants. Complex design and construction activities also require many professional inputs from different organisations whose different backgrounds, interests, and knowledge restrict effective communication between them (Kubal, 1995). Meanwhile, communication activities are always required to coordinate the interfaces of each design and construction activity when these activities are undertaken by different organisations. In addition, different types of building projects, for example commercial or residential projects, have various degrees of complexity in construction and design activities and therefore also impact project team communication.

Implementing a complex building project increasingly involves many subcontracting professional participants. The large number of subcontracting companies involved in a complex project brings about difficulties to project team communication. As the number of participants from the different organisations involved increases, the complexity of the communication structure and the number of levels and filters that project information flows need to pass also increases (Thomas *et al*., 1998). Different organisational participants also have different working patterns and different interests which often restrict effective communication between them.

Limited working time further increases the complexity of a building project and complicates the construction communication activities. Nowadays, building projects are often under a tight timetable. A project duration is compressed by "overlapping the design and construction of individual work packages" which is called a fast-track process (Newton, 1995). Under this tight timetable designers have limited time to conduct design activities. Usually, the complete set of design working drawings is not available before site work commences in fast-track projects, presenting great challenges to design and construction communication in building projects. The designers must ensure that design information is delivered on time to the construction team. However, there are still many communication problems due to time constraints caused by the fast-track process. Mead (1999) found that fast track projects typically suffer from communication problems of accuracy and completeness.

Project Client Experience

The client is the developer of a building project who defines the project. Inexpert clients will bring about many barriers to project team communication (Brown, 2001). Thus, the constraints from the clients would influence implementing projects and communication activities in building projects..

Wong *et al*. (2004) specified the emphases from clients as one of the communication factors. The emphases on the objectives of a project can impact project team communication activities.. The project client's emphases direct the working focus of a project team. If a client requires quickly completing a project, limited developing time may lead to low quality information from project team members. If a client applies limited resources in order to save money, the lack of development of the communication media infrastructure or document management systems may cause delays. Mead (1999) said that too much focus on the compression of programmes and on saving money would cause the communication problems of accuracy and completeness.

Project Information Technology (IT) Applications

Nowadays, information technology (IT) is applied in the communication process and plays a very important role in the communication activities between project participants. As paper-based communication of project information is inadequate in coping with the high level of functionality (in terms of speed, accuracy, usability, ease of modification, enhanced visualisation, improved coordination, etc.) required in a collaborative working environment in the construction industry (Anumba and Evbuomwan, 1999). The building industry is now pursuing computer-aided communication, such as the internet, multimedia applications, virtual reality, wireless facilities and broadband communication networks, etc. (Anumba and Evbuomwan, 1999; CRC CI, 2005; Luiten and Tolman, 1997; Shen, 1992).

Information technology (IT) is becoming a critical factor to project team communication and has dramatically changed the communication environment in the construction industry (Anumba and Evbuomwan, 1999; Shohet and Frydman, 2003). IT presents opportunities to project team communication and improves its performance. Research studies indicate that when firms embrace IT they can improve information flows and optimise the way a team communicates (Back and Bell, 1994; Basu, 1996; Hammer and Champy, 1993).

IT techniques improve project team communication performance by impacting on some elements of the communication process, usually on information and media, for example, realising instant media, visualising information expression, and sharing project information. The typical information technologies for communication between project participants are classified into three groups according to which aspects of the communication process they impact.

- Internet based communication media
  - – Electronic mail
  - – Video conferencing
  - – Project intranets as a communication media
  - – Groupware e.g. online-chatting system
- Integrated document system for information sharing
  - – Project intranets such as InfoBase
- Visualisation for information expression
  - – Computer aided design (CAD): 2D, 3D
  - – Virtual reality
  - – Multimedia: videos, slides, etc.

The media of electronic mail, video conferencing, and project intranets are gradually becoming more frequently used in project team communication with the wide use of the internet. Project team members can timely access to shared information through the networked project document management system (project intranet). IT is also used to visualise information expression, for example using 2D and 3D computer aided design (CAD).

Project Organisation Management Approaches

Project organisation management approaches, such as procurement methods and measures controlling organisational relations of participants, significantly impact the project team communication. The procurement route (also called contract arrangements) establishes the project organisational structure which defines the responsibility relations between each involved participant. The procurement method therefore sets up lines of communication and information flows among project team members during the course of a project (Mead, 1999; Pietroforte, 1997). In different building projects, different procurement methods are usually used, which will establish the different patterns for communication between parties. Other project organisation management approaches used in building projects, such as the methods of partnering or formal team building, determine the relationships between involved participants and thus impact project team communication performance.

Project Communication Media Infrastructure

Previous studies have identified communication media as the one of the critical factors for communication activities at different levels and in different contexts

(Goldhaber, 1990 cited in Mead, 1999; Guevara, 1979; PMI, 2000; Wong *et al*., 2004). The media is the essential element of the communication process. In building projects, project information should be communicated among the involved participants using a variety of media including paper based written documents distributed through post and fax, electronic documents transmitted through electronic mail or by accessing shared networked project electronic databases (project intranet), project meetings or videoconferencing, and interpersonal face to face contacts.

Therefore, to manage project team communication and improve its performance, there is a need to establish appropriate communications media infrastructure in a project. The project communication media infrastructure is established various means for communication between project participants. This media infrastructure should facilitate all kinds of communication between participants and emphasise the use of multiple media to achieve communication objectives (Anumba *et al*., 1997; Anumba and Evbuomwan, 1999; Pietrofer, 1999).

Project Information Documentation

Project information documentation defines and manages information which is used by different participants in a building project. Information is the key element in the communication process. A large amount of information is communicated among the project participants during the construction stage. The project information documentation refers to building up common rules and an environment in which project information produced by different participating organisations is managed. The rules should define the format of information used by different participants. The document produced during the project process should be clearly classified and stored in a system for easy accessing by all participants. These can facilitate the efficient use of information and its communication between different participants.

Agreed formats and conventions of information description are important for communication between different participants. The building project involves independent participating organisations. Communication and information exchange between different participants are complicated by the factors of the different interpretation frameworks, different conventions to present content, and different types of software applications (Mead, 1999; Pietroforte, 1997; PMI, 2000). Therefore, consistent formats and presentation conventions, especially for IT based information exchanged between collaborating parties, should be established at the outset of the project (Anumba and Evbuomwan, 1999; Xie, 2002).

Clear classified project information stored in a shared project document system is important and benefits communication between project team members. A large number of documents, such as design drawings, specifications, project progress reports etc., are produced by independent participants during the project process. These large numbers of documents should be stored in a central document management system and can be shared by all project team members. Each participant can easily access all project information, significantly improving communication among the project participants. This central project document management system can be a manual filing system or an electronic database that is open to all project team members (PMI, 2000). Project documents should also be clearly classified and filed i for easily retrieval.

Arrangement of Organisational Structure

Many previous studies stated that organisational communication depends largely on the structure of an organisation (Guevara, 1979; Mead, 1999; PMI, 2000; Thomas *et al*., 1998; Wong *et al*., 2004; Xie, 2002). Monge and Eisenberg (1987) illustrated that organisational communication could be analysed in terms of positional roles. This is the classical view of structural communication theory. He stated that the early work in this area can be dated back to the work of Weber (1947) and Parsons (1951). This theory concluded that the communication structure can be understood as a pattern of relations among positions within an organisation, which is the meaning of the organisational structure.

The organisational structures impact team communication in building projects by establishing a structural framework to mandate how participants should communicate and how information should flow among them (Eisenberg *et al*., 1985; Guevara and Boyer, 1981; Mead, 1999; Pietroforte, 1997; PMI, 2000). Tenah's (1986) and PMI's (2000) studies also found that communication requirements and information needs are often related to the management responsibilities of each member of the project team, which are defined in an organisational structures.

However, previous researchers noted that inter-organisational structures are always characterised by a complex, ambiguous representation of each organisation, and unclear relations among them (Eisenberg *et al*., 1985; Gibson and Hodgetts, 1990; Mead 1999; Thomas *et al*., 1998; PMI, 2000; Wong *et al*., 2004; Xie, 2002). This poor project organisational structure often obstructs communication among the project participants and causes many communication problems (Eisenberg *et al*., 1985). The ambiguous representation of project participants could contribute to a lack of essential information. Additionally, as the number of organisational levels increases in a complex project organisational structure, the number of information filters will also increase (Flippo and Munsinger, 1975). If they are without adequate controls, communication channels can overload and filter the amount of information (Gibson and Hodgetts, 1990; Thomas *et al*., 1998). Carter (1993 cited in Xie, 2002) investigated the communication problems and confirmed some of the problems resulting from the organisational structure, including information omission, underload, overload and gatekeeping.

Therefore, a project organisational structure, giving clearly defining roles and relations between the project team members, should be set up (Gibson and Hodgetts, 1990; Mead, 1999; Xie, 2002). This defined inter-organisational structure therefore forms a basic communication system in a building project (Guevara and Boyer, 1981; Parsons, 1951; Weber, 1947). Each participant in a project should also clearly understand the project organisational structure and know the responsibilities of all other project participants and who to contact for information and support (Chris, 2001; Xie, 2002)

In addition, a structure defined for document distribution is important for information transmission among the relevant participants. A distribution structure details who should send and receive each kind of document (*design drawing and specification, project schedule, project progress reports, etc.*) (PMI, 2000). It clearly assigns information coordinators for each participant, whose responsibilities are to receive and send the information from and to other project participants. This document distribution structure forms major formal channels to facilitate information flows among the participants. This distribution structure should also be compatible with the responsibilities and reporting relationships as defined by the project organisational structure (PMI, 2000).

Schedule for Communication and Information Distribution

The schedule for communication and information distribution between the project team members is important for project team communication in a building project. Effective communication needs information transmitted on time between the participants. However, design and construction activities are conducted by different organisations following different programmes. Each participant may not clearly know others' working progress. This situation lead to receiving information late from other participants. An agreed schedule should be therefore set up and show when each type of communication and information distribution between participants will be conducted (PMI, 2000). This established communication schedule is a commonly referred timetable which helps senders and receivers to know the planning of a whole project and the demands of each participant. The schedule assists each participant in the preparation of their own work and ensures that information is communicated and transmitted to other participants on time. Additionally, current building projects often overlap design and construction phases. This increases pressure on designers to clearly know the schedule for releasing design information to ensure the construction team receives information and conducts the work on time (Xie *et al*., 2000).

Information with High-Quality Content

The high-quality information for implementing construction work is an important factor in project team communication. During the construction stage, different kinds of project related information are communicated between project participants. The information includes design drawing, changes documents, the project schedule, project progress reports, construction execution programs, as well as some information produced during the implementation of construction work. Without sufficient, correct, and coordinated information, participants cannot have effective communication for coordinating work and making sensible decisions. Xie (2002) emphasised that information quality is important to communication performance and that an inability to supply good quality information can be one of the reasons for communication failure. Herbert (2001) further identified that coordinated information is a key factor during the project implementation process. Project team communication at the construction stage aims to implement and coordinate construction work conducted by different organisations. This requires common protocols for conducting collaborative work. These work protocol are the information about the project and construction plan. They define the requirements of a project and execution of implementing work. Therefore, high-quality content information for implementing construction work is very important for project team communication and accomplishing project.

Social and Informal Mechanisms for a Cooperative Working Environment

A collaborative working environment in a building project is important for the effectiveness of project team communication. The project team is characteristic of a multi-organisation nature (Xie, 2002). Participants with different backgrounds come to a project with competitive interests, different perceptions of success, and different organisational constraints and priorities (Sonnenwald, 1996). These different backgrounds can restrict project team communication and break up the communication process. Therefore, for effective inter-organisational communication, project participants should not only focus on forging and maintaining information linkages, but also on forging and maintaining social linkages to remove or mitigate the barriers of different organisations (Eisenberg *et al*., 1985). To forge and maintain social linkages between project participants, a collaborative working environment should be set up in a building project. The social and information mechanisms for a collaborative working environment include setting up trust and open inter-organisational relationships, ensuring committed attitudes to a project, and defining shared values and aligned objectives in a project.

Many previous studies have identified that inter-organisational relationships are important factors for communication among building project team members. Early reports, for example Emmerson (1962) and Higgins and Jessop (1965), explored project communication and interaction, and discovered that the main factor lying behind communications difficulties is the nature of the relationships between the communicators and organisations. This is further confirmed by later works (Carter, 1993, cited in Xie, 2002; Guevara, 1979; Marshall-Ponting and Aouad, 2005; Mead, 1999; Wong *et al*., 2004).

Trusting and open inter-organisational working relationships contribute to effective project team communication by mitigating conflicting interests of different organisations. Project team members are usually from different organisations with competitive interests (Sonnenwald, 1996). Project participants are inclined to protect their own profits and maintain their competitive edge. This inclination often restricts information shared among team members and breaks down the project team communication process. However, established collaborative inter-organisational relationships may ensure that project participants communicate in an open and truthful manner which results in effectiveness communication (Mead, 1999; Xie, 2002). The collaborative organisational relationships can be established before and during the construction process (Pietroforte, 1997).

The committed attitudes to a project formed as a group culture also contribute to the collaborative working environment and benefit project team communication performance. The attitudes of communicators are important to communication in building projects (Wong *et al*., 2004). In building projects, the commonly competitive relationships make project participants inclined to focus on their own work and not pay more attention to the whole project. If two parties have no contractual relationship obligations, they tend to be inactive in communication. Therefore, a group culture encouraging each participant to engage in a project and be ready to help others could forge and maintain a collaborative working environment.

Another main social point in inter-organisation communication is the alignment of individual goals and value judgments (Gelernter, 1970; Xie, 2002; Yoshda, 1980). Good project team communication performance can't be achieved if the receiver is not interested in the information or perceives it to be of little importance (Pietroforte, 1997; Shannon and Weaver, 1949). Project team members usually come to a project with different backgrounds and varying organisational priorities (Thomas *et al*., 1998).

Different interests, experiences, and values may be a source of different perceptions in the communication process which often cause communication problems (Guevara, 1979; Hardcastle, 1990; Sonnenwald, 1996; Wong *et al*., 2004; Xie, 2002). Therefore, shared working values and project objectives should be set up among project team members to align different objectives and values.

Capable Project Manager

The project manager for managing construction work plays a very important role in the project team communication activities during the construction stage (Emmitt and Gorse, 2003; Xie, 2002). Project managers act as information coordinators and are regarded as communication stars in project team (Xie, 2002). They often receive and transmit information from and to other participants especially in non-routine tasks. Therefore, project managers control project information flow with their professional and project knowledge, and occupy an important role in the inter-organisational communication structure at the construction stage.

Project managers are also regarded as social stars, acting to maintain good relationships among all the involved participants in a building project. The project team is built up from different organisations with competitive interests, and different organisational priorities and objectives (Sonnenwald, 1996; Xie, 2002). These different interests and objectives sometimes break the communication process between project participants. Project managers, whose responsibilities also include managing work from each participant, act as relationship coordinators. They are responsible for maintaining working and social relationships among all participants. They are responsible for improving mutual understanding between each participant and better understanding aligned project objectives. Therefore, capable project managers with good communication skills are very important to project team communication.

5.4 FORMULATION OF A LIST OF COMMUNICATION FACTORS

Based on the discussion of the significance and impacts of each factor on the project team communication in the above section, a detailed list of communication factors is provided (Table 5.4).

These factors – significant from a theoretical perspective – became the foundation for the next stage work. To further explore the significance and comprehension of these factors, a pilot survey investigation with practical professionals is undertaken in next chapter.

Table 5.4 Included factors in the pilot study

A. Project-characteristics factors
Project Complexity
1. The location of a project;
2. The size of a project;
3. The type of a project;
4. The complexity of project design and construction;
5. The numbers of companies in a project;
6. Time constraints for design and construction work;
Project Client Experience
7. Specific constraints from the client;
B. Management-measure factors
Project Information Technology (IT) Applications
8. The level of IT applied in a project;
9. Computer software applications in a project;
10. Computer hardware applications in a project;
Project Organisation Management Approaches
11. The type of procurement method
Project Communication Media Infrastructure:
12. Kinds of used communication media;
Project Information Documentation
13. The format of information;
14. Classified information storing system;
Arrangement of Organisation Structure
15. The project organisational structure;
16. Participants' understanding on project organisation structure;
17. The document distribution structure;
18. Information dissemination coordinators;
Schedule for Communication and Information Distribution
19. The schedule of communication and information distribution;
Information with High-Quality Content
20. The quality of information content for implementing construction;
Social and Informal Mechanisms for a Cooperative Working Environment
21. Inter-organisational collaborative working relationships;
22. Group culture ensuring committed attitudes to a project;
23. The alignment of objectives and working values among participants;
24. Previous cooperation experience between participants;
Capable Project Manager
25. Project manager's capacity and contribution, such as communication skills and professional knowledge.

5.5 SUMMARY OF THE CHAPTER

A list of communication factors for managing project team communication is established in this chapter. The factors were identified through a synthesis of specific literature reviews on research systematically studying construction communication factor, brainstorming sessions, and an extensive literature review. These factors include two groups: project-characteristics factors and management-measure factors. The significance and the impacts of these factors on the project team communication are discussed in this chapter based on the literature review. This comprehensive discussion leads to the development of a detailed list of factors from a theoretical perspective shown in Table 5.4 which provides the foundation for further study. In the next chapter, the significance and the comprehension of these factors are further explored by a pilot survey investigation with construction professionals.

CHAPTER 6. INVESTIGATION ON THE COMMUNICATION FACTORS THROUGH A PILOT SURVEY

6.1 INTRODUCTION

Having formulated the 11 communication factors in the previous chapter, this chapter employs a pilot survey to further investigate the significance and comprehension of these factors from construction professionals' perspectives. First, the pilot survey for studying the communication factors is described. This is followed by a presentation of the results of the significance of communication factors and a comparison of the perceptions of different organisations on such factors. Then, other factors added by construction professionals and their comments on the meaning of the factors are illustrated by analysing the results from the open-ended questions. Finally, through this pilot survey, the identified factors in the previous chapter were developed into a comprehensive framework of 13 factors for managing the project team communication. This framework of factors can be used by project managers to manage project team communication, which could ultimately lead to improved communication performance. Based on this framework, further exploration of the effectiveness of these factors and their impacts on project team communication performance in current projects is conducted in the next stage.

6.2 METHOD FOR THE SURVEY

It is important to explore the factors for managing project team communication both from theoretical and practical perspectives. A pilot survey with construction professionals was therefore conducted to study the significance and comprehensions of the factors addressed in Chapter 5 and develop a comprehensive framework of factors for improving project team communication performance.

To achieve the above aims, questionnaires were designed to explore the opinions of construction professionals in each major participants of a project team at the construction stage. The pilot survey was mainly conducted in Hong Kong. The context of the research indicates what the population of the survey should be (Fellows and Liu, 2003). The targeted survey population in this survey includes the companies of clients, architects and design consultants, main-contractors, subcontractors and suppliers in Hong Kong. The list of these companies was obtained from directories of different organisations: Environment, Transport and Works Bureau (ETWB), Housing Authority & Housing Department (HKHA), and some construction professional associations in Hong Kong, including the Hong Kong Contractor Association (HKCA), the Hong Kong Institute of Architect (HKIA), and the Hong Kong Institute of Survey (HKIS).

Project managers or organisation representatives in each participants at the construction stage were approached as the respondents to this pilot questionnaire survey. The main communicators in project team communication are identified as project managers or representatives from each participating organisation during the construction phase. This pilot survey sought opinions on the communication factors from construction professionals. Therefore, project managers or organisation representatives who play important roles in communication with other participants were requested to complete the questionnaire.

The list of the communication factors formulated in the previous chapter, with reference to Table 5.4, was adopted for conducting the pilot study. The respondents were required to provide opinions on the extent of the influence of each factor on project team communication using a five-point Likert-type scale and to complement additional factors. The questionnaire in the pilot study comprises three sections: section I to obtain general information about the participants and their companies; section II to investigate the significance and comprehensions of the communication factors and additional communication factors; then, section III to in query other communication issues at the construction stage of a building project.

Before sending out large quantities of questionnaires to the targeted respondents in this survey, a questionnaire test was conducted to validate the meaning of the content and terminology of the questionnaire by visiting three project managers and six researchers who have experience in conducting surveys in their research works. Revision on the questionnaire was made based on the comments from the test. Then, the modified questionnaires were addressed with the attachment of a cover letter to managing directors of targeted firms. The cover letter indicated the objectives of the research and requested that the questionnaire be completed by a project manager in the firm.

6.3 DETAILS OF THE SURVEY

580 questionnaires were sent to managing directors of organisations in various groups: clients, architects or design consultants, main contractors, and sub-contractors or suppliers in the Hong Kong construction industry. In order to secure a better response rate, 100 large companies in the survey list were approached twice. As a result, 97 questionnaires were returned, leading to the overall response rate of about 17%. However, 7 returned questionnaires were incomplete. This led to 90 returned questionnaires effective for further statistical analysis. It is interesting to note that among the respondents, 33% requested a report of the questionnaire outcomes. This may indicate that they considered the significance of the research topic.

The type of organisations

The 90 effective respondents were distributed into four groups: clients, consultants, contractors, and sub-contractors, as shown in Table 6.1 and Figure 6.1. Among all the respondents, 50.0% were contractors, 27.8% were consultants, 15.5% of respondents were clients, and 6.7% were sub-contractors. It can be seen that the targeted firms come from various kinds of organisations in four groups, providing an effective representation of the industry.

Table 6.1 The organisation types of the respondents in the pilot survey

Organisation type	Number	Percent %
Contractors	45	50.0
Consultants	25	27.8
Clients	14	15.5
Sub-contractors	6	6.7
Total	90	100

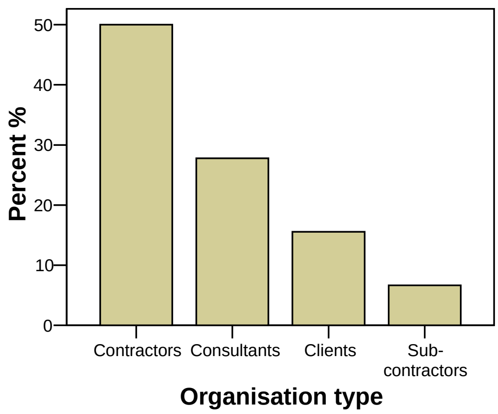

Figure 6.1 Graphical representation of the organisation types of the survey respondents

The size of organisations

The firms involved in the survey were also classified into four groups based on the turnover of the firm, as the measure of a company size. Watt (1980) said that the size of a company can be measured in terms of the number of employees, the net assets (capital employed), the value added (net output), and the turnover. The turnover in the previous financial years was adopted to measure the organisation size. Table 6.2 and Figure 6.2 show the grouping of different sized firms in terms of the turnover. The organisations, classified by the different sizes, represented a good and even range.

Table 6.2 The size of the respondent firms

Grouping	Turnover (HK$)	Number	Percent %
Very small	Less than 100 Million	25	27.8
Small	100-500 Million	23	25.6
Medium	500Million-1.5 Billion	16	17.8
large	Over 1.5 Billion	19	21.1
Not indicated	Not indicated	7	7.8
Total		90	100.0

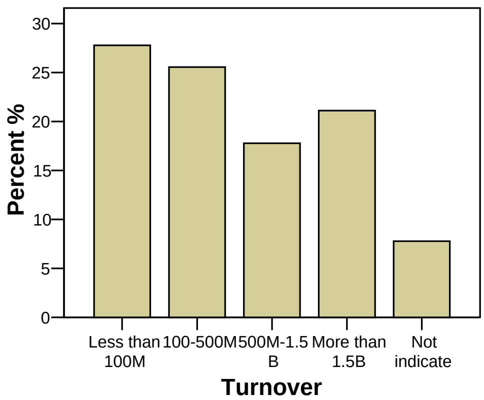

Figure 6.2 Graphical representation of the size of the respondent firms

The business scope

Furthermore, the respondent firms can be presented in terms of their business scopes. Table 6.3 and Figure 6.3 show the business scopes of the respondent firms. Table 6.3 depicts the work scope of the firms involved in the survey, showing that 80.1% of the respondents engage in building projects. The implication is that the communication practice investigated by this survey relates to building work, which has been defined as the scope of this research previously.

Table 6.3 Business scope of the respondent firms

Business scope	Building projects	Civil projects	Both	Others	Total
Number	46	11	27	6	90
Percent %	51.1	12.2	30.0	6.7	100

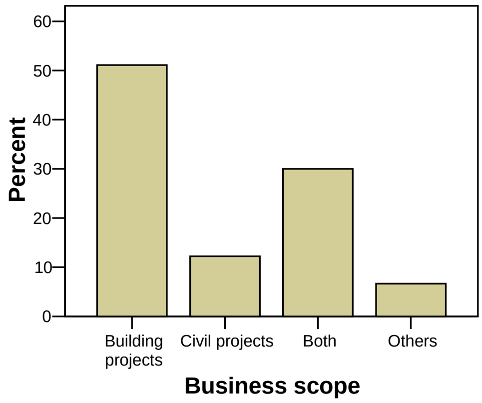

Figure 6.3 Graphical representation of the business scopes of the respondent firms

The experience and position of respondents

It is considered that the quality of this survey is good as the respondents were both experienced and at senior managerial level. The respondents were classified according to their positions and their working experience in the construction industry. Tables 6.4 and 6.5 show the designation positions and the construction industry experience of the respondents respectively. It can be seen that the respondents were mainly above the project manager level, with more than 10 years work experience in the construction industry. Their professional experience guaranteed the quality of the feedback of the survey. Considerable numbers of respondents were in high positions in their companies, which can show, to a certain extent, that the industry has an interest in understanding how to improve project team communication performance.

The construction stage has the most frequent communication problems

The construction stage was considered by the respondents as the stage of a project where there were the most frequent communication problems. Different stages of a building project have different activities and different participants involved. 58% of respondents regarded that the most communication problems happened at the construction stage due to the complex construction activities and the multiple organisations involved. The respondents listed the following reasons: the multiple organisations involved (for example too many parties involved, information needs to exchange from/to lots of parties, multi-layered subcontracting existing), complex and uncertain building projects (for example unforeseen site conditions, time and quality control are difficult and important stage to ensure project is completed on schedule). This finding further established that the construction stage is the concerned stage in this study.

Main-contractor as the actual centre of project team communication at the construction stage

Main-contractors were regarded by most respondents as the centre of project team communication at the construction stage. When asked who should be the centre of communication at the construction stage of a project, 52% of respondents stated that the contractor should be the communication centre. This is different from the defined situation in the traditional contract arrangement in which architects dominate leader positions at the construction stage. The respondents explained that main-contractors were the co-coordinators liaising with clients, design teams, and construction teams (for example, the main contractor is usually in the middle position of the organisational chart; the role of main contractors is to act as a co-coordinator liaising with consultants, clients (upstream) and subcontractors at downstream; to gather design information from designers and distribute to sub-contractors; contractors can gather difficulties which encountered and seek for consultant comment; construction project manager in contractor gets the most updated and current information). One respondent commented that main-contractors are in charge of the entire construction process of the construction therefore must be provided with all information in flow. Thus, main-contractors could be the centre of team communication to coordinate information flow among the project participants at the construction stage. Communication with the main-contractor could be an important management area for the improvement of a project's communication performance.

6.4 DATA ANALYSIS AND RESULTS

Data was analysed to examine the significance and the meanings of the identified communication factors in the chapter, as seen by various professionals in the construction industry. As a result, ranks of communication factors by their degree of significance were produced according to their mean score of responses. This is followed by comparing the means among the different organisations using a specific technique called analysis of variance (ANOVA) which is used to test the null hypothesis that the mean of the individual variable is equal in all the groups. The analyses were conducted with the help of computing tools Microsoft Excel and the Statistical Package for Social Sciences (SPSS 12.0).

In the questionnaire, open-end questions were invited from respondents. It is highly appreciated that extra factors were suggested by respondents. The framework of the communication factors were then established in last section of this chapter.

6.4.1 The significance of the communication factors and the comparison of perceptions from different organisations

Respondents were asked to indicate the extent of influence of the categorised communication factors on project team communication performance. The relevant significance of the factors was identified by ranking the means of them. Then, opinions about the significance of factors among the different organisations were compared using an analysis of variance (ANOVA).

1. The significance of the communication factors

As part of the analysis, the Cronbach alpha reliability (the scale of coefficient) was produced, which measures internal consistency among the factors. Cronbach alpha reliability measures or tests the reliability of the five-point Likert-type scale used for the study (Norusis, 1993b). The Cronbach's coefficient alpha was 0.906 (F statistic = 9.322, p = 0.000), which was greater than 0.7, indicating that the 5-point Likert scale used for measuring influences of factors on project team communication performance is reliable at a 5% significant level. The ranking of the significance of each factor based on the means and the standard deviations of all the samples is shown in Table 6.4.

The 19 top factors of the communication factors (value of mean > 3.50, 3 means neutral) were identified as significantly influencing project team communication performance. The six unimportant factors (value of mean < 3.50) were not included and deleted from the list of factors *(information dissemination coordinators, previous cooperation experience between participants, computer software applications in a project, computer hardware applications in a project, the type of a project, and the location of a project).*

Table 6.4 Communication factors ranked by the significance

Factors	**Min.**	**Max.**	***C•V* %**	**S. D.**	***Mean***	**Rank**
The complexity of project design and construction	1	5	21.39	0.894	***4.18***	***1***
The schedule of communication and information distribution	1	5	23.01	0.918	***3.99***	***2***
Time constraints for design and construction work	1	5	27.47	1.096	***3.99***	***3***
The numbers of companies in a project	1	5	25.43	0.974	***3.83***	***4***
Project managers' capacity and contribution	1	5	24.54	0.93	***3.79***	***5***
Inter-organisational collaborative working relationships	1	5	25.63	0.969	***3.78***	***6***
The document distribution structure	1	5	24.19	0.9	***3.72***	***7***
The size of a project	1	5	27.04	1.006	***3.72***	***8***
The quality of information content for implementing construction	1	5	24.78	0.917	***3.7***	***9***
Kinds of used communication media	1	5	29.05	1.069	***3.68***	***10***
Classified information storing system	1	5	24.6	0.893	***3.63***	***11***
Specific constraints from the client	1	5	26.38	0.955	***3.62***	***12***
The project organisational structure	1	5	22.24	0.803	***3.61***	***13***
Group culture ensuring committed attitudes to a project	1	5	27.56	0.992	***3.6***	***14***
The level of information technologies applied in a project	1	5	25.18	0.889	***3.53***	***15***
Participants' understanding on project organisation structure	1	5	27.9	0.985	***3.53***	***16***
The type of procurement method	1	5	25.59	0.902	***3.52***	***17***
The alignment of objectives and working values among participants	1	5	27.40	0.963	***3.51***	***18***
The format of information	1	5	29.74	1.041	***3.5***	***19***
Information dissemination coordinators	1	5	27.24	0.937	***3.44***	***20***
Previous cooperation experience between participants	1	5	29.65	1.017	***3.43***	***21***
Computer software applications in a project	1	5	28.2	0.956	***3.39***	***22***
Computer hardware applications in a project	1	5	28.54	0.939	***3.29***	***23***
The type of a project	1	5	35.88	1.116	***3.11***	***24***
The location of a project	1	5	36.9	1.096	***2.97***	***25***

The top ten significant factors leading to project team communication effectiveness are listed according to the significant sequence as: *the complexity of project design and construction, the schedule of communication and information distribution, time constraints for design and construction work, the numbers of companies in a project, project managers' capacity and contribution, inter-organisational collaborative working relationships, the document distribution structure*, *the size of a project*, *the quality of information content for implementing construction*, and *kinds of used communication media*.

Among the top ten factors, four factors are related to project-characteristics that are *the complexity of project design and construction* (ranking 1st), *time constraints for design and construction work* (ranking 3rd), *the number of companies of a project* (ranking 4th), and *the size of a project* (ranking 8th). The complexity of design and construction, the size of a project, and the limited time for project implementation create a complex environment for project team communication. At the same time, increasingly technological complexity is shifting project control toward specialized subcontractors which requires effective management of the interfaces between these organizations (Baldwin *et al*., 1998; Kubal, 1995; Potter, 1995). It presents the project communication a great challenge.

The significance of *the schedule of communication and information distribution* (ranking 2nd) was perceived by the respondents. This echoes Project Management

Institute's (2000) suggestion that a communication schedule should be set up at the outset of a project to ensure each participant gets project related information on time. This communication schedule should show when each type of communication and information distribution will be produced.

Same as the previous studies, *project managers' capacity and contribution* (ranking 5th) was identified the important communication factor by the survey. Project managers play important roles in communication and co-ordination activities during the project development. The other human issue identified is *inter-organisational collaborative working relationships* (ranking 6th). Xie (2002) stated that human issues, such as trust, respect, good working relationships and appreciation, can lower the communication barrier and build a good environment for communication.

The document distribution structure (ranking 7th) was also identified. This reflected Guevara and Boyer's (1981) argument that the importance of a communication system through which project information would flow. This ability to process information along the formal communication system largely depends on the structural characteristics of an organization (Mead 1999).

The quality of information content for implementing construction (ranking 9th); and *kinds of used communication media* (ranking 10th) were also confirmed as the important communication factors. It is easily understood because these factors are the fundamental elements of the communication process.

2. The comparison of perceptions from different organisations

The means of each factor among different organisations – being clients, design consultants, contractors, and sub-contractors – were compared in order to investigate the different perceptions on the communication factors. The difference of the means of each factor in the different organisations was compared by an analysis of variance (ANOVA) which tests the null hypothesis that the mean of an individual variable is equal in all the groups. The results of means ranking and ANOVA are shown in Table 6.5.

Table 6.5 The significance of the communication factors in different organizations

Factors	***F***	**Sig.**	**Overall (N=90)**		**Contractors (N=45)**		**Consultants (N=25)**		**Clients (N=14)**		**Sub-contractors (N=6)**	
			Mean	**Rank**	**Mean**	**Rank**	**Mean**	**Rank**	**Mean**	**Rank**	**Mean**	**Rank**
The complexity of project design and construction	1.309	.277	4.18	1	4	1	4.4	1	4.36	1	4.17	3
The schedule of communication and information distribution	.940	.425	3.99	2	3.84	2	4.08	5	4.29	2	4	4
Time constraints for design and construction work	.809	.492	3.99	3	3.84	3	4.12	4	4	5	4.5	1
The numbers of companies in a project	***2.389***	***.074***	***3.83***	***4***	***3.64***	***9***	***4.12***	***3***	***4.14***	***3***	***3.33***	***21***
Project managers' capacity and contribution	.039	.990	3.79	5	3.78	4	3.76	13	3.86	10	3.83	10
Inter-organisational collaborative working relationships	.238	.869	3.78	6	3.71	6	3.84	9	3.93	8	3.67	16
The document distribution structure	***4.990***	***.003***	***3.72***	***7***	***3.44***	***18***	***4.2***	***2***	***3.93***	***7***	***3.33***	***23***
The size of a project	.442	.724	3.72	8	3.67	8	3.64	16	3.93	6	4	5

Factors	***F***	**Sig.**	**Overall (N=90)**		**Contractors (N=45)**		**Consultants (N=25)**		**Clients (N=14)**		**Sub-contractors (N=6)**	
			Mean	**Rank**	**Mean**	**Rank**	**Mean**	**Rank**	**Mean**	**Rank**	**Mean**	**Rank**
The quality of information content for implementing construction	.930	.430	3.70	9	3.67	7	3.8	11	3.86	9	3.17	24
Kinds of used communication media	.589	.624	3.68	10	3.56	11	3.88	7	3.79	11	3.5	20
Classified information storing system	.763	.518	3.63	11	3.73	5	3.6	17	3.57	15	3.17	25
Specific constraints from the client	1.808	.152	3.62	12	3.51	13	3.72	14	3.71	12	4.33	2
The project organisational structure	.449	.719	3.61	13	3.56	10	3.76	12	3.5	18	3.67	13
Group culture ensuring committed attitudes to a project	1.508	.218	3.60	14	3.47	17	3.64	15	4.07	4	3.33	22
The level of information technologies applied in a project	.653	.583	3.53	15	3.49	14	3.56	19	3.43	21	4	7
Participants' understanding on project organisation structure	1.593	.197	3.53	16	3.4	19	3.84	10	3.29	22	3.83	11
The type of procurement method	.879	.455	3.52	17	3.55	12	3.31	22	3.68	13	3.87	9
The alignment of objectives and working values among participants	1.967	.125	3.51	18	3.30	20	3.88	6	3.54	17	3.54	17
The format of information	.298	.827	3.50	19	3.49	15	3.4	21	3.57	14	3.83	12
Information dissemination coordinators	***2.669***	***.053***	***3.44***	***20***	***3.2***	***22***	***3.84***	***8***	***3.5***	***19***	***3.5***	***19***
Previous cooperation experience between participants	***2.931***	***.038***	***3.43***	***21***	***3.47***	***16***	***3.6***	***18***	***2.79***	***24***	***4***	***8***
Computer software applications in a project	.509	.677	3.39	22	3.27	21	3.48	20	3.57	16	3.5	18
Computer hardware applications in a project	.764	.517	3.29	23	3.18	23	3.28	23	3.5	20	3.67	14
The type of a project	1.762	.160	3.11	24	2.98	24	3.24	24	2.93	23	4	6
The location of a project	1.145	.336	2.97	25	2.91	25	3.04	25	2.71	25	3.67	15

There was no statistically significant difference in the opinions of different organisation types with the exception of four factors: *the document distribution structure* and *previous cooperation experience between participants* whose variance were significant at 5% level; *information dissemination coordinators* and *the number of companies in a project* whose variance were significant at 10% level (Table 6.5). This suggests that the different construction participants generally have similar opinions regarding the significance of factors to project team communication performance.

The respondents from the different organisations had different opinions on the four factors' influence on project team communication performance (Table 6.6). Regarding to the factor of *the number of companies in a project*, data showed that sub-contractor did not perceived this factor's significance. But this may be due to only 6 respondents from the sub-contractor group.

Table 6.6 Factors about which different types of organisations have different opinions

Organisation type	**Emphasised factors**
Client and design consultants	The document distribution structure Information dissemination coordinators
Construction team	Previous cooperation experience between participants

The clients and the design consultants regarded that the influence of factors *the document distribution structure* and *information dissemination coordinators* were more significant than construction teams did (Table 6.5). The results in Table 6.5

revealed that the factor of *the document distribution structure* was ranked 18th and 23rd by the contractors and the sub-contractors respectively; but this is a major factor for the clients and the design consultants with ranks of 2nd and 7th respectively. It shows that the clients and the design consultants give more attention to the document distribution structure than the construction team (main-contractors and subcontractors). The client and the design consultants are at the top level of the project organisation structure and responsible for issuing design and requirement information at the construction stage. Such information distribution always follows the formal channels. The main-contractors and sub-contractors are at the bottom level of the project organisation structure and are responsible for applying this information to construct projects. Thus, the clients and consultants might pay more attention to the formal communication channels defined by the document distribution structure in issuing the information. In addition, the design consultants paid more attention to the factor *information dissemination coordinators* which is the composition of the document distribution structure (Table 6.5). This also shows that as producers of design information for realising a project, design consultants place more emphasis on establishing formal communication channels for transmitting information to others. In contrast to this, the construction team do not consider *the document distribution structure* as a very important issue for project team communication. The main-contractors are responsible for sending design information to subcontractors and reporting construction information to other project participants, however, they did not emphasise the significance of formal cannels defined by the document distribution structure for project team communication. Possibly, the construction teams more frequently deal with non-routine information.

The main-contractors and the subcontractors paid more attention to *previous cooperation experience between participants* compared to the clients and the design teams (Table 6.5). The factor of *previous cooperation experience between participants* was ranked 16th and 8th by the contractors and the sub-contractors respectively compared with ranks of 18th and 24th by the clients and the design consultants respectively (Table 6.5). This suggests that the construction team more highly perceives the significance of a previous relationship with other participants. At the construction stage, the responsibilities of contractors and sub-contractors are to conduct construction work and coordinate the inputs from all participants. As the work coordinators, they focus on maintaining good relationships with other parties. Meanwhile, their low status in the traditional contract makes the construction teams pay more attention to long-term good relationships.

In a nutshell, the respondents in the different organisations generally had the same opinions on the significance of the communication factors to project team communication performance. Meanwhile, they had different opinions on some factors due to their different work areas and responsibilities. Thomas *et al.* (1998) suggested communication issues were assumed to be specific to phases of a project, particular groups, and work performed. Project team communication has different interfaces between participants, for example main-contractors to design consultants, main-contractors to sub-contractors, design consultants to clients and others. Different organisations perform different work and have different focuses of communication. For instance, in the traditional contract arrangement, suppliers communicate with clients or design consultants about submittal reviews and approvals; whereas communicate with main-contractors about information relating to installation, project progress, and material supplying. However, the scope of this study is about project team which is whole communication between participants at a project level. The aim is to achieve good project team communication performance in a project. The focus is not individual communication activities and each specific communication interface between project participants, but the integration of them.

3. The top significant factors

The five top significant factors chosen by the different organisations are shown in Table 6.7. The results indicated that the selected top five significant factors by the different organisations were almost similar. All the respondents regarded *the complexity of project design and construction*, *the schedule for communication and information distribution*, *time constraints for design and construction work* as the very significant factors.

Table 6.7 The top five factors in different organisation

Rank	All (N=90)	Contractors (N=45)	Sub-contractors (N=6)	Consultants (N=25)	Clients (N=14)
1	*4. the complexity of project design and construction*	*4. the complexity of project design and construction*	*6. Time constraints for design and construction work*	*4. the complexity of project design and construction*	*4. the complexity of project design and construction*
2	*19. Schedule for communication and information distribution*	*19. Schedule for communication and information distribution*	7. Specific constraints from the client	17. The document distribution structure	*19. Schedule for communication and information distribution*
3	*6. Time constraints for design and construction work*	*6. Time constraints for design and construction work*	*4. the complexity of project design and construction*	5. The number of companies in a project	5. The number of companies in a project
4	5. The number of companies in a project	25. The project manager's capacity and contribution	*19. Schedule for communication and information distribution*	*6. Time constraints for design and construction work*	22. Group culture ensuring committed attitudes to a project
5	25. The project manager's capacity and contribution	14. Classified information storing system	2. The size of a project	*19. Schedule for communication and information distribution*	*6. Time constraints for design and construction work*

The results in Table 6.7 show that *the complexity of project design and construction* and *schedule for communication and information distribution* were regarded as critical factors to project team communication performance. Communication between project team participants at the construction stage is the way how information is transmitted and work coordinated for the implementation of a building project. The factor of *the complexity of project design and construction work* creates an environment for project team communication. All professionals perceived the significance of *schedule for communication and information distribution*. This echoes PMI's (2000) suggestion that a communication schedule should be set up at the outset of a project to ensure each participant gets project related information on time.

The main-contractors believed the importance of the factors *the project manager's capacity and contribution* and *classified information storing system* for project team communication performance. As discussed in the previous section significance of variance, the main-contractors employ design and other project related information to implement projects. Therefore, classified information storing system can assist them in effectively using the information to realise a building project. The construction teams also perceived the significance of *project manager's capacity and contribution* to project team communication performance at the construction stage..

The sub-contractors perceived the importance of *specific constraints from the clien*t and *the size of a project*. There may not be clear reasons that explain why subcontractors paid more attention to these two factors. This may be caused by the few respondents (six responses) in this group.

Comparatively, the clients and the design teams agreed on the importance of the factor *the number of companies in a project*. Building projects tend to involve more participants, especially participants of professional sub-contractors. The clients and design consultants now need and depend on professional advice and inputs from sub-contractors on defining functions and specifications. The clients and the design consultants have much more communication with professional subcontractors. Therefore, the clients and the design consultants perceived the importance of the number of subcontracting companies involved in a building project for managing project team communication.

The clients also regarded the factor *group culture ensuring committed attitudes to a project* as one of the top five significant factors. As the developer of a building project and the organiser of the project team, the clients perceived the importance of committed attitudes of each party to the project.

The design consultants ranked the factor *the document distribution structure* as one of the top five significant factors. In the previous section, significance of variance, it has been discussed that the design consultants believed the significance of the factor *the document distribution structure* in the transmission of the design information.

6.4.2 The communication factors

The primary aim of this pilot survey is to investigate the significance and meanings of these factors from construction professionals' perspectives. It is greatly appreciated that some extra factors were suggested by respondents which are described in this section.

1. The unimportant communication factors

Six factors were deleted from the list of communication factors for their unimportance to project team communication performance (Table 6.8), as indicated by the respondents through the survey. Among these six factors, two were the factor of *project complexity* (*the type of a project*, and *the location of a project*); two belonged to the factor of *project information technology (IT) applications* (*computer software applications in a project, computer hardware applications in a project*); one belonged to the factor *arrangement of organisation structure* (*information dissemination coordinator*); and one belonged to the factor *social and informal mechanisms for a cooperative working environment* (*previous cooperation experience between participants*).

Table 6.8 The unimportant communication factors

Factors	Mean	Rank
Project complexity		
3. The type of a project	3.11	24
1. The location of a project	2.97	25
Project Information Technology Applications		
9. Computer software applications in a project	3.39	22
10. Computer hardware applications in a project	3.29	23
Arrangement of organisation structure		
18. Information dissemination coordinators	3.44	20
Social and informal mechanisms for cooperative working environment		
24. Previous cooperation experience between participants	3.43	21

2. Additional factors

The questionnaire also included open-ended questions to solicit comments and additional communication factors. The responses were then analysed by a technique called content analysis. In its simplest form, content analysis is the extraction and categorisation of information from text (Simister, 1995). It is a typical method of qualitative analysis.

The responses to the open questions in the questionnaire induced a number of additional communication factors which were not included in the list of the communication factors in Table 5.4. Three additional factors were considered important (listed in Table 6.9), which are *expertise and background of staff, interpersonal relationship*, and *advanced organisation management approaches*.

Table 6.9 Additional communication factors identified in the pilot survey

Additional factors	**Number of respondents**
Expertise and background of staff	13
Interpersonal relationship	4
Advanced organisation management approaches such as partnering methods	3

Expertise and background of staff

The respondents said that expertise and background of staff is an important factor influencing project team communication performance. This indicates that each participant should have qualified staff. The respondents also described the meaning and implications of this factor. They pointed out that the level of education, professional experience, technical knowledge level, language competency, and communication skills of participants could definitely impact the effectiveness of communication. Although the concern of this study is the performance of inter-organisational communication on a project level, each communication activity is realised by individuals. Therefore, this factor was added to the communication factor list.

Interpersonal relationships

Inter-personal relationships were also added as an important factor to project team communication performance by the respondents. The respondents said that there is a lack of communication and interaction between persons from different participants. They suggested that good inter-personal relationships should be developed and maintained. Inter-personal relationship is important to form a stable social network in a project, which can benefit informal communication in non-routine tasks and help to maintain good organisational relationships. Thus, developing good inter-personal relationships was added to the list of the communication factors.

Advanced organisation management approaches

The respondents also suggested some new management approaches for improving project team communication, for example Design and Build (D&B) contract, Construction Management (CM) contract, and partnering methods. The respondents explained that in D&B and CM contract arrangements, a main-contractor or a project management agent becomes the leading role at the construction stage, resulting in more effective project communication. Some respondents suggested that partnering methods can facilitate effective communication between project participants because participants share risks with contractors and the project team communication environment becomes more open and collaborative.

These newly identified factors were integrated into the communication factor framework established in the previous section, and are discussed in the next section.

***3. The comprehension of the communication factor*s**

The respondents suggested that the abstract concepts of the factors should be specified to encompass their meanings and implications in practice. This supports the understanding the communication factors is considered very important in the industry.

The respondents perceived the significance of *information with high quality content*. They recommended that this factor should be specified in terms of the most important information for construction. They further clarified that timely and high-quality requirements and design information are very important because construction teams always have to wait for detailed drawings and wait for the approval for submittals from the architect and client. They also suggested that procedures managing the construction process should be set up and aligned to the project management requirements. The design information about building and the construction information about process procedure build up a normative communication environment and provide each project participant common information about construction work.

They suggested that effective project meetings should be frequently organised, which indicated the factor *project communication media infrastructure* should be specified by each medium.

They suggested that project intranet and e-mail system are now considered to be important information technologies in a building project for communication with other parties. This implies that different kinds of IT should be explored for examining the factor project IT applications in practice.

Communication skill, are also mentioned by the respondents, which explain the meaning of project managers' capacity. As suggested by the respondents, *project managers' capacity and contribution* should take into account their expertise, professional technical knowledge, communication skills and other aspects which contribute to project team communication.

They also explained that to build up communication systems, transparent lines of reporting, reporting procedures, responsibilities and relations should be clearly spelled out in the arrangement of organisation structure.

The respondents perceived the importance of *schedule for communication and information distribution* to project team communication. They further recommended that for timely updating of information and real time communication, the mechanisms of updating design, requirements, and schedule changes, and real time communication about project performance and emergent problems should be set up.

The respondents perceived the significance of *social and informal mechanisms for a cooperative working environment*. Some of respondents believed that the main barriers for effective communication are human factors, for example unequal positions in a project team, competitive relationships caused by conflicting interests and assuming unbalanced risks, and different priorities due to different cultures and work spirits. Therefore, they agreed on the significance of setting up mutually trusting, open and collaborative attitudes in the inter-organisational working environment to control these barriers. They also listed the following benefits of the open and collaborative working environment: on the contractors' side, the more transparency of information exposed, the more loopholes may be found; on the consultants' side, the more time in hand, a decision could be reached, allowing for optimisation of design.

Based on these discussions, the comprehensive framework of the communication factors was built up. The meanings of each communication factor in the framework are described in the following section.

6.5 A COMPREHENSIVE COMMUNICATION FACTOR FRAMEWORK

Through the pilot study, the significance and meanings of the communication factors were explored, the communication factor list was therefore developed to a comprehensive framework. The communication factor framework for project team communication is proposed in this section (Figure 6.4). This framework of factors can be used by project managers to manage project team communication, which can ultimately lead to improved communication performance. Based on this framework, an empirical questionnaire to explore the effectiveness of these factors and their impacts on team communication performance in building projects is then designed in next chapter. The categorised factors are described in the following.

Project Complexity

Project complexity is one of the major categorised factors that can impact project team communication performance. It is the background information of a building project. *Project complexity* is reflected by the five factors: *project size, design complexity, construction method complexity, the numbers of subcontracting companies,* and *time constraints for design and construction*. These factors were evaluated as significant impacts of project team communication. As the context of project team communication, *project complexity* determines the complexity of communication activities.

Project Client Experience

Project client experience is a significant categorised factor to project team communication performance. It is the factor of project characteristics. The comprehension of *project client experience* is reflected by the three factors, being *the client's experience in the building project, client supporting high quality of required information*, and *the time requirement from the client*. As the developer of a building project, the experience of clients impacts their definition of the project, setting up the project team, and determining the communication management strategies.

Project Team Communication Management

Project Complexity
- Project size
- Design complexity
- Construction method complexity
- The numbers of subcontracting companies
- Time constraints for design and construction

Project Client Experience
- Experience in building project
- Supporting high quality of required information
- The time requirement from the client

Project Information Technology (IT) Applications
- IT application level: electronic mail, video conferencing, project intranets, 2D and 3D computer aided design (CAD), and 4D virtual reality

Project Organisation Management Approaches
- The type of procurement used
- Other management approach used: partnering, formal team building

Project Communication Media Infrastructure
- The media used: post, fax, telephone, meetings, face to face discussion, email, project intranet, and e-conferencing

Project Information Documentation
- The project document management system
- The information description protocol

Arrangement of Organisation Structure
- The structure of project organisation
- The communication and reporting system
- The document distribution structure
- Participants' understanding of organisation structure

Schedule for Communication and Information Distribution
- Schedule for communication and information distribution
- Construction team updating progress and performance to others
- Contractor updating design and requirement changes to all construction team members

Design Information with High-Quality Content
- Accurate and timely design information
- Coordinated design information
- High buildability design information

Effective Procedures for Construction Work
- Construction work planning and programming
- Construction work flow procedures defining scope, interfaces and sequence of activities

Expertise and Background of Staff
- Knowledge of domain field and other discipline
- Sufficient and stable employees.

Social and Informal Mechanisms for a Cooperative Working Environment
- Procedures for maintaining inter-organisational working relationships
- Policies for shared work values and project objectives among participants
- Activities for promoting committed attitudes of participants
- Interaction for developing inter-personal relationships
- Previous cooperation relationship between participants.

Capable Project Managers
- Professional technical skills, Knowledge of other disciplines, A good information gatekeeper, Communication skill, Coordination skill, Engagement in the project, Working relationship with others, Stability of this team leader

Figure 6.4 The framework of critical factors for managing project team communication which influence team communication performance

Project Information Technology (IT) Applications

The categorised factor of *project information technology (IT) applications* was regarded as critical to project team communication performance. It is the technical system applied in a project to support team communication. Project information technology (IT) impacts on project team communication performance through applying different kinds of IT techniques in projects. The techniques applied in building projects include *electronic mail*, *video conference*, *project intranets*, *2D and 3D computer aided design (CAD)*, and *4D virtual reality*. The performance of communication between project participants could be improved by using these kinds of IT techniques to facilitate communication activities.

Project Organisation Management Approaches

The categorised factor, *project organisation management approaches*, was confirmed as being significant to the project team communication by the respondents. It is the organisational management system to support team communication during a project process. *Project organisation management approaches* include *the type of procurement method applied* and *other advanced management approaches used* such as partnering methods and formal team building methods. These organisation management approaches set up the communication structure and manage inter-organisational relationships.

Project Communication Media Infrastructure

Project communication media infrastructure is a critical categorised factor in improving project team communication performance. Communication media is a key element of the communication process. A project communication media infrastructure builds up a set of different media in a project which can be used to support different functions of project team communication. This media infrastructure includes *post*, *fax*, *telephone*, *face to face discussion*, *meeting*, *e-mail*, *e-conference*, and *a project intranet*. The uses and effectiveness of each medium determines the impacts of the media infrastructure on project team communication performance.

Project Information Documentation

Project information documentation is significant in improving project team communication performance. It defines and manages information which needs to communicated and transmitted between project participants. The categorised factor of *project information documentation* includes two factors, being clearly classified information storage in *the project document management system*, and congruent formats and conventions defined by *the information description protocol*. These management strategies may smooth and facilitate information transmission and communication among project participants.

Arrangement of Organisation Structure

Arrangement of organisation structure was regarded as significant to project team communication performance. The organisational structures define the roles and responsibilities of the involved participants or organisations in different situations. It defines communication channels between project participants and forms the communication system in a project. This categorised factor is reflected by four factors, being *the communication and reporting system* by clearly defining reporting line and communication linkage, *the structure of project organisation* by clearly defining roles and responsibilities of each project participant, *the document distribution structure* by clearly assigning information coordinators, and *participants' understanding of organisation structure* by clear understanding of roles and responsibility.

Schedule for Communication and Information Distribution

Schedule for communication and information distribution is important for improving project team communication performance. It is the procedure of managing the timing of information transmission and communication activities in a building project. The categorised factor of *schedule for communication and information distribution* includes three factors, being *schedule for communication and information distribution*, *construction team updating progress and performance to others*, and *contractor updating design and requirement changes to all construction team members*.

Design Information with High Quality

Qualified design information was regarded as critical to project team communication performance. Design information is important information communicated between project participants at the construction stage, and it also serves as the requirement protocol of construction work which is conducted by different organisations. To conduct construction work, timely and high quality design information which describes the expected building is needed. The quality of design information is reflected by three factors, being *coordinated design information*, *high buildability design information*, and *accurate and timely design information*.

Effective Procedures for Construction Work

Effective procedures for construction work were suggested as a critical factor to project team communication. Procedures for construction work describe how to implement and realise the expected building. During the construction stage, information of procedures for construction work is communicated among construction team members. This construction information also serves as the working protocol for construction work which is conducted by different organisations. *Effective procedures for construction work* is reflected by two factors, being *construction work planning and programming*, and *construction work flow procedures defining scope, interfaces and sequence of activities*.

Expertise and Background of Staff

Expertise and background of staff was added as a critical factor for project team communication performance. This factor describes the knowledge and skills of staff in each project participant. This factor implies that each participant should have qualified and sufficient staff which ensures high quality information inputted and multi-skill communicators. In this work, *expertise and background of staff* is reflected by two factors, being *knowledge of the domain field and other disciplines*, and *sufficient and stable employees*.

<u>Social and Informal Mechanisms for a Cooperative Working Environment</u>

Social and informal mechanisms for a cooperative working environment are important in project team communication. Social mechanisms define the social relationships and environment among the project participants who are from different organisations. It could manage and mitigate barriers between participants from different organisations, thereby improving the performance of project team communication. This categorised factor includes five factors which are *procedures for maintaining inter-organisational working relationships*, *activities for promoting committed attitudes of participants*, *policies for shared working values and project objectives among participants*, *interaction for developing inter-personal relationships*, and *previous cooperation experience between participants*.

<u>Capable Project Manager</u>

The categorised factor of *capable project manager* was regarded as critical to project team communication performance. Project managers are the representatives of each participant in a building project. Project managers are the key stars in communication between project participants. They can be coordinators for maintaining social linkages, information linkages, and knowledge linkages. Project managers’ capacity can be described by eight variables, being *professional technical skills, knowledge of other disciplines, a good information gatekeeper, communication skill, coordination skill, engagement in the project, working relationship with others, and stability of this team leader*.

6.6 SUMMARY OF THE CHAPTER

The significance of the 11 identified categorised factors in the previous chapter was further investigated in the pilot study in this chapter. The factor list was then developed into a comprehensive framework of the communication factors based on the responses from construction professionals. This framework of the communication factors, consisting of 13 categorised factors and their encompassed factors, can be used to manage project team communication at the construction stage and impact project team communication performance. In the next chapter, based on this framework a comprehensive empirical questionnaire survey is designed for exploring the effectiveness of these factors and their impacts on project team communication performance.

CHAPTER 7. METHODS OF EMPRICAL SURVEY FOR UNDERSTANDING THE IMPACTS OF COMMUNICATION FACTORS ON COMMUNICATION PERFORMANCE

7.1 INTRODUCTION

The empirical study exploring the impacts of the factors on communication performance in practice is conducted based on the communication factors framework developed in Chapter 6 and the communication performance assessment tool identified in Chapter 4. This chapter sets out the research methods adopted in the empirical study including the questionnaire design, data collection procedures, and data analysis methods. The primary method of collecting data was a mailed questionnaire. The variable measuring and empirical questionnaire design for exploring the communication factors' impacts on communication performance is first presented in this chapter. It is followed by a discussion of the data collection process. This chapter concludes with a presentation of the methods used to analyse the data.

7.2 A FRAMEWORK OF THE COMMUNICATION FACTORS' IMPACTS ON THE PERFORMANCE OF PROJECT TEAM COMMUNICATION

With the aid of previous research, as detailed in Chapters 4, 5 and 6, a model of the communication factors' impacts on the performance of project team communication was developed for the empirical questionnaire. Sidwell (1985), as cited in Chan

(2004), noted that the technique of using models to represent or explain phenomena and relationships in the real world, which were developed for use in the formal sciences, is now being adopted in the social sciences. In this study, the model is used to show the reality of the relationship between the factors and the communication performance.

The critical factors perceived to be of significance were identified and discussed in Chapters 5 and 6. Figure 6.4 formulates the critical factors for managing project team communication which include 13 factors: *project complexity, project client experience, project information technology (IT) applications, project organisation management approaches, project communication media infrastructure, project information documentation, arrangement of organisation structure, schedule for communication and information distribution, design information with high-quality content, effective procedures for construction work, expertise and background of staff, social and informal mechanisms for a cooperative working environment, and capable project managers*. Some of them are inter-related and intra-related. These factors form the determining variables of the model.

The communication performance assessment tool is discussed in Chapter 4. Figure 4.1 suggests that the performance of project team communication can be measured using a consolidated framework of COMPASS (CII, 1997) and Guevara’s (1979) communication variables. The indicators of project team communication performance as the influenced variable of the model include eight indicators in*accuracy, misunderstanding, untimeliness, barriers (accessing), information underload, information overload, information distortion, and information gatekeeping*

With the combination of Figures 4.1 and 6.4, a model of the factors' impacts on the performance of project team communication was developed for the empirical questionnaire (Figure 7.1). It sets out the relationships between the determining variable (the communication factors) and influenced variable (the performance indicators of project team communication). Based on this model, an empirical questionnaire study is designed to explore the impacts of communication factors on project team communication performance.

7.3 QUESTIONNAIRE DEVELOPMENT

Several data collection methods can be chosen for conducting social science research. Robson (1993) suggests that research design in social sciences should typically consist of choosing one of three methodologies: a survey, an experiment or a case study. Especially for team communication and interaction, Wallace (1987, cited in Xie, 2002) concluded that there are four main methodological approaches to the study of team interaction: experimental direct observation and naturalistic direct observation, research interview, research questionnaire, and documentary evidence.

Communication Performance

- Inaccuracy
- Untimeliness
- Misunderstanding
- Barriers
- Information Underload
- Information Overload
- Information Distortion
- Information Gatekeeping

Project Complexity
- Project size
- Design complexity
- Construction method complexity
- The numbers of subcontracting companies
- Time constraints for design and construction

Project Client Experience
- Experience in building project
- Supporting high quality of required information
- The time requirement from the client

Project Information Technology (IT) Applications
- IT application level: electronic mail, video conferencing, project intranets, 2D and 3D computer aided design (CAD), and 4D virtual reality

Project Organisation Management Approaches
- The type of procurement used
- Other management approach used: partnering, formal team building

Project Communication Media Infrastructure
- The media used: post, fax, telephone, meetings, face to face discussion, email, project intranet, and e-conferencing

Project Information Documentation
- The project document management system
- The information description protocol

Arrangement of Organisation Structure
- The structure of project organisation
- The communication and reporting system
- The document distribution structure
- Participants' understanding of organisation structure

Schedule for Communication and Information Distribution
- Schedule for communication and information distribution
- Construction team updating progress and performance to others
- Contractor updating design and requirement changes to all construction team members

Design Information with High-Quality Content
- Accurate and timely design information
- Coordinated design information
- High buildability design information

Effective Procedures for Construction Work
- Construction work planning and programming
- Construction work flow procedures defining scope, interfaces and sequence of activities

Expertise and Background of Staff
- Knowledge of domain field and other discipline
- Sufficient and stable employees.

Social and Informal Mechanisms for a Cooperative Working Environment
- Procedures for maintaining inter-organisational working relationships
- Policies for shared work values and project objectives among participants
- Activities for promoting committed attitudes of participants
- Interaction for developing inter-personal relationships
- Previous cooperation relationship between participants.

Capable Project Managers
- Professional technical skills, Knowledge of other disciplines, A good information gatekeeper, Communication skill, Coordination skill, Engagement in the project, Working relationship with others, Stability of this team leader

Figure 7.1 The model of the communication factors' impacts on the performance of project team communication

In this study, a postal empirical questionnaire survey was chosen as the primary data collection method. A postal questionnaire was the most efficient data collection technique and the least biased (Thomas, 1996; Guevara, 1979). Therefore, a questionnaire survey was selected as the primary instrument for data acquisition in this study so that information could be obtained faster with less bias.

Data acquisition by the post questionnaire survey was used to analyse the relationship between the communication variables (communication critical factors and communication performance indicators) in this study. A questionnaire survey can indicate a common behaviour of phenomenon through statistical analysis, even if it may not effectively uncover the nature of the research (Oppenheim, 1992). In this study, the aim is to quantitatively analyse the relationship between the communication factors and the communication performance indicators. Therefore, the post questionnaire survey is applied to conduct these quantitative analyses. The causal relationships between the communication factors and the communication performance indicators in practice could be analysed from this empirical questionnaire survey. Also, a picture of the existing status in building projects in terms of the effectiveness of communication factors and the performance of team communication can be drawn from the questionnaire survey.

7.3.1 Design of the empirical questionnaire

A questionnaire is a pre-formulated written set of questions to which respondents record their answer, usually within rather closely defined alternatives (Sekaran, 2003). Questionnaire design should follow some principles about measuring variables, question categorisation and order, scaling and coding of variables and questions, wording of the questions, and general appearance. This is discussed in this section.

Designing the questions to measure the concerned variables

The questions were designed to measure the indicators of project team communication performance and the factors of project characteristics and management measures in practice after a comprehensive literature review and the pilot study. Designing questions in a questionnaire involves devising the specific variables to measure and exploring the abstract research concepts through a practical survey (Lin and Liu, 2004). In this study, the performance of project team communication was measured by the indicators and associated questions in a consolidated framework (Figure 4.1 addressed in Chapter 4). In this study, the communication factors and associated questions were established through a comprehensive literature review and the pilot study which was addressed in Chapters 5 and 6. To devise questions for the communication factors, a review was also conducted on some studies about measuring the factors of organisational structure, the characteristics of the project, the capacity of the project manager, IT applications, and media usages. Since the time required for filling out the questionnaire was an important factor for the response rate (Guevara, 1979), emphasis was placed on designing appropriate questions for representing variables, not describing all the aspects of the variables. Measurement methods should also consider their influences on the reliability and validity of the results. Thus, based on the variables and associated questions in the model of the communication factors' impacts on the performance of project team communication established in section 7.2 (Figure 7.1), questions were designed for each variable.

Types of information explored in the questionnaire

Dane (1990) observed that three types of information can be collected by conducting a survey study, including facts (phenomena or characteristics available to anyone who knows how to observe them), opinions (expressions of a respondent's preferences, feelings, or behavioural intentions), and behaviours (actions completed by a respondent). In this study, the fact-type information was collected by asking the respondents questions on the communication factors and the communication performance in a building project. The following three kinds of questions were designed for measuring the facts of a project, based on personal perceptions. The questions are described in detail in section 7.3.2.

- Measuring the frequency of communication problems and the project communication performance: How often…? How well…?
- Measuring the effectiveness of management actions and strategies, the level of capacity: How effective…? The level of agreement…? The level of capacity…?
- Measuring the characteristics of a project, kinds of management actions and procedures applied: what kind…?

Measurement tools – scaling and coding

Most of the pre-coded answers in this study were set to a nominal or ordinal scale. Scaling is the process of assessing numbers or other symbols to an attribute or characteristic for the purpose of measuring that attribute or characteristic (Kendall and Kendall, 2002). Scaling and coding answers can also help to conduct a set of quantitative analyses. Kendall and Kendall (2002) suggest that scales should be carefully constructed to avoid the problems of leniency, central tendency, and the halo effect. The ordinal scale of a five-point Likert is used in this study to assess the numbers to the relevant variables.

Questionnaire wording and general appearance

The questions and the general appearance of a questionnaire should be designed to be clear, concise, unbiased, and easy to answer and analyse. Hoinville *et al.* (1977), Fowler (1993) and Prescott (1993) recommended some principles of questionnaire design. These recommendations include:

- The questionnaire must be clear, unambiguous and easy to answer;
- The questionnaire should use short sentences and be brief;
- The questionnaire should be written in simple language;
- The questionnaire should be self-explanatory;
- Biased terms should be avoided in order to get a real view from the respondents;
- The questionnaire must be designed to enable easy analysis;

- The questions should be ranked in order of importance;
- The questionnaire should be attractively spaced and uncluttered.

Pre-testing and revision of the questionnaire

Testing of the questionnaire was also conducted for the face validity of the questionnaire. Individual questionnaires should appear to have face validity. Sekaran (2003) points out that sound questionnaire design should ensure the clarity of the wording, the categorisation of the questions, and the general appearance of the questionnaire. Therefore, the preliminary questionnaire was sent to six academic staff in the department and three expert project managers in the Hong Kong construction industry to test the face validity. The interviewees were invited to indicate questions which were confusing or not differentiable, and give comments on the general appearance of the questionnaire. The general comment from interviewees was that the questionnaire was lengthy. The time required for filling out the questionnaire is an important factor in the response rate. Therefore, some questions have been excluded on the grounds that they reduced clarity or were redundant, including the questions measuring the factor of participants' expertise, the questions about the previous cooperation experience, and questions about coordination skill of all project managers, information controlling skills and engagement of the design team leaders and the client representative.

Based on the previous discussion on designing the questionnaire, the following section provides detailed contents in the questionnaire.

7.3.2 The contents in the empirical questionnaire

The questionnaire covers four pages and is divided into three sections (Appendix D) including: project profile, management strategies, and project team communication performance.

Section I Project profile

The first section of the questionnaire explores general background information about the respondent organisation and project, as well as the communication factor of *project complexity*, *project client experience*, *project organisation management applications*, and *project IT applications*.

1) Organisation background and project particulars

The background information about the organisation contained two questions: organisation type and organisation size in terms of turnover in the last financial year. There were a total of eight questions about general background information about project. They are the respondent's position in the project; project location; project classification in terms of the function of building, the type of construction work, the scheduled construction duration, and the current stage in construction process.

2) Project complexity

The project complexity was explored by measuring the project size in terms of original total contract sum; gross floor area (GFA); the degree of subcontracting in terms of work percentage performed by sub-contractors; the degree of fast-tracking in terms of the extent of design completion at the construction start; and the level of complexity of design and construction method.

Project design and construction method complexity were assessed in terms of:

- Complex building functions leading to difficulty in design
- Complex design buildability leading to difficulty to construct

The respondents were asked to rate the level of complexity of the project using a five-point scale of complexity level.

Scale: level of complexity

1	2	3	4	5
very simple		↔		very complex

3) Project client experience

The factors of project characteristics also include the factor of project client experience which is investigated in terms of:

- Experience and expertise in building projects
- Supporting high quality of required information

Ability to well arrange time for design and construction.

The respondents were asked to assess the experience of project client using a five-point scale of capacity level:

Scale: level of capacity

1	2	3	4	5
very weak		↔		very strong

4) Project organisation management approaches

The variables of the procurement system and management approaches for improving project communication adopted in each project were also examined in this section. The coding of the different categories of each variable was as follows.

The procurement system	**Code**
Traditional Procurement	1
Design & Build	2
Construction Management	3
Others	4

Management approaches	**Code**
Partnering/alliances	1
Formal team building	2
Others	3

5) Project information technology (IT) applications

The information technology (IT) adopted in the project was also examined. The coding of the different categories of each variable was as follows.

The IT system	Code Used/not used
Email	1/0
Project intranet	1/0
3-D design drawing	1/0
4-D simulation construction	1/0
Video conference	1/0
On-line chat system	1/0
Others	1/0

Section II Management strategies

1) Project communication media infrastructure

The using frequency and effectiveness of each kind of media were explored. The investigated media includes:

- Hard copy distribution or post
- Access to networked project database/intranet
- Meeting
- E-mail
- Fax
- Telephone
- Face to face discussion
- Video-conference, teleconference
- Others

The respondents were asked to rate the frequency of using each media by a five-point scale of using frequency. Then, their effectiveness in communication for problem solving, work coordination and information exchange was assessed by a rating on another five-point scale of the level of effectiveness.

Scale: using frequency

1	2	3	4	5
never		↔		always

Scale: the effective level

1	2	3	4	5
not effective		↔		very effective

2) Arrangement of organisational structure

The respondents were also asked to provide performance information about the arrangement of the organisational structure for communication. The arrangement of the organisational structure for communication was examined by questions:

- I am familiar with other parties' roles and responsibilities.
- Roles, and responsibilities of each party in this project are clear defined by the formal procedures (e.g. Contract Arrangement etc.).
- Communication linkages and reporting lines with other parties are well described by established inter-organisational chart in formal procedures e.g. Contract Arrangement
- The document distribution structure clearly formed for releasing and distributing documents among project parties.

The respondents were asked to provide performance information about the arrangement of the organisational structure for communication by rating the level of agreement on a five-point scale.

Scale: the degree of agreement

1	2	3	4	5
highly disagree		↔		highly agree

3) Social and informal mechanisms for a cooperative working environment

The factor of social and informal mechanisms for a cooperative working environment was examined in terms of the following questions:

- Good cooperative working relationships among different parties established by formal procedures. People in different organizations trust and help each other.
- Organisational work values and objectives are aligned to shared values and objectives by project culture and policies.
- Committed attitudes of participants developed by some organised activities. People are happy to be involved in the project.
- There are many social interactions between the project parties. Therefore, good inter-personal friendships and affinity with other parties are formed.

The respondents were asked to provide information on the social and informal mechanisms for cooperation working environment by rating the level of agreement on the scale of the degree of agreement.

Scale: the degree of agreement

1	2	3	4	5
highly disagree		↔		highly agree

4) Project information documentation

The respondents were invited to assess the effectiveness of procedures/strategies for project documentation taken by the project team according to the following questions:

- Project document management system: clear classification of collected information
- Protocols for information description and used IT to define congruent formats and communication etiquette

The same five-point scale of the degree of effectiveness mentioned before was used to assess the effectiveness of each question.

Scale: the effective level

1	2	3	4	5
not effective		↔		very effective

5) Schedule for communication and information distribution

This part is about assessing the effectiveness of schedules for communication and information distribution taken by the project team in terms of:

- Schedule for communication and information distribution along with production flow
- Mechanisms applied by main-contractor for being aware of and updating design and requirement changes to all construction team members in advance and controlling document versions
- Mechanisms applied by main-contractor for timely updating all parties the

project progress and performance, as well as informing required inputs

The respondents were asked to assess the effectiveness of the procedures on these aspects by the same five-point scale of the effectiveness degree.

Scale: the effective level

1	2	3	4	5
not effective		↔		very effective

6) Effective procedures for construction work:

This part asked the respondents to describe the main-contractor's capacity to provide the effective procedures for implementing construction work. The explored questions are listed below:

- Ability to develop effective procedures of construction planning and programming outlining work flows and sequence
- Ability to develop effective procedures defining construction work scopes and interfaces of each construction team member

The respondents were asked to assess the level of performance of the main-contactor by the five-point scale of the capacity level.

Scale: level of capacity

1	2	3	4	5
very weak		↔		very strong

7) Design information with high-quality content:

The respondents were asked to describe the capacity of the design team to provide the high-quality design information by the following questions:

- Knowledge of construction, outputting high buildability design
- Ability to supply high quality of design information, good controlling design changes
- Ability to supply coordinated design information

The five-point scale of the capacity level was used to measure the performance of design team to provide high-quality information.

Scale: level of capacity

1	2	3	4	5
very weak		↔		very strong

8) Capable project managers

The capacity of project managers in the project team was explored by the following aspects:

- Professional technical skills
- Knowledge of other disciplines
- A good information gatekeeper to control information flow (not applied to the design team leaders and the client representative)
- Communication skill
- Early and continued engagement in the project, always available to contact

(not applied to the design team leaders and the client representative)

- Working relationship with others
- Stability of this team leader

The respondents are invited to assess the competency of construction project manager, client's representative, and design team leader with another five-point scale of the level of competency:

Scale: level of competency

1	2	3	4	5
weak		↔		strong

Section III Project communication performance

Aiming to assess the performance of the project communication, in this section the respondents were asked to indicate the frequency of the following communication problems.

- Misunderstanding what information other parties expect from you,
- Receiving conflicting information from others,
- Poor communication or lack of coordination with other parties,
- Having less information than you need,
- Too much information than you can efficiently use,
- Have not been kept up to date with design changes,
- Have not been kept up to date with schedule changes,
- Information changed in meaning or lost during the dissemination,

- Information withheld during its dissemination by those who control information flow,
- Inadequate accessing to the information sources (information provider or information database). Please indicate barriers_____(1-interpersoanl issues, 2-accessibility, 3-logistic issues, 4-others)

A five-point scale of the frequency was adopted to measure the project communication performance.

Scale: experiencing frequency

1	2	3	4	5
always		↔		never

Respondents were also invited to give an overall assessment of the project communication effectiveness at the construction stage.

- Overall, how effective do you think communication between project participants is at the construction stage on this project?

The five-point scale of the degree of effectiveness was used to assess the overall assessment of the project communication effectiveness:

Scale: the effective level

1	2	3	4	5
not effective		↔		very effective

Besides closed-end questions, the respondents were encouraged to point out the primary barriers to effective communication and improvement strategies in the relevant project.

The final version of the questionnaire document used in the empirical survey is shown in Appendix D.

7.4 DATA COLLECTION PROCEDURES

Having finalised the empirical questionnaire, the research proceeded with data collection. This section outlines the procedures in the data collection process. In summary, this involved identifying the survey sample, distributing and collecting survey questionnaires, and the data preparation tasks of coding and uploading the data.

7.4.1 Distributing and collection of survey questionnaires

The targeted populations in the empirical survey are building projects in progress or just completed in Hong Kong (HK) and Beijing (BJ). From the discussion in the previous chapter, to reflect different social and economic influence on communication performance, the empirical questionnaire surveys were conducted in Hong Kong and Beijing, mainland China. The empirical study is to explore the communication factors' impacts on the team communication performance at a building project level. Therefore, the building projects in progress or just completed are the targeted populations.

To quickly get more data about the project team communication, questionnaires were sent in several ways. The questionnaires were firstly sent to the major construction companies in Hong Kong and Beijing, for example China State Construction Engineering Group (BJ), Beijing Construction Engineering Group (BJ), Gammon Construction Limited (HK), China State Construction International Holdings Limited (HK). They were invited to attend to this survey and asked to send the questionnaire to those involved in relevant projects. The construction project manager helped circulate the questionnaire to representatives of other involved participants at the construction stage. In Hong Kong, the questionnaires were also sent to the companies involved in the construction industry whose list was set up in the pilot study by searching HKIA, HKCA, HKSA, ETWB, and HKHA. The questionnaires were addressed to the managing director of each of these firms who were requested to circulate the questionnaire to project managers in the firm. In Beijing, the questionnaire was also sent to construction professionals in all involved organisations at the construction stage through personal contacts. All respondents are required to provide information about projects that they were involved with that were in progress or had just finished.

Questionnaire documents attached with a cover letter were addressed to project managers and representatives of each participating organisation at the construction stage. Project managers and representatives from each participating organisation at the construction stage were approached as the primary respondents to the questionnaire survey. The questionnaire packages, including a cover letter and a sealable envelope, were circulated to these respondents. The cover letter explained the importance and purpose of the research, provided instructions for survey administration, and ensured the respondent of the confidentiality of responses. A copy of the letter is provided in Appendix C.

7.4.2 Respondents

A total of 350 questionnaires were sent out to the companies in the Hong Kong construction industry, of which 58 completed questionnaires were returned. One questionnaire was returned but not filled in. The response rate is around 16%. That is totally 57 questionnaires which could be used in statistical analysis. Among the respondents, 34.9% requested a report of the outcome of the questionnaire.

A total of 400 questionnaires were sent out to companies in the Beijing construction industry, of which 108 completed questionnaires representing projects were returned. (Among them were 52 questionnaires from 10 projects and 56 from construction and consultant companies). The response rate is around 27%. But the 22 questionnaires were not included in the data analysis for the low quality of the data. That is totally 86 questionnaires (32 from 8 project, 54 from individual responses) representing 62 projects which were used in the statistical analysis. Among the respondents, 45.0%

requested a report of the outcome of the questionnaire. Tables 7.1 summarise the descriptive data of the respondents included in the study.

Table 7.1 Respondents profiles

Respondents from Hong Kong							
Respondents' position	Manager 5	Project Manager 27	Senior Project Manager 5	Project Director 5	Chief Eng. Supervisor N/A	Not indicated 15	Total 57
Organisation type	Client 7	Designer 22	Main contractor 17	Sub-contractor & supplier 10	Engineering supervisor N/A	Not indicated 1	Total 57
Organisation size: turnover	Small <50M 7	Medium 50-500 M 11	Large 500M-10B 23	Very large>10B 10	Not indicated 6	Total 57	
Respondents from Beijing							
Respondents' position	Manager 22	Project Manager 23	Senior Project Manager 15	Project Director 16	Chief Eng. Supervisor 6	Not indicated 4	Total 86
Organisation type	Client 22	Designer 28	Main contractor 20	Sub-contractor & supplier 8	Engineering supervisor 7	Not indicated 1	Total 86
Organisation size: turnover	Small <50M 25	Medium 50-500 M 25	Large 500M-10B 24	Very large>10B 8	Not indicated 4	Total 86	

- Respondents' position: describes the geographical position of the respondents. Respectively in Hong Kong and Beijing, more than 81% and 65.9% of the respondents held positions above project manager, ensuring the respondents have good project experience.
- Organisation type: all respondents are classified into five groups: client, designer, main-contractor, sub-contractor & supplier, and engineering supervisor (only in Beijing). The respondents represented different members in the project team in a building project.
- Organisation turnover: the firms involved in the survey have been classified into

four different sizes of organisation based on the turnover of the firm. In Hong Kong the dominant respondents are large companies. In Beijing, respondents cover the different the sizes of company about evenly.

7.5 DATA ANALYSIS PROTOCOL

Data analysis in the empirical questionnaire survey was carried out by exploring the effectiveness of communication factors and the communication performance in building projects and the impacts of communication factors on communication performance in practice using a number of statistical tools. These statistical analyses include frequency and means descriptive analysis, two-tailed t-test, factor analysis, regression analysis, and correlation analysis. The analyses were conducted with the help of the Statistical Package for the Social Sciences (SPSS for Windows, Release 12).

Proper data analysis requires effective data management. The length of the questionnaire, the number of completed surveys, and the data analysis software to be used all had to be considered in selecting a database management system. In this study, Microsoft Excel was used to manage the data from the empirical study.

In the following parts of this section, the data analysis process is first discussed, followed by the introductions of several of the statistical analysis methods employed.

7.5.1 Data analysis process

Analysis of the data commenced with an examination of the current performance of team communication and effectiveness of the communication factors, and then proceeded to an investigation of the impacts of communication factors on communication performance in practice. The analysis process is listed simply as follows:

- A descriptive analysis of the level of the communication performance indicators, that is the frequency of each communication problem, in Hong Kong and Beijing building projects, and a t-test for comparing the different performance in Hong Kong and Beijing building projects;
- Establishing the formulation of project team communication effectiveness in this study context;
- A descriptive analysis examining the effectiveness of each communication factor in current practice;
- Selecting significant variables in analysing the communication factors' impacts on the communication performance indicators by conducting regression analysis;
- Correlation analysis of the impacts of the communication factors on the communication performance indicators.

7.5.2 Data analysis methods

Several employed statistical analysis methods are introduced in the following parts of this section. These statistical analyses include frequency and means descriptive analysis, two-tailed t-test, factor analysis, regression analysis, and correlation analysis.

7.5.2.1 Descriptive analysis and ranking analysis

Analysis of the data commenced with an examination of the current status of communication performance and communication factors in practice. Univariate analysis was first employed to describe these variables. The univariate analysis is typically a preliminary method of analysis which includes analysing percentages, central tendency (means) and dispersion (standard deviations) of one variable (Tharenou *et al*., 2007). Means of the score of each communication performance indicator were examined in Hong Kong and Beijing building projects. The application status of each communication factor current projects was also explored, for example, the usage of IT applications and organisation management approaches, the using frequency and effectiveness of each kind of media, the effectiveness of each management strategy for communication in practice. Ranking analysis was also conducted to compare the means of the score of each communication performance indicator, the usage of different kinds of IT and organisation management approaches, as well as the means of the effectiveness of the management strategies factors.

7.5.2.2 Correlation Analysis

In order to set up a formulation to calculate the effectiveness of the project team communication performance, the weight of each communication indicator to the overall effectiveness was calculated. These weights were calculated by applying bivariate correlation analysis between each indicator with a global performance question.

Correlation analysis was also applied to analyse the impacts of each communication factor on the each performance indicator and project team communication effectiveness. Correlation analysis can be used in the situation of obtaining an indication of the initial relationship between the dependent variable and each independent variable (Tharenou *et al.*, 2007). To determine which communication factors correlate well with each performance indicator, correlation analysis was applied.

In correlation analysis, the Pearson product-moment correlation coefficient (r) was applied to measure the relationship between two variables in this study. The Pearson product-moment correlation coefficient is commonly used to calculate the strength and direction of the linear relationship between two continuous variables (Kline, 2005). It is computed through an examination of the proportion of variance that is shared by variables. The raw score formula is:

$$\gamma_{xy} = \frac{N\sum XY - \sum X \sum Y}{\sqrt{\left[N\sum X^2 - (\sum X)^2\right]\left[N\sum Y^2 - (\sum Y)^2\right]}} \qquad \text{Equation 7.1}$$

Where:

r_{xy}= the correlation coefficient between X and Y

N= the size of the sample

X= the individual's score on the X variable

Y= the individual's score on the Y variable

It is conventional to first test if the correlation coefficient is significantly different from zero. This is done with a test of statistical significance. This test tells us whether there is enough evidence to reject the null hypothesis that the observed relationship is zero in the population from which the sample came. The researcher should first check the probability values associated with the correlation coefficient to determine whether the relationship is statistically significant or not ($p < 0.05$); if the latter, it is called non-significant.

If statistically significant, the researcher should check the direction and magnitude of the correlation coefficient to gauge how strong or weak it is and whether it is a positive or negative association. The Pearson correlation coefficient ranges from -1.0 to 1.0, where 0 is no association and 1 represents perfect association. The direction (or sign) of the correlation can be positive (as one variable increases, the other variable also increases) or negative (as one variable increases, the other variable decreases). Cohen (1988) suggested that, as a rule of thumb, $r = 0.10$ is a small effect size, $r = 0.30$ is a medium effect size, and $r = 0.50$ is a large effect size. However, Cohen also cautioned that any evaluation of effect size requires judgement regarding the practical importance of the study effects within a given context.

When a correlation matrix is constructed, it should often include the dependent variable and the independent variable defined by researchers. The researcher can then see how related each independent variable is to the dependent variable at the bivariate level. In this study, the communication factors are regarded as independent variables and the communication performance indicators as dependent variables.

7.5.2.3 Significance tests of the difference between means

The significance test of t-tests was conducted to compare the difference between means in different groups. In this study T-tests were conducted to compare communication performance and communication factor application in two different cities, Hong Kong and Beijing.

The independent t-test tests the null hypothesis that the population mean of a variable is the same for two groups of cases. The confidence interval for the difference between the population means in the two groups is also derived (Norusis, 2003b). If the result of the t-test is significant, this indicates that the researcher can conclude that there is a high likelihood that the populations from which the samples were drawn had different means (Sheskin, 2004). The difference would be statistically significant at the 5% level if the corresponding *p*-value is smaller than or equal to 0.05. Equation 7.2 is a general equation for this test and can be employed for sample sizes that are both equal and unequal.

$$t = \frac{\overline{X}_1 - \overline{X}_2}{\sqrt{\frac{(n_1 - 1)s_1{}^2 + (n_2 - 1)s_2{}^2}{n_1 + n_2 - 2} \frac{n_1 + n_2}{n_1 n_2}}}$$

Equation 7.2

Where:

$\overline{X}_1$ = the mean for group 1

$\overline{X}_2$ = the mean for group 2

n_1 = the number of participants in group 1

n_2 = the number of participants in group 2

s_1^2 = the variance for group 1

s_2^2 = the variance for group 2

7.5.2.4 Factor analysis

Factor analysis was conducted in this study to assess the validity of the communication factor structure which described each categorised communication factor and its associated variables. The communication factor framework set up a set of communication factors which were measured by its associated variables. Whether this framework is supported by the data was tested by conducting confirmatory factor analysis before analysing the factors' impacts on communication performance.

Factor analysis is a multivariate technique used to identify a relatively small number of factors (factor extraction) that can be used to represent relationships among sets of many interrelated variables (Norusis, 1993a). Having developed a new multi-item measure for a study, a researcher needs to subject the scale items to factor analysis to determine their validity (Tharenou *et al*., 2007). The aim of factor analysis in scale construction is to examine the stability of the factor structure and provide information that will facilitate the refinement of a new measure (Hinkin, 1995). This is the aim of applying factor analysis in this study.

The first stage test in factor analysis is usually to ensure the appropriateness of the factor analysis for the factor extraction. Matrices of correlation coefficients or partial correlation coefficients of the variables are usually set up to determine the strength of the relationship among the variables. According to Norusis (1993a), the partial correlations should be close to zero when factor analysis assumptions are met, and if the proportion of large coefficients is high then the use of the factor model should be reconsidered. Other tests based on the correlation matrix are required to test the appropriateness of the factor analysis for the factor extraction, including the Kaiser-Meyer-Olkin (KMO) (measure of sampling accuracy), anti-image correlation (measure of sampling activities (MSA)) and Bartlett’s test of sphericity. The value of the MSA must be reasonably high for a good factor analysis. Bartlett's test of sphericity tests the hypothesis that the correlation matrix is an identity matrix. Practically, the most important is the value of KMO. If the value of KMO > 0.6, the factor analysis is suitable; otherwise it is necessary to compound or delete some factors (Kaiser, 1974).

To generate a small number of factors, factor extraction is usually done by means of principal components analysis which transforms the original set of variables into a smaller set of linear combinations that account for most of the variation of the original set. The *m*th principal component $PC_{(m)}$ is that weighted linear combination of the observed variables X depicted as Equation 7.4.

$$PC_{(m)} = w_{(m)1}X_1 + w_{(m)2}X_2 + ... + w_{(m)p}X_p \qquad \text{Equation 7.4}$$

The number of factors to be retained must be determined since the distinctive characteristic of principal components analysis is its data-reduction capacity. Kaiser (1958) suggests that one criterion for determining the number of retained factors is to exclude factors with variances less than one. Another approach, the 'scree test', is proposed by Cattell (1966), where the eigenvalues of each component are plotted against their associated component. The scree plot helps to identify the number of factors to be retained by looking for a relatively large interval between eigenvalues.

The rotation and interpretation of the factors is then carried out to obtain a clearer picture of what these factors represent. Meaningful interpretation of the factors generated is important. An unrotated principal component analysis factor matrix indicates only the relationship between individual factors and the variables, and sometimes it is difficult to interpret the pattern. There are several rotation methods and the more common ones are varimax and oblimin. The varimax method, which was used in this study, is most popularly used to rotate principal components solutions (Dillon and Goldstein, 1984). The procedure seeks to rotate factors so that the variation of the squared factor loadings for a given factor is made large to allow ease of interpretation based on the significance of the loadings. Factor loading (or coefficients) gives the correlation between variables and factors. A factor loading of 0.30 is often used as a cut-off for significance which means factor loadings of less than 0.30 are not included in the factor.

7.5.2.5 Regression analysis

Regression analysis was used to determine which variables were significant to the effectiveness of project team communication. Due to the limited sample size, the original 60 ordinal variables were selected for analysing the communication factors' impacts on communication performance. Ones that had no significant relationship with the effectiveness of project team communication were deleted from the following analysis.

Regression analysis, a form of general linear modelling, is a technique for quantifying the relationship between a criterion variable (dependent variable) and one or more predictor variables (independent variables). It is used to predict the criterion variable based on specified values for the predictor variables and to understand how the predictor variables influence or relate to the criterion variable (Wittink, 1988). The multiple linear regression equation of dependent variable (y) upon the independent variables ($x_1,\ldots x_p$) is expressed in Equation 7.5.

$$y = \beta_0 + \beta_1(x_1) + \beta_2(x_2) + ... + \beta_p(x_p) + e \qquad \text{Equation 7.5}$$

where y represents the dependent variable, $x_1,\ldots x_p$ are the independent variables; the parameters β_1, $\beta_2,\ldots\beta_p$ are the partial regression coefficients; the intercept β_0 is the regression constant; and e is the error term.

7.6 SUMMARY OF THE CHAPTER

This chapter discussed the research methods in the empirical questionnaire survey, which include the development of the questionnaire, the data collection methods and data analysis methods. First, the questionnaire design process and contents were described in detail. Then, the data collection process, the size of the sample, and the background information of the respondents were presented. This was followed by a discussion of the data analysis process and the several methods used in data analysis, namely descriptive analysis, ranking analysis, the significance test, regression analysis, factor analysis, and correlation analysis. Details of these data analyses are presented in the next two chapters.

CHAPTER 8. COMMUNICATION PERFORMANCE AND COMMUNICATION FACTORS IN PRACTICE

8.1 INTRODUCTION

Effective project team communication is essential to a project's success. However, poor management of communication can easily lead to communication problems. In this chapter, the level of communication performance in practice is explored and the effectiveness of communication factors in current building projects is examined by undertaking a descriptive analysis of the data. The data were collected by employing questionnaires, which has been addressed in the previous chapter. This chapter is divided into two main parts. First, the existing communication problems in construction practice were identified and analysed. A formula for assessing the effectiveness of project team communication in a project (PCE) was also developed. This formula was constructed by calculating the weightings of the each communication indicator. Second, the situation and effectiveness of the each communication factor in current building projects was examined. This chapter presents an overall picture of communication performance and the communication factors in current construction practice.

8.2 COMMUNICATION PERFORMANCE IN PRACTICE

An analysis of the performance of project team communication in practice was conducted based on the responses from the empirical questionnaire survey. The results are reported in this section. First, the existence of communication problems in Hong Kong and Beijing building projects was investigated. Then, a formula for assessing the effectiveness of project team communication in a project (PCE) was developed.

8.2.1 Communication problems in Hong Kong and Beijing construction practice

Communication performance was explored in practice by the performance indicators which are the frequency of communication problems. Thus, analysis of the data commenced with an investigation of the existing communication problems in construction practice using the data from the questionnaire survey.

1. Ranking of the frequency of communication problems

The frequency of the various kinds of communication problems in building projects was examined, indicating the performance of project team communication. The ranking of the frequency of the communication problems in Hong Kong and Beijing is shown in Table 8.1.

Table 8.1 The rank of the communication problems

Rank	Hong Kong	Mean	S. D.	Beijing	Mean	S. D.
1	Information underload	2.74	0.97	Information underload	3.23	1.07
2	Untimeliness	2.89	0.70	Barriers	3.32	0.95
3	Inaccuracy	3.07	0.64	Inaccuracy	3.32	0.84
4	Barriers	3.19	0.69	Information gatekeeping	3.34	0.89
5	Misunderstanding	3.21	0.71	Misunderstanding	3.53	0.78
6	Information gatekeeping	3.23	0.76	Untimeliness	3.58	0.92
7	Information distortion	3.24	0.81	Information overload	3.66	1.00
8	Information overload	3.27	0.86	Information distortion	3.78	0.87

Remarks: A lower mean indicates worse performance.

The results indicate a difference in the frequency of each communication problems. *Information underload* was the most frequent communication problem in Hong Kong building projects, which was followed by *untimeliness*, *inaccuracy*, *barriers*, and *misunderstanding*. *Information gatekeeping*, *information distortion*, and *information overload* were the three least existing communication problems in Hong Kong building projects. In Beijing building projects, *information underload* also was the most frequent communication problem, followed by barriers, *inaccuracy*, *information gatekeeping*, and *misunderstanding*. *Untimeliness*, *information overload*, and *information distortion* were the three least frequent communication problems in Beijing building projects

2. A comparison of the communication problems between Hong Kong and Beijing construction

A t-test was conducted to compare the different communication performance in Hong Kong building projects and in Beijing building projects. The two-tailed t-test tests the null hypothesis that the population mean of a variable is the same for two groups of cases. If the result of the t-test is significant, this indicates that the researcher can conclude that there is a high likelihood that the populations from which the samples were drawn had different means (Sheskin, 2004). The t-test results and the comparison of the two groups are shown in Tables 8.2 and 8.3.

Table 8.2 T-test for equality of communication performance in Hong Kong and Beijing

Communication problems	T	df	Sig. (2-tailed)	Mean Difference
Inaccuracy	-1.845	116	0.065	-0.2554
Untimeliness	-4.501	116	0.000	-0.6807
Misunderstanding	-2.282	115	0.024	-0.3149
Barriers	-0.798	116	***0.422***	-0.1226
Information underload	-2.634	116	0.01	-0.4963
Information overload	-2.27	115	0.025	-0.3948
Information distortion	-3.461	116	0.001	-0.5357
Information gatekeeping	-0.738	116	***0.462***	-0.1129

Table 8.3 The comparison of communication performance in Hong Kong and Beijing

Communication problems	Mean		Std. D.	
	Hong Kong	Beijing	Hong Kong	Beijing
Inaccuracy	3.07	3.32	0.64	0.84
Untimeliness	2.89	3.58	0.70	0.92
Misunderstanding	3.21	3.53	0.71	0.78
Barriers	3.19	3.32	0.69	0.95
Information underload	2.74	3.23	0.97	1.07
Information overload	3.27	3.66	0.86	1.00
Information distortion	3.24	3.78	0.81	0.87
Information gatekeeping	3.23	3.34	0.76	0.89

Remarks: A lower mean indicates more frequently worse performance.

By comparing the frequency of each communication problem in Hong Kong and in

Beijing, it was found that a significant difference existed between the two groups in all communication performance aspects except the communication problems of *barrier*s and *information gatekeeping* (Table 8.2). This indicates that building participants in Hong Kong and Beijing faced different project team communication problems. A different social environment and the different application situations of the communication factors may lead to the different degree of communication problems.

The data in Table 8.3 indicates Beijing building projects have better communication performance in all aspects of the indicators. A different social and building environment, as well as different application situations of the communication factors may lead to the different degree of communication problems. However, this difference of the communication performance may be due to the weakness of the communication performance assessment tool. The communication performance indicators were identified by Construction Industry Institution (CII) and Guevara (1979), which have been used by some researchers. Their reliability has been proved by these previous studies. However, this method assessed the indicators by human perception which is influenced by the personal judgement. Personal judgements are likely to differ for their value-sets and social culture (Rittel and Webber, 1973). Therefore, the better communication performance of Beijing building projects may therefore be caused by the inherent weakness of the assessment tool.

3. Discussion of each communication problem

Inaccuracy

The communication problem of *inaccuracy* includes two aspects: conflicting instructions, and poor communication and lack of coordination. The communication problem *inaccuracy* was identified as the third most frequent communication problem bothe in Hong Kong and in Beijing building projects. This indicates that *inaccuracy* was a common existing project team communication problem in Hong Kang and Beijing. Problems involving inaccuracy and conflicting information have also been reported as common communication problems by several previous studies (Dawood *et al*., 2002; Newton, 1995; Shen, 1992; Watkinson, 1992; Xie, 2002). Therefore, project participants should pay more attention to control the communication problems of conflicting instructions and poor coordination.

Misunderstanding

Misunderstanding is represented by the problem of misunderstanding information expectations and requirements between project team members. This problem was ranked as the fifth most frequent problem in Hong Kong and Beijing building projects. This indicates that *misunderstanding* was not a major communication problem at the construction stage. Xie *et al*. (2000) also found the problem of *misunderstanding* was not a major issue. However, she further argued that previous researchers considered misunderstanding as a main communication problem in the multi-team construction process. Perhaps, this problem was overcome by the current applied effective management strategies. According to Thomas *et al*. (1998), the reason causing this difference may be that the problem of *misunderstanding* is difficult to diagnose.

Untimeliness

The communication problem of *untimeliness* is indicated by the frequency and timeliness of updating changes in design and the schedule. Untimely information was identified as the second most frequent problem in Hong Kong building projects, but the sixth most frequent problem in Beijing building projects. This implies that late information was a severe problem in Hong Kong, but not a major issue in Beijing. Xie *et al*. (2000) also found that late information about design was prevalent in building projects. Watkinson (1992) and Shen (1992) perceived that late information, affecting the planning of work or ordering of materials, was due to untimely collection or distribution. Many researchers believed that each member of the project team should have timely access and get updated key project information (Bocij and Chaffey, 2003; Mead, 1999; Newton, 1995; Shen, 1992; Thomas *et al*., 1998; Watkinson, 1992; Xie, 2000). Therefore, project participants in Hong Kong building projects should pay more attention to the problem of untimeliness. In Beijing, fast-track construction methods were not commonly used in building projects. The construction team usually receive design drawings before they start construction. Consequently, the communication problem of untimeliness was not severe in Beijing building projects.

Barriers

The problem of barriers is inadequate access to the information sources. The problem of *barriers* was the second most frequent problem in Beijing building projects and the fourth most frequent problem in Hong Kong building projects. It implies *barriers* was a very severe problem in Beijing, but not a very big issue in Hong Kong. The difference in the effect on performance of *barriers* existed in the previous studies. Shen (1992) perceived that information was inaccessible due to poor presentation or hierarchy barriers. In Xie *et al*.'s (2000) study, barriers were not the major communication problem.

Information underload

Information underload is a situation where one does not have enough information to make decisions and implement their work. *Information underload* was the most frequent communication problem in Hong Kong and Beijing building projects. This indicates that *information underload* was a significant communication problem at the construction stage. Xie *et al*. (2000) examined communication problems in building projects and found that information underload was prevalent in construction design. Watkinson (1992) and Shen (1992) pointed out the communication problem of information underload for decision making or action taking was due to information not being produced or not being distributed to sites in building projects. However, In Guevara & Boyer's (1981) study examining communication problems within construction companies, the problem of underload was not a severe problem. Sufficient information is very important for overall project team communication performance. Therefore, the project participants should put more effort into the control this problem of *information underload*.

Information overload

Information overload is a situation in which the individual or system has more information than that can be utilised or processed. *Information overload* was identified as the least frequent problem in Hong Kong building project and the second least frequent problem in Beijing building projects. This indicates that *information overload* was not a major issue at the construction stage. Xie *et al*. (2000) also found that information overload was not a major issue in construction design communication in building projects. However, in Guevara & Boyer's (1981) study on communication problems within construction companies, information overload was the prevalent problem. This may indicate that information overload often happens in internal communications.

Information distortion

Information distortion occurs when the meaning of a message is changed or at least partially missed during diffusion. *Information distortion* was identified as the second least frequent problem in Hong Kong building projects and the least frequent problem in Beijing building projects. *Information distortion* was not a major issue at the construction stage. In Xie *et al*.'s study (2000) which examined project team communication problems relating to design issues, information distortion were also not a common problem. Nevertheless, in Guevara & Boyer's study (1981)which explored communication problem within construction companies, the distortion of information was a severe problem. Information distortion may more frequently happen in internal communications.

Information gatekeeping

Information gatekeeping is the act of withholding information. *Information gatekeeping* was ranked as the sixed most frequent problem in Hong Kong building projects, but ranked as the fourth most frequent problem in Beijing building projects. This demonstrates that *information gatekeeping* was not a frequent problem in Hong Kong, but participants in Beijing building projects experienced problems relating to *information gatekeeping*. In Guevara & Boyer's (1981) study on communication problems within construction companies, *information gatekeeping* was a severe problem. Information is sometimes withheld by a gatekeeper intentionally or unconsciously during the communication process. To achieve good project team communication, project participants should have a good gatekeeper to smooth and direct the information flow.

8.2.2 Assessment of project team communication effectiveness (PCE)

A formula for assessing the effectiveness of project team communication in a project (PCE) was also developed. It was constructed by calculating the weightings of the each communication indicator. This effectiveness score of a project's team communication performance can be a means to examine the impacts of the communication factors on project team communication performance in the next chapter.

The overall team communication performance of a project is analysed by employing communication effectiveness score-project team communication effectiveness (PCE). This summary score, designed to indicate the overall team communication performance of a project, was constructed according to the score model:

$$PCE = \sum_{i}^{N} w_i I_i, \quad N = 8 \qquad \text{Equation 8.1}$$

Where:

PCE is the score of project team communication effectiveness;

W_i – the weighting value of the performance indicator *i;*

I_i – the performance score of the performance indicator *i*.

1. Communication indicators and contained questions

The project team communication effectiveness score was calculated from the summary of the scores of the included indicators and their associated questions, which are shown in Table 8.4.

The communication performance indicators in this study were the variables in the assessment tool COMPASS (Thomas *et al*., 1998) and the variables of four communication problems in Guevara's study (1979) which were addressed in Chapter 4. These variables also confirmed the suitability of measuring communication performance by other researchers (Hunter, 1993, cited in Xie, 2002; Mead, 1999; Murray, 2003; Xie, 2002).

Table 8.4 Communication performance indicators and included questions

Indicators	Included questions
Inaccuracy	Receiving conflicting information from others
	Poor communication or lack of coordination with other parties
Untimeliness	Haven't been kept current with design changes
	Haven't been kept current with schedule changes
Misunderstanding	Misunderstanding what information other parties expect from you
Barriers	Inadequate accessing to the information sources (information providers or information database)
Information Underload	Having less information than you need
Information Overload	Too much information than you can efficiently use
Information Distortion	Information changed in meaning or lost in some contents during the dissemination
Information Gatekeeping	Information withheld during its dissemination by ones who control information flow

Prior to using these indexes for further statistical analysis, a reliability assessment was performed to ensure internal consistency of the component variables. Reliability testing was done to determine the extent to which items in the index relate to each other. The Cronbach's Alpha was used in this research, which is a measure of the internal consistency of the variables in the index. Alphas (α) of 0.7 or higher are desirable values (Knoke and Bohmstedt, 1994). Table 8.5 shows that the communication performance indicator index had α>0.7, which indicates there is high consistency among the variables. No variables were dropped from the index as a result of reliability testing.

Table 8.5 Cronbach's Alpha to test internal consistency

Cronbach's Alpha (α)	No. of Items
.838	8

2. Weighting values of each communication indicator

The project communications performance can be scored in different ways using survey data. For example, data of included indictors could simply be added by providing a score to indicate the overall score of a project. Such the score would not reflect the relevant importance of the included indicators. In this study, the category scores of each indicator were weighted based upon the correlations determined during the statistical analysis. It should be noted that all respondents from Hong Kong and Beijing were inputted to calculate the weights in order to have more data to reflect the relationship between the variables.

The category weights were determined based upon the strengths of the underlying questions' correlations with the global communication performance item. Correlation coefficients for component questions were averaged and then normalised. The weights thus retained the relative importance of the underlying questions. The indicators and their weights for the project communication effectiveness scores are shown in Table 8.6.

Table 8.6 The weigh of each communication performance indicator

Communication performance	**Inaccuracy** Y_1		**Untimeliness** Y_2		**Misunder-standing** Y_3	**Barriers** Y_4	**Information Underload** Y_5	**Information Overload** Y_6	**Information Distortion** Y_7	**Information Gatekeeping** Y_8
	Conflicting information	Poor communication	Design Changes Update	Schedule Changes Update	Information Requirement	Barriers	Information Underload	Information Overload	Information Distortion	Information Gatekeeping
Correlation coefficient with the global question	.383(**)	.528(**)	.446(**)	.396(**)	.408(**)	.390(**)	.378(**)	.226(**)	.369(**)	.425(**)
Weight	0.455		0.421		0.408	0.390	0.378	0.226	0.369	0.425
Normalised weight	0.148		0.137		0.133	0.127	0.123	0.074	0.120	0.138

** Correlation is significant at the 0.05 level (2-tailed), ** Correlation is significant at the 0.01 level (2-tailed).*

3. Summarising to an overall score of project team communication effectiveness

Once the weight of each indicator is developed (Tables 8.6), the scores of each criterion can be inputted and become a compound score that reflects a project's overall level of performance (Equation 8.2). The index, based upon the survey questionnaire, provides a summary score and sufficient detail to each category of communication performance indicators.

Project team communication effectiveness score = Equation 8.2

$$0.148 \times Y_1 + 0.137 \times Y_2 + 0.133 \times Y_3 + 0.127 \times Y_4 + 0.123 \times Y_5 + 0.074 \times Y_6 + 0.120 \times Y_7 + 0.138 \times Y_8$$

The project team communication effectiveness score can be used to compare the team communication performance between individual projects and also to analyse the impacts of the communication factors on the overall project communication performance in the next chapter.

8.3 THE DESCRIPTIVE ANALYSIS OF THE COMMUNICATION FACTORS

Descriptive analysis was conducted on the twelve categorised factors according to the data collected from the empirical questionnaire survey which has been described in the previous chapter. In this section, the practical conditions of the communication factors are described. Each communication factor was explored by its included questions which were investigated in the questionnaire survey.

8.3.1 Factors of project characteristics

Project complexity

Being the context of project team communication, *project complexity* influenced project team communication and determined the complexity of communication. The situation of the complexity of the building projects in Hong Kong and in Beijing is presented in Tables 8.7. The comparison of the different situations of *project complexity* in Hong Kong and in Beijing was conducted by employing the t-test. The results are shown in Table 8.8.

Table 8.7 The level of project complexity

	Hong Kong			**Beijing**		
	N	**Mean**	**S.D.**	**N**	**Mean**	**S.D.**
Project size (contract sum)	33	3.33	1.338	58	3.52	1.301
Project size (GFA)	24	3.50	0.978	56	3.34	1.100
The portion of construction performed by subcontractors	35	**1.91**	0.919	49	**3.00**	0.913
The extent of design at construction start	36	**2.03**	1.158	58	**3.02**	1.162
Design Complexity	56	2.86	0.883	61	2.83	1.093
Construction method complexity	57	2.81	0.972	60	2.92	1.041

Remarks: A larger mean value indicate less complex, i.e. small size of project, small portion conducted by subcontractors, design almost completed, simple for design and construction.

Table 8.8 T-test for equality of project complexity in Hong Kong and Beijing

	T	**df**	**Sig. (2-tailed)**	**Mean Difference**
Project size (contract sum)	-0.642	89	0.523	-0.1839
Project size (GFA)	0.618	78	0.538	0.1607
The portion of construction performed by subcontractors	-5.358	82	***0.000***	-1.0860
The extent of design at construction start	-4.018	92	***0.000***	-0.9890
Design Complexity	0.129	115	0.897	0.0239
Construction method complexity	-0.593	115	0.555	-0.1105

The results showed that a difference of *the portion of construction performed by subcontractors* and *the extent of design at construction start* existed between projects in Hong Kong and Beijing. The results showed that in Hong Kong, most projects were conducted with the fast-track process and involved a lot of subcontracting companies, which increased the complexity to project team communication. In the fast-track process of building projects, information is always insufficient, late, or uncertain because construction usually starts before the design has been completed. This situation manifests itself in communication performance, with more severe communication problems of *information underload*, *untimeliness*, *inaccuracy* in Hong Kong building projects (Section 8.2.1). Other physical characteristics of building projects, which include *project size, design complexity*, and *construction method complexity*, were similar in Hong Kong and Beijing.

Project client experience

The performance of *project client experienc*e in Hong Kong and in Beijing is presented in Tables 8.9. The comparison of the different expertise of *project client experienc*e in Hong Kong and in Beijing was also conducted by employing t-test. The results are shown in Table 8.10.

Table 8.9 Project client experience

	Hong Kong			Beijing		
	N	**Mean**	**S.D.**	**N**	**Mean**	**S.D.**
Client's experience and expertise in building projects	57	3.35	0.896	57	3.43	0.888
Client's ability to well arrange time for design and construction	57	3.16	1.031	57	3.15	0.983
Client’s supporting high quality of requirement information	57	3.32	0.890	57	3.29	0.947

Table 8.10 T-test for equality of project complexity in Hong Kong and Beijing

	T	**df**	**Sig. (2-tailed)**	**Mean Difference**
Client's experience and expertise in building projects	-0.451	112	0.653	-0.07544
Client's ability to well arrange time for design and construction	0.054	112	0.957	0.01018
Client’s supporting high quality of requirement information	0.122	112	0.903	0.02105

As the developers of projects, clients build up the project team and the management environment for team communication. The results showed that all questions of *project client experience* in Hong Kong and Beijing building projects were more than a neutral level of the expertise (value > 3.0). The level of the client expertise was similar Hong Kong and in Beijing.

8.3.2 Factors of management measures – system applied (nominal variables)

Project information technology (IT) applications

This section describes the application scene of some kinds of information technologies (IT) in practice which could improve the performance of project team communication. The application of different kinds of IT techniques ranked from most popular used to the least used (Tables 8.11 and 8.12). Figure 8.1 clearly showed the application status of IT techniques.

Table 8.11 Current applied IT techniques in building projects (Hong Kong)

	Have		Do not have	
	Count	**%**	**Count**	**%**
E-mail	57	100.0%		
Project intranet	34	59.6%	23	40.4%
3-D design drawing	19	33.3%	38	66.7%
On-line chat	9	15.8%	48	84.2%
Video conference	5	8.8%	52	91.2%
4-D simulation construction	3	5.3%	54	94.7%

Table 8.12 Current applied IT techniques in building projects (Beijing)

	Have		Do not have	
	Count	**%**	**Count**	**%**
E-mail	58	93.5%	4	6.5%
Project intranet	21	33.9%	41	66.1%
On-line chat	16	25.8%	46	74.2%
3-D design drawing	8	12.9%	54	87.1%
Video conference	3	4.8%	59	95.2%
4-D simulation construction	1	1.6%	61	98.4%

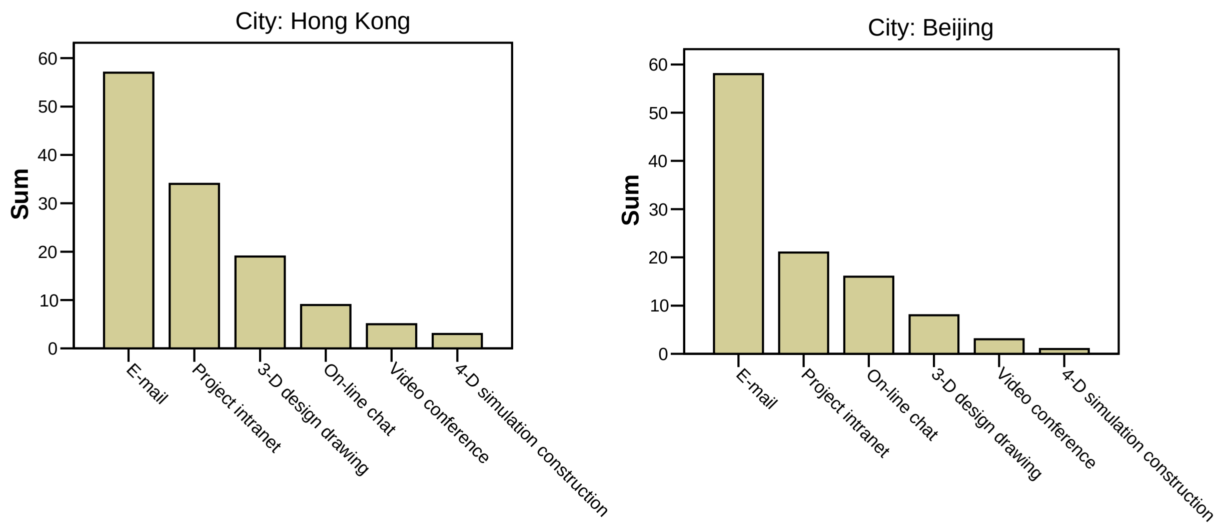

Figure 8.1 Current applied IT techniques in the project

The comparison of the different application scene in Hong Kong and Beijing building projects is shown in Table 8.13.

Table 8.13 Comparison of current applied IT techniques in Hong Kong and Beijing

	Hong Kong	**Beijing**
E-mail	**100.00%**	**93.5%**
Project intranet	**59.60%**	**33.9%**
3-D design drawing	**33.30%**	12.9%
On-line chat	15.80%	25.8%
Video conference	*8.80%*	*4.8%*
4-D simulation construction	*5.30%*	*1.6%*

Figure 8.1 clearly shows that the two most popularly used IT techniques in both Hong Kong and Beijing were *e-mail* and *project intranet*. An *e-mail* system was used by all respondents in projects in Hong Kong. Over 90% of respondents indicated that an *e-mail* system was used in building projects in Beijing. In Hong Kong, Over 50% of respondents indicated that *project intranet* was used in their projects. In Beijing, over

30% of respondents reported that a *project intranet* was applied for project team communication in projects. In Hong Kong, another prevalent IT technique was *3-D design drawing*. Over 30% of respondents in Hong Kong indicated that the technique of *3-D design drawing* was applied. On the other hand, less than 10% of respondents used the IT techniques of *video conference*, and *4-D construction simulation*. This means that these techniques were rarely applied in building projects for project team communication.

When the application scene in Hong Kong and in Beijing was compared, the results showed that IT techniques were more prevalently applied in Hong Kong building projects than in Beijing building projects. The results from interviews should be mentioned here because actual IT usage in Beijing building projects was not the same as the shown data. When conducting follow-up interviews in some projects in Beijing, it was found that most of the IT techniques were applied but not actually used in Beijing building projects. Some of the project participants have the facilities to support email, a project intranet, and on-line chat, but they were used only very occasionally for communication with other participants. Only one of eight projects that the author visited had a real worked project intranet, but even this was not frequently used to circulate project documents among participants. It seems that IT techniques are new approaches in the Beijing construction industry. They are still under developed and their uses and benefits should be more considered in the future in Beijing.

Project organisation management approaches

In this section, the application of the organisation management approaches in practice is examined, including the procurement system used and the application of the other advanced organisation management approaches. Procurement systems applied by clients in Hong Kong building projects and Beijing building projects are shown in Table 8.14.

Table 8.14 The procurement system used in building projects

		Traditional procurement	Design & build	Construction management	Others	Missing	Total
Hong Kong	**Frequency**	38	10	5	-	4	57
	Percent	66.7%	17.5%	8.8%	-	7%	100
Beijing	**Frequency**	46	5	8	2	1	62
	Percent	74.2%	8.1%	12.9%	3.2%	1.6%	100

The most frequently used procurement system in building projects was the traditional procurement system. Previous research shows that the new forms of procurement systems – Design and Build, and Construction Management – have gradually been used more frequently in managing building projects instead of a strict and rigid application of the traditional procurement system. The results of this study indicate that in Hong Kong and Beijing practice, the traditional procurement system is still the predominant procurement method for managing building projects, and that was regarded as a constraint in the next analysis.

This section also describes the application of some kinds of advanced organisational management approaches in practice for improving the project team communication. The application of two kinds of typical management approaches for improving project team communication, *partnering methods* and *formal team building*, are shown in Table 8.15 and Figure 8.2.

Table 8.15 The management approaches applied for improved team communication

		Do not have		**Have**	
		Count	**%**	**Count**	**%**
Hong Kong	Partnering methods	33	57.9%	24	42.1%
	Formal team building	29	50.9%	28	49.1%
Beijing	Partnering methods	48	77.4%	14	22.6%
	Formal team building	28	45.2%	34	54.8%

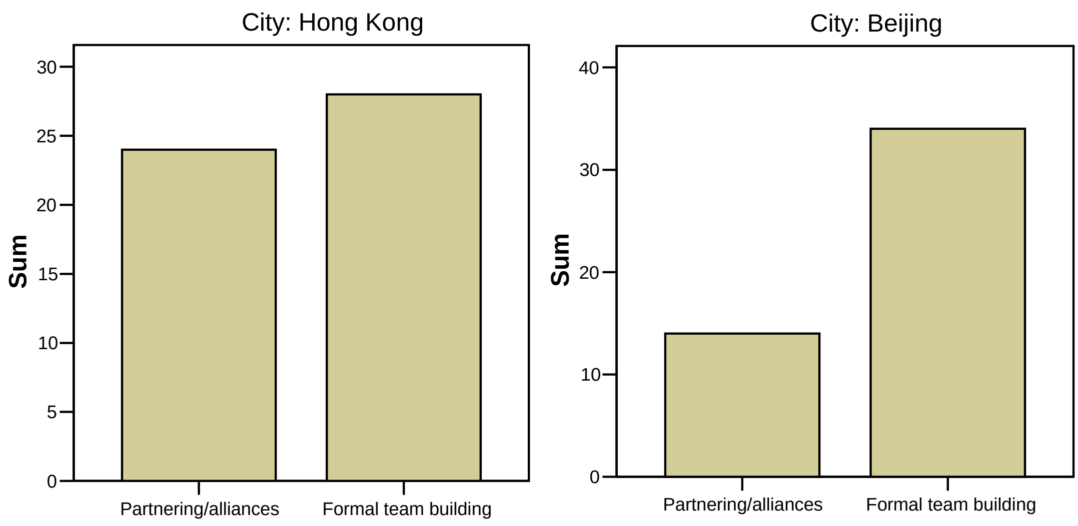

Figure 8.2 The management approaches applied

The percentage of *formal team building* uses was around 50% in both Hong Kong and Beijing. The management approach of partnering, which recently drew much attention from academics and practices, is used to improve project teamwork. In this study, it was used by almost 50% of the respondents in Hong Kong, but only used by just above 20% of respondents in Beijing. This result shows the management level of building projects in Beijing is behind the level in Hong Kong. When conducting follow-up interviews, interviewees from Beijing pointed out *partnering* and *formal team building* were applied but not effectively used in the Beijing building projects. They further stated that these management approaches were advanced. Their benefits and possible uses in the future in building projects in China should be considered.

8.3.3 Factors of management measures – strategies applied (ordinal variables)

Project communication media infrastructure

To manage communication, multiple media should be applied in building projects to facilitate all kinds of communication between participants. The use and the effectiveness of typical communication media used in construction practices are examined.

The usage frequency of different media

The usage of communication media in building projects is ranked from the most frequent to the least (Table 8.16).

Table 8.16 The rank of usage frequency of the media used

Rank	Hong Kong	Mean	Beijing	Mean
1	E-mail	4.38	Telephone	4.63
2	Telephone	4.36	Meeting	4.40
3	Meeting	4.25	Face to face discussion	4.26
4	Post	4.21	Fax	4.10
5	Fax	4.15	*Post*	3.82
6	Face to face discussion	4.00	E-mail	3.82
7	Project intranet	2.26	*Project intranet*	1.34
8	E-conference	0.29	E-conference	0.18
All non-IT		4.19		4.24
All IT		2.31		1.78

The results indicate a clear difference in the frequency of use of each communication medium. *E-mail* was the most frequently used in Hong Kong building projects. But in Beijing, the most frequently used media was *telephone*. The following two most frequently used media in Hong Kong were *telephone*, and *meeting*; and in Beijing the following two were interactive media: meeting and *face to face discussion*. Other IT-based communication media – project intranet and e-conference – were the two least used media in both Hong Kong and Beijing building projects. When all non-IT media and all IT media were compared, the results show the non-IT media were much more frequently used than the IT media. If the frequency of all IT media was compared, Hong Kong has a higher density of use of IT media than Beijing.

The comparison of the frequency of each different medium used in Hong Kong and Beijing building projects was conducted by applying the variance significance test. The results are shown in Table 8.17.

Table 8.17 T-test for equality of using frequency of media in Hong Kong and Beijing

		Sig. (2-tailed)	T	Mean Difference	Mean (HK)	Mean (Beijing)
Hong Kong more frequently used	E-mail	***0.006***	2.726	0.56	4.38	3.82
	Project intranet	***0.015***	2.480	0.93	2.26	1.34
	Post	***0.051***	1.918	0.39	4.21	3.82
Beijing more frequently used	Telephone	***0.046***	-2.055	-0.27	4.36	4.63
	Face to face discussion	***0.106***	-1.629	-0.26	4.00	4.26
No significant difference	Meeting	0.287	-1.069	-0.16	4.25	4.40
	E-conference	0.521	0.645	0.11	0.29	0.18
	Fax	0.729	0.347	0.05	4.15	4.10

There was no statistically significant difference in the usage of meetings, faxes, and e-conferences in Hong Kong and Beijing building projects. However, the variance differences of using *e-mail*, *project intranet*, and *telephone* in Hong Kong and Beijing building projects were significant at the 5% level. The variance differences of using *post* and *face to face discussion* in Hong Kong and Beijing building projects were significant at 0.051 and 0.106 which are also regarded as significant in this context. *E-mail* and *project intranet*, and *post* were more frequently used in Hong Kong building projects. It indicates that IT based media are more frequently used in Hong Kong. These three media are the lean media used to transfer written documents. While in Beijing building projects, two oral and rich media – *telephone* and *face to face discussion* – were more frequently used.

The effectiveness of different media for communication

The effectiveness of communication media for transmitting information and exchanging ideas during building projects were also explored. Table 8.18 illustrates the rank of the effectiveness of media in Hong Kong building projects. Three traditional oral and rich communication media – *face to face discussion, telephone,* and *meeting* – were regarded as more effective than the traditional written communication media i.e. post and fax. Electronic communication media were regarded as having different levels of effectiveness for communication. *E-mail* was the most effective media. *Project intranets* were more effective than the other traditional written media, being *fax* and *post*. *E-conferences* were regarded as the least effective media. It may be due to its limited application, with only five respondents rating the e-conference.

Table 8.18 The rank of the media's effectiveness in communication (Hong Kong)

		Mean	**S.D.**	**Valid**	**Missing**
1	E-mail	4.15	.756	55	2
2	Face to face discussion	4.15	.803	55	2
3	Telephone	4.13	.771	55	2
4	Meeting	3.91	.853	54	3
5	Project intranet	3.85	.834	33	24
6	Fax	3.69	.690	55	2
7	Post	3.67	.834	52	5
8	E-conference	3.20	1.095	5	52

Table 8.19 displays the rank of the effectiveness of media in Beijing building projects. The traditional oral communication media i.e. f*ace to face discussio*n, *telephone,* and *meeting* were also regarded as more effective than traditional written media i.e. post in Beijing building projects. Except for *faxes*, it was ranked as the third most effective in Beijing building projects. Electronic media, which included *e-mail*, *e-conferences*,

and *project intranet* were generally looked at as being less effective in Beijing building projects.

Table 8.19 The rank of the media's effectiveness in communication (Beijing)

		Mean	S.D.	Valid	Missing
1	Face to face discussion	4.28	0.772	60	2
2	Telephone	4.17	0.842	60	2
3	*Fax*	3.92	0.873	60	2
4	Meeting	3.83	0.869	60	2
5	E-mail	3.66	0.969	58	4
6	E-conference	3.62	1.109	4	58
7	*Post*	3.45	0.957	60	2
8	Project intranet	3.41	1.159	21	41

The variance significance test was also conducted to compare the opinions between professionals in two cities and the results are shown in Table 8.20. Except for *e-mail*, the respondents in Hong Kong and Beijing had similar opinions about the effectiveness of each medium for communication. The media are objective tools in the communication process and their attributes could not be significantly influenced by the social and business environment. However, it could be influenced by the application situation. *E-mail* was frequently used in Hong Kong building projects. Its wide application benefits the users and makes them regard it as the most effective media. Although *e-mail* was also used in Beijing building projects, it was not very widely applied in communication between project participants in Beijing building projects. Some project team members, such as contractors and sub-contractors, did not have the facilities to receive email at the construction site.

Table 8.20 T-test for equality of means (media effectiveness) in Hong Kong and Beijing

	T	**df**	**Sig. (2-tailed)**	**Mean Difference**
E-mail	2.947	111	***0.004***	0.48
Fax	-1.563	113	0.121	-0.23
Project intranet	1.606	52	0.145	0.44
Post	1.294	110	0.198	0.22
Face to face discussion	-0.893	113	0.374	-0.13
Video-conference	-0.575	7	0.583	-0.42
Meeting	0.481	112	0.631	0.08
Telephone	-0.312	113	0.756	-0.05

The utility of different media

A variable of utility was calculated. This was the effectiveness of a medium divided by the frequency of a medium (Table 8.21). This variable could improve the understanding of the application status of each medium in practice.

Table 8.21 The utility (effectiveness/frequency) of media

	Hong Kong			**Beijing**		
	Utility	**Effectiveness**	**Frequency**	**Utility**	**Effectiveness**	**Frequency**
Video-conference	***11.03***	3.20	0.29	***20.11***	3.62	0.18
Project intranet	***1.70***	3.85	2.26	***2.54***	3.41	1.34
Face to face discussion	***1.04***	4.15	4.00	1.00	4.28	4.26
E-mail	0.95	4.15	4.38	0.96	3.66	3.82
Telephone	0.95	4.13	4.36	0.90	4.17	4.63
Meeting	0.92	3.91	4.25	0.87	3.83	4.4
Fax	0.89	3.69	4.15	0.96	3.92	4.1
Post	0.87	3.67	4.21	0.90	3.45	3.82

Figure 8.3 and Figure 8.4 clearly display the application status of each media. The media located above the diagonal line were the media whose effectiveness was more than their use (utility > 1). That implies that the industry should pay more attention to

increase their use. While those below the diagonal line were the media which were less effective based on their use. The industry should pay attention to managing their usage and improving their effectiveness for communication. *E-conference* and *project intranet* were located above the diagonal line both in Hong Kong and Beijing building projects. These two kinds of computer-based media were not used frequently in practice but were effective. They should be more widely applied in practice. In Hong Kong, *face to face discussion* was also located above the diagonal line. It was regarded as effective but not used so frequently compared to its functions. *E-mail*, *telephone*, *meeting*, *fax*, and *post* were located below the diagonal line. These media were judged to be less effective based on their usage frequency. The industry should pay more attention on making more effective use of their functions for communication.

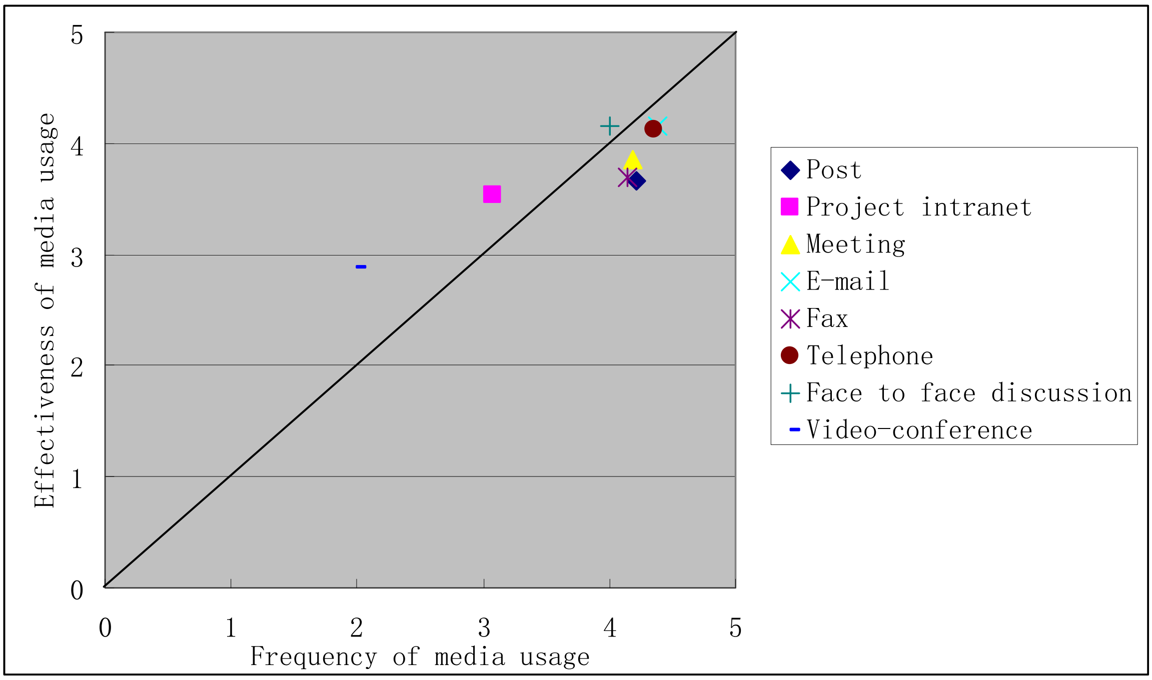

Figure 8.3 The effectiveness/frequency of media (Hong Kong)

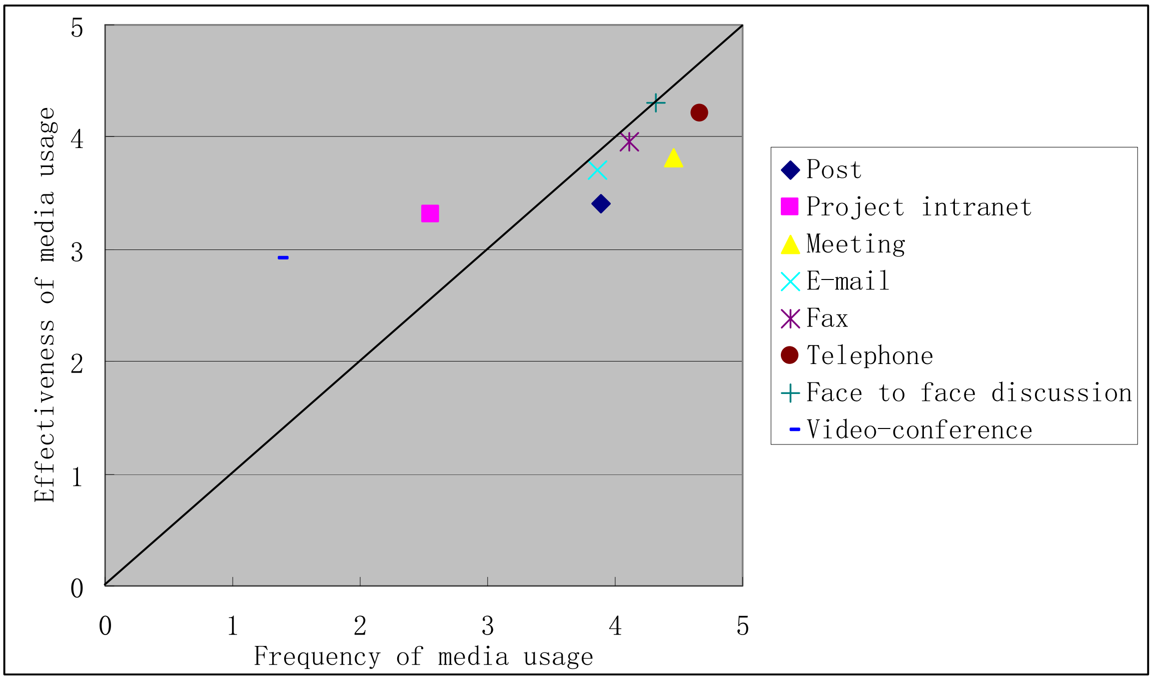

Figure 8.4 The effectiveness/frequency of media (Beijing)

Project information documentation

This section presents the effectiveness of *project information documentation* in the respondent projects in Hong Kong and Beijing (Tables 8.22). These management measures included *protocol for information description* and *project document management system*. A comparison of the different performance of *project information documentation* in Hong Kong and in Beijing was also conducted by employing the t-test. The results are shown in Table 8.23.

Table 8.22 The effectivnes of project information documentation

	Hong Kong			Beijing		
	N	**Mean**	**S.D.**	**N**	**Mean**	**S.D.**
Project document management system	57	3.63	.723	61	3.50	0.923
Protocol for information description	57	3.18	.658	58	2.96	0.931

Table 8.23 T-test for equality of effectiveness of project information documentation in Hong Kong and Beijing

	T	df	Sig. (2-tailed)	Mean Difference
Project document management system	0.886	116	0.378	0.136
Protocol for information description	1.464	113	0.146	0.220

Project information documentation builds up common rules and environments for managing project information produced by different participating organisation. The analysis showed that except for *protocol for information description* all included questions of *project information documentation* in Hong Kong and Beijing building projects were more than the neutral level of effectiveness (value > 3.0). The performance of *protocol for information description* in Beijing building projects was under the neutral level (value < 3.0).

Schedule for communication and information distribution

This section examines the effectiveness of the factor *schedule for communication and information distribution* in practice. The effectiveness of each factors of *schedule for communication and information distribution* in Hong Kong and Beijing building projects is presented in Tables 8.24. The comparison of the different performance of *schedule for communication and information distribution* in Hong Kong and Beijing building projects was conducted by employing the t-test. The results are shown in Table 8.25.

Table 8.24 Effectiveness of schedule for communication and information distribution

	Hong Kong			Beijing		
	N	**Mean**	**S.D.**	**N**	**Mean**	**S.D.**
Schedule for communication and information distribution	57	3.33	0.690	62	3.41	0.966
Contractor updating progress and performance to others	55	3.21	0.716	56	3.43	0.812
Construction team updating design and requirement changes to all construction team members	55	3.22	0.704	56	3.26	0.754

Table 8.25 T-test for equality of effectiveness of schedule for communication and information distribution in Hong Kong and Beijing

	T	**df**	**Sig. (2-tailed)**	**Mean Difference**
Schedule for communication and information distribution	-0.520	117	0.599	-0.081
Construction team updating progress and performance to others	-1.505	109	0.135	-0.219
Constructor updating design and requirement changes to all construction team members	-0.319	109	0.750	-0.044

An agreed schedule should be set up and show when each type of communication and information distribution between participants is conducted. The results of analysis showed that the aspects of *schedule for communication and information distribution* in Hong Kong and Beijing building projects were more than the neutral level of effectiveness (value > 3.0).

Arrangement of organisational structure

Many previous studies stated that organisational communication depends largely on the structural characteristics of an organisation. The practical performance of the organisational structure in Hong Kong and Beijing building projects, and the comparison between these two cities are shown in Tables 8.26 and 8.27.

Table 8.26 Effectiveness of the arrangement of organisational structure

	Hong Kong			**Beijing**		
	N	**Mean**	**S.D.**	**N**	**Mean**	**S.D.**
The structure of project organisation	56	3.61	.802	62	3.98	1.014
The communication and reporting system	56	3.59	.682	61	3.64	1.081
The document distribution structure	57	3.63	.473	62	3.56	.738
Participants' understanding of organisation structure	56	3.80	.644	61	3.82	.903

Table 8.27 T-test for equality of effectiveness of arrangement of organisation structure in Hong Kong and Beijing

	T	**df**	**Sig. (2-tailed)**	**Mean Difference**
The document distribution structure	-2.227	116	***0.028***	-0.378
The structure of project organisation	-0.276	115	0.779	-0.047
The communication and reporting system	0.595	117	0.546	0.068
Participants' understanding of organisation structure	-0.079	115	0.937	-0.012

Arrangement of organisation structure forms the communication system in building projects. The clear and effective *arrangement of organisation structure* is one of major communication factors to improving project communication performance. The results of the description of the effectiveness of *arrangement of organisation structure* showed that this factor was more than the neutral level of effectiveness (value > 3.5) in both Hong Kong and Beijing building projects. The performance of most included questions of *arrangement of organisation structure* was similar in Hong Kong and in Beijing. The performance of *the structure of project organisation* in Beijing building projects was more effective than that in Hong Kong building projects.

Design information with high-quality content

This section describes the quality of *design information with high-quality content* in Hong Kong and Beijing building projects (Table 8.28). *Design information with high-quality content* was measured by three included questions: *accurate and timely design information*, *coordinated design information*, and *high buildability design information*. The comparison of the different performance of the quality of design information in Hong Kong and in Beijing is shown in Table 8.29.

Table 8.28 The quality of design information

	Hong Kong			**Beijing**		
	N	**Mean**	**S.D.**	**N**	**Mean**	**S.D.**
Accurate and timely design information	56	3.23	.934	59	3.47	0.900
Coordinated design information	57	3.19	.766	59	3.38	0.894
High buildability design information	57	3.33	.951	59	3.53	0.850

Table 8.29 T-test for equality of the quality of design information in Hong Kong and Beijing

	T	df	Sig. (2-tailed)	Mean Difference
Accurate and timely design information	-1.403	113	0.163	-0.240
Coordinated design information	-1.207	114	0.230	-0.187
High buildability design information	-1.189	114	0.237	-0.199

*Design information with high-quality conten*t was regarded as critical to project team communication performance. The results showed that all included questions of *design information with high-quality content* in Hong Kong and Beijing building projects were more than the neutral level of the quality (value > 3.0). The performance of all included questions of *design information with high-quality content* was similar in Hong Kong and in Beijing.

Effective procedures for construction work

Effective procedures for construction work in Hong Kong and Beijing building projects is presented in Tables 8.30. The comparison of the different levels of the effectiveness of procedures for construction work in Hong Kong and in Beijing is shown in Table 8.31.

Table 8.30 The effectiveness of procedures for construction work

	Hong Kong			Beijing		
	N	Mean	S.D.	N	Mean	S.D.
Construction work planning and programming	55	3.23	0.722	56	3.53	0.815
Construction work flow procedures defining scope, interfaces and sequence of activities	55	3.16	0.918	56	3.37	0.903

Table 8.31 T-test for equality of effectiveness of procedures for construction work in Hong Kong and Beijing

	T	df	Sig. (2-tailed)	Mean Difference
Construction work planning and programming	-2.045	109	***0.043***	-0.299
Construction work flow procedures defining scope, interfaces and sequence of activities	-1.181	109	0.240	-0.204

Effective procedures for construction work describe how to implement and realise the expected building. The results of describing *effective procedures for construction work* showed that all included questions of *effective procedures for construction work* in Hong Kong and Beijing building projects were more than the neutral level of expertise (value > 3.0). The performance of all included questions of *construction work planning and programming* was slightly different in Hong Kong and in Beijing. Hong Kong construction companies have a good reputation for their professional level. However, the results showed the converse status: in Beijing, *construction work planning and programming* was more effective. But, it may not reflect the real situation. The sample size, the measurement questions and personal judgements can also influence the results.

Social and informal mechanisms for a cooperative working environment

This section describes the effectiveness of *social and informal mechanisms for a cooperative working environment* of the respondent projects in Hong Kong and Beijing (Table 8.32). A comparison of the different performance of *social and* *informal mechanisms for a cooperative working environment* in Hong Kong and in Beijing was conducted and the results are shown in Table 8.33.

Table 8.32 Effectiveness of social and informal mechanisms for a cooperative working environment

	Hong Kong			Beijing		
	N	**Mean**	**S.D.**	**N**	**Mean**	**S.D.**
Procedures for maintaining inter-organisational working relationships	56	3.38	0.906	61	3.50	0.919
Policies for shared work values and project objectives among participants	56	3.52	0.687	62	3.54	0.825
Activities for promoting committed attitudes of participants	57	3.35	0.604	61	3.11	0.799
Interaction for developing inter-personal relationships	57	3.35	0.668	61	3.37	0.899

Table 8.33 T-test for equality of effectiveness of social and informal mechanisms for a cooperative working environment in Hong Kong and Beijing

	T	**df**	**Sig. (2-tailed)**	**Mean Difference**
Procedures for maintaining inter-organisational working relationships	-0.757	115	0.450	-0.128
Policies for shared work values and project objectives among participants	-0.151	116	0.881	-0.021
Activities for promoting committed attitudes of participants	1.842	116	***0.068***	0.241
Interaction for developing inter-personal relationships	-0.132	116	0.896	-0.019

*Social and informal mechanisms for a cooperative working environmen*t manages the human aspects of project team communication. The results showed that, all aspects of *social and informal mechanisms for a cooperative working environment* in Hong Kong and Beijing building projects were more than the neutral level of performance (value > 3.0). The results of comparison showed that the performance of *activities for promoting committed attitudes of participants* in Beijing building projects was less effective than in Hong Kong.

Capable project managers

The performance of *capable construction project managers* in Hong Kong and Beijing building projects are presented in Tables 8.34. The results of the comparison of the different performance of these project managers' capacity in Hong Kong and in Beijing are presented in Table 8.35.

Project managers are regarded as coordinators with other participants to coordinate work from different participants, smooth information flow between participants, and maintain good inter-organisational relationships. The results showed that all included questions of *capable project manages* in Hong Kong and Beijing building projects were more than the neutral level of expertise (value > 3.0). The results of comparison showed that some aspects of project managers' capacities had different performance in Hong Kong and Beijing building projects. The overall performance of construction project manager's capacity was better in Beijing building projects than in Hong Kong building projects.

Table 8.34 The capacity of project managers

	Hong Kong			Beijing		
	N	Mean	S.D.	N	Mean	S.D.
Construction team leader's Professional technical skills	55	3.60	0.852	56	3.45	1.021
Construction team leader's Knowledge of other disciplines	55	**3.56**	0.856	54	3.29	0.865
Construction team leader's A good information gatekeeper to control information flow	54	3.22	0.861	53	3.29	0.896
Construction team leader's Communication skill	55	3.44	0.834	54	**3.90**	0.757
Construction team leader's Early and continued engagement in the project	55	3.64	0.910	55	**4.02**	0.978
Construction team leader's Working relationship with others	55	3.55	0.812	54	**3.81**	0.793
Construction team leader's Stability of this team leader	55	3.69	0.836	55	**4.10**	0.794
Client representative's Professional technical skills	54	3.50	0.863	56	3.33	1.073
Client representative's Knowledge of other disciplines	54	**3.46**	0.862	55	3.15	0.823
Client representative's Communication skill	54	3.59	0.740	54	3.77	0.822
Client representative's Working relationship with others	54	3.52	0.746	54	3.73	0.734
Client representative's Stability of this team leader	53	3.70	0.822	54	3.94	0.850
Design team leader's Professional technical skills	49	3.51	0.960	59	3.78	0.859
Design team leader's Knowledge of other disciplines	49	3.27	0.995	59	3.47	0.943
Design team leader's Communication skill	49	3.55	0.843	58	3.67	0.820
Design team leader's Working relationship with others	48	3.46	0.874	59	3.65	0.818
Design team leader's Stability of this team leader	49	3.53	0.868	58	**3.89**	0.947

Table 8.35 T-test for equality of the capacity of project managers in Hong Kong and Beijing

	T	df	Sig. (2-tailed)	Mean Difference
Construction team leader's Professional technical skills	0.835	109	0.406	0.149
Construction team leader's Knowledge of other disciplines	1.690	107	***0.094***	0.278
Construction team leader's A good information gatekeeper to control information flow	-0.386	105	0.701	-0.066
Construction team leader's Communication skill	-3.062	107	***0.003***	-0.467
Construction team leader's Early and continued engagement in the project	-2.119	108	***0.036***	-0.382
Construction team leader's Working relationship with others	-1.721	107	***0.088***	-0.265
Construction team leader's Stability of this team leader	-2.656	108	***0.009***	-0.413
Client representative's Professional technical skills	0.935	108	0.352	0.174
Client representative's Knowledge of other disciplines	1.956	107	***0.053***	0.316
Client representative's Communication skill	-1.175	106	0.243	-0.177
Client representative's Working relationship with others	-1.468	106	0.145	-0.209
Client representative's Stability of this team leader	-1.525	105	0.130	-0.247
Design team leader's Professional technical skills	-1.527	106	0.130	-0.267
Design team leader's Knowledge of other disciplines	-1.113	106	0.268	-0.208
Design team leader's Communication skill	-0.707	105	0.481	-0.114
Design team leader's Working relationship with others	-1.150	105	0.253	-0.189
Design team leader's Stability of this team leader	-2.055	105	***0.042***	-0.364

8.4 SUMMARY OF THE CHAPTER

This chapter reports the results of the descriptive analysis undertaken on the data of communication indicators and communication factors in building projects. By analysing data collected from the empirical questionnaires survey, the level of project team communication performance in current Hong Kong and Beijing building projects were examined and compared. The weights of eight criteria, including *inaccuracy, untimeliness, misunderstanding, barriers, information underload, information overload, information distortion, and information gatekeeping* were calculated for setting up an overall score of team communication effectiveness in a project (PCE). The eight indicators and computed PCE scores will be used for analysing the impacts of the communication factors on project team communication performance in the next chapter. Finally, the practical situations and performance of communication factors in Hong Kong and Beijing building projects were also described and compared. The next chapter will continue to present the data analysis results which focus on analysing the communication factors' impacts on project team communication performance.

CHAPTER 9. IMPACTS OF COMMUNICAITON FACTORS ON COMMUNICATION PERFORMANCE

9.1 INTRODUCTION

This chapter reports the results of the statistical analysis of the impacts of the communication factors on the project team communication performance. First, the variables of communication factors which had significant impacts on project team communication effectiveness were selected by applying regression analysis from 60 original variables solicited in the questionnaire. Reliability and validation of the factors and their selected associated variables were further tested by calculating the Cronbach's Alpha and applying Factor Analysis. Second, the correlation analysis method was applied to analyse the impacts of eight selected communication factors on the project team communication performance indicators. Based on an understanding of the impacts of the communication factors, the project participants can effectively manage the communication factors to enhance the performance of project team communication in the future.

9.2 THE SELECTION OF VARIABLES IN THE APPLICATION OF ANALYSING COMMUNICATION FACTORS' IMPACTS

The significant variables of communication factors were selected before analysing the impacts of the communication factors on the project team communication performance. The impacts of the communication factors on the project team communication performance in practice were further explored in the empirical questionnaire survey. The statistical significance of each variable of factors' impacts on the project team communication effectiveness was firstly analysed by applying regression analysis. Some variables that had a significant impact on project team communication effectiveness in practice were selected. The reliability and validation of the framework of factors and their associated variables were assessed by using Cronbach's Alpha and Factor Analysis. Ten communication factors with selected variables were then put into an analysis of their impacts on the project team communication performance indicators in the next stage.

9.2.1 The significant variables of the communication factors in the empirical study

To select variables of factors having statistically significant influence on the project team communication performance in practice, the relationship of each explored variable with the overall score of project team communication effectiveness was analysed. Totally, the 60 original variables of the factors were investigated in the questionnaire survey in the empirical study. The relationships of each variable with the overall score of project team effectiveness were examined by applying regression analysis. It should be mentioned that relatively objective relationships exist between factors and communication performance. Therefore, data from Hong Kong and Beijing were all inputted to analyse the significance of the factors to the communication performance in this study. These linear correlation coefficients are listed in Table 9.1. If the coefficients between the variables of factors and the overall score of project team communication effectiveness (PCE) were significant, the coefficients were flagged with an asterisk (*) or (**).

Table 9.1 The correlation coefficients of variables of the communication factors with PCE

		Project team communication effectiveness (PCE)
F1	**Project complexity**	
1	*Project size (contract sum)*	*-0.133*
2	*Project size (GFA)*	*-0.091*
3	*The portion of construction performed by subcontractors*	*0.143*
4	*The extent of design at construction start*	*0.230*
5	*Design Complexity*	*-0.037*
6	*Construction method complexity*	*-0.123*
F2	**Project client experience**	
7	Client's ability to well arrange time for design and construction	**.283(**)**
8	Client's experience and expertise in building projects	**.359(**)**
9	Client's supporting high quality of requirement information	**.338(**)**
F3	**Project communication media infrastructure**	
10	*Project intranet (frequency)*	*-0.098*
11	*Project intranet (effectiveness)*	*0.031*
12	*E-mail (frequency)*	*-0.092*
13	*E-mail (effectiveness)*	*0.009*
14	*Fax (frequency)*	*-0.088*
15	*Fax (effectiveness)*	*0.125*
16	*Meeting (frequency)*	*0.069*
17	Meeting (effectiveness)	**.224(*)**
18	Post (frequency)	*0.056*
19	Post (effectiveness)	**.220(*)**
20	*Face to face discussion (frequency)*	*0.001*
21	*Face to face discussion (effectiveness)*	*0.017*
22	*Telephone (frequency)*	*0.082*
23	*Telephone (effectiveness)*	*0.079*
24	*E-conference (frequency)*	*0.134*
25	*E-conference (effectiveness)*	*0.201*

		Project team communication effectiveness (PCE)
F4	**Arrangement of organisation structure**	
26	The structure of project organisation	**.385(**)**
27	The communication and reporting system	**.388(**)**
28	The document distribution structure	**.401(**)**
29	*Participants' understanding of organisation structure*	**.248(**)**
F5	**Project information documentation**	
30	Protocols for information description	**.221(*)**
31	Project document management system	**.295(**)**
F6	**Schedule for Communication and Information Distribution**	
32	Schedule for communication and information distribution	**.276(**)**
33	Construction team updating progress and performance to others	**.503(**)**
34	Contractor updating design and requirement changes to all construction team members	**.455(**)**
F7	**Procedure for construction work**	
35	Construction work planning and programming	**.433(**)**
36	Construction work flow procedures defining scope, interfaces and sequence of activities	**.365(**)**
F8	**Design information**	
37	Accurate and timely design information	**.355(**)**
38	Coordinated design information	**.394(**)**
39	High buildability design information	**.322(**)**
F9	**Capable project managers**	
40	Construction project manager's Professional technical skills	**.321(**)**
41	Construction project manager's Knowledge of other disciplines	**.212(*)**
42	Construction project manager's A good information gatekeeper	**.313(**)**
43	Construction project manager's Communication skill	**.336(**)**
44	Construction project manager's Engagement in the project	**.307(**)**
45	Construction project manager's Working relationship with others	**.267(**)**
46	Construction project manager's Stability of this team leader	**.291(**)**
47	Client representative's Professional technical skills	**.403(**)**
48	Client representative's Knowledge of other disciplines	**.212(*)**
49	Client representative's Communication skill	**.294(**)**
50	Client representative's Working relationship with others	**.323(**)**
51	Client representative's Stability of this team leader	**.255(**)**
52	Design team leader's Professional technical skills	**.322(**)**
53	Design team leader's Knowledge of other disciplines	**.292(**)**
54	Design team leader's Communication skill	**.228(*)**
55	Design team leader's Working relationship with others	**.332(**)**
56	Design team leader's Stability of this team leader	**.257(**)**

		Project team communication effectiveness (PCE)
F10	**Social and informal mechanisms for cooperation working environment**	
57	Procedures for maintaining inter-organisational working relationships	**.442(**)**
58	Policies for shared work values and project objectives among participants	**.441(**)**
59	Activities for promoting committed attitudes of participants	**.362(**)**
60	Interaction for developing inter-personal relationships	**.362(**)**

** means the relationship is significant at the 5% level, ** means the relationship is significant at the 1% level*

Through analysing the relationship between each variables of the communication factor and the PCE, it was found that 40 variables had a significant linear relationship with the score of project team communication effectiveness, indicating that the data of these variables are significantly related to the communication performance in practice (Table 9.1). The statistical relationships of other variables of factors with project team communication effectiveness were not reflected by the data collected from the empirical study (Table 9.1). Therefore, these variables were excluded from the factors list. The included and excluded variables which were inputted into the following analysis are listed in Table 9.2

Table 9.2 The include and exclude variables of communication factors

	Variable included
F2	**Project client experience**
1	Client's ability to well arranged time for design and construction
2	Client's experience and expertise in building projects
3	Client's supporting high quality of requirement information
F3	**Project communication media infrastructure**
4	Meeting (effectiveness)
5	Post (effectiveness)

F4	**Arrangement of organisation structure**
6	The structure of project organisation
7	The communication and reporting system
8	The document distribution structure
9	Participants’ understanding of organisation structure
F5	**Project information documentation**
10	Protocols for information description
11	Project document management system
F6	**Schedule for Communication and Information Distribution**
12	Schedule for communication and information distribution
13	Construction team updating progress and performance to others
14	Contractor updating design and requirement changes to all construction team members
F7	**Procedure for construction work**
15	Construction work planning and programming
16	Construction work flow procedures defining scope, interfaces and sequence of activities
F8	**Design information**
17	Accurate and timely design information
18	Coordinated design information
19	High buildability design information
F9	**Capable project managers**
20	Construction project manager’s Professional technical skills
21	Construction project manager’s Knowledge of other disciplines
22	Construction project manager’s A good information gatekeeper
23	Construction project manager’s Communication skill
24	Construction project manager’s Engagement in the project
25	Construction project manager’s Working relationship with others
26	Construction project manager’s Stability of this team leader
27	Client representative’s Professional technical skills
28	Client representative’s Knowledge of other disciplines
29	Client representative’s Communication skill
30	Client representative’s Working relationship with others
31	Client representative’s Stability of this team leader
32	Design team leader’s Professional technical skills
33	Design team leader’s Knowledge of other disciplines
34	Design team leader’s Communication skill
35	Design team leader’s Working relationship with others
36	Design team leader’s Stability of this team leader
F10	**Social and informal mechanisms for cooperation working environment**
37	Procedures for maintaining inter-organisational working relationships
38	Policies for shared work values and project objectives among participants
39	Activities for promoting committed attitudes of participants
40	Interaction for developing inter-personal relationships

	Variable excluded
F1	**Project complexity**
1	*Project size (contract sum)*
2	*Project size (GFA)*
3	*The portion of construction performed by subcontractors*
4	*The extent of design at construction start*
5	*Design Complexity*
6	*Construction method Complexity*
F3	**Project communication media infrastructure**
7	*Project intranet (frequency)*
8	*Project intranet (effectiveness)*
9	*E-mail (frequency)*
10	*E-mail (effectiveness)*
11	*Fax (frequency)*
12	*Fax (effectiveness)*
13	*Meeting (frequency)*
14	*Post (frequency)*
15	*Face to face discussion (frequency)*
16	*Face to face discussion (effectiveness)*
17	*Telephone (frequency)*
18	*Telephone (effectiveness)*
19	*E-conference (frequency)*
20	*E-conference (effectiveness)*

9.2.2 The validation of the communication factors framework

The remained factors and their associated variables were then analysed by applying a Factor Analysis to test the structure and validation of the communication factors. The variables of communication factors were related to each other. Factor Analysis was performed to group these interrelated variables into a smaller number of underlying factors (Chan, 1996) and test the validation of the original communication factor category structure. The original research design solicited 60 variables of 10 ordinal communication factors among which the data of 40 variables showed significant to project team communication effectiveness in the empirical survey. These 40 variables of communication factors were then input to the Factor Analysis process to test the suitability of the original categories of factors. It should be pointed out that objective relationships exist between the factors. Data from Hong Kong and Beijing was therefore all put into Factor Analysis process.

1. Evaluating the appropriateness of employing Factor Analysis

In considering the use of Factor Analysis, the appropriateness of the factor model must first be evaluated. This can be achieved through the Kaiser-Meyer-Olkin (KMO) measuring sampling adequacy and Bartlett's test to ensure the data matrix has sufficient correlations.

The results of KMO and Bartlett's Test are shown in Table 9.3. Kaiser (1974) recommended that values of KMO greater than 0.6 are suitable. The KMO measure of sampling adequacy was 0.757 which, as indicated in Table 9.3, was mediocre but acceptable. The value of the Bartlett's test of sphericity was 2397.205 and the associated significance level was small, so it appeared unlikely that the population correlation matrix was an identity. Since the model met the requirements of both the KMO measure and Bartlett's test of sphericity, the Factor Analysis was considered an appropriate statistical method.

Table 9.3 KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.757
Bartlett's Test of Sphericity	Approx. Chi-Square	2397.205
	df	780
	Sig.	.000

2. Factor extraction

The extraction of the factors was then carried out to determine how many dimensions there are (Norusis, 1993a). The aim of factor extraction is to determine and test the underlying factors. Principal components analysis was used to identify the underlying factors. To determine and find the number of factors to use in a model, one criterion was used which suggests that only factors that account for variances greater than one should be included. The percentage of total variance explained by each was examined. The total variance is the sum of the variance of each variable. Table 9.4 shows that almost 72.2% of the total variance is attributable to the first 8 factors that account for variances greater than one. The remaining 32 factors together account for only 27.8% of the total variance. Thus, a model with 8 factors is adequate to represent the data.

A scree plot was also protracted to confirm the number of the extracted factors. Figure 9.1 is a scree plot of total variance associated with each factor. The plot shows a distinct break between the steep slope of the large factors and the gradual trailing off of the rest. The figure confirmed that an 8-factor model should be sufficient for the research model.

Table 9.4 Total variance explained of Factor extracted

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	14.131	35.328	35.328	14.131	35.328	35.328	5.484	13.710	13.710
2	3.231	8.078	43.405	3.231	8.078	43.405	5.021	12.552	26.262
3	2.934	7.336	50.741	2.934	7.336	50.741	4.845	12.114	38.376
4	2.702	6.755	57.496	2.702	6.755	57.496	3.755	9.388	47.763
5	1.875	4.687	62.183	1.875	4.687	62.183	3.154	7.885	55.648
6	1.523	3.809	65.992	1.523	3.809	65.992	2.855	7.137	62.785
7	1.423	3.558	69.550	1.423	3.558	69.550	2.213	5.533	68.319
8	1.066	2.665	72.215	1.066	2.665	**72.215**	1.558	3.896	72.215
9	.996	2.491	74.705						
10	.936	2.340	77.045						
11	.885	2.213	79.258						
12	.790	1.975	81.234						
13	.639	1.597	82.831						
14	.616	1.540	84.370						
15	.599	1.499	85.869						
16	.514	1.286	87.155						
17	.492	1.231	88.386						
18	.489	1.222	89.608						
19	.441	1.103	90.711						
20	.398	.995	91.706						
21	.367	.918	92.624						
22	.349	.872	93.496						
23	.334	.835	94.331						
24	.289	.722	95.053						
25	.269	.673	95.727						
26	.244	.609	96.336						
27	.216	.539	96.875						
28	.185	.463	97.338						
29	.157	.393	97.731						
30	.140	.350	98.082						
31	.129	.322	98.403						
32	.119	.297	98.700						
33	.110	.276	98.976						
34	.090	.224	99.200						
35	.082	.206	99.406						
36	.073	.183	99.589						
37	.058	.145	99.734						
38	.050	.125	99.859						
39	.033	.082	99.941						
40	.024	.059	100.000						

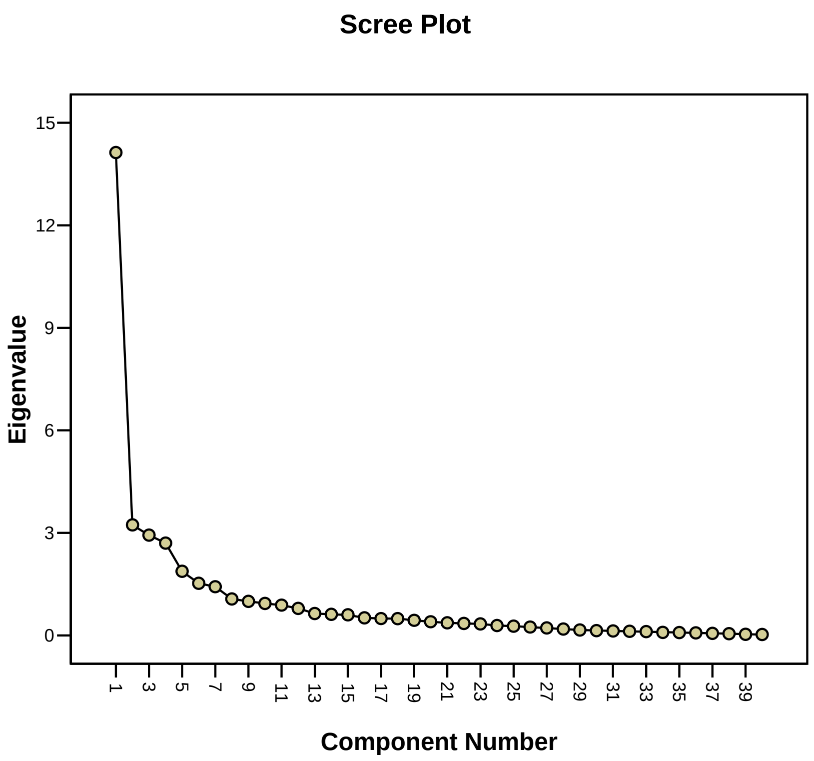

Figure 9.1 Scree plot for the extracted factors

3. Rotating the factors

The rotation of the factors was conducted after extracting factors to achieve the simple and meaningful factor structure. The rotation of the factors is the other important step in a Factor Analysis. It is performed to obtain a clearer picture of what these dimensions (or factors) represent (Norusis, 1993a). Since the purpose of Factor Analysis is to group variables into the underlying factors, it is important that the generated factors are meaningful.

Varimax orthogonal rotation of principal component analysis was used to rotate for easily interpretation of the extracted factors. An unrotated principal component analysis factor matrix indicates only the relationship between individual factors and the variables, and sometimes it is difficult to interpret the pattern. Rotation techniques, such as the varimax method, transform the factor matrix produced from an unrotated principal component matrix into one that is easier to interpret. The factor grouping based on varimax rotation is shown in Table 9.5.

The communication factors structures which included the factors and associated variables are shown in Table 9.5. Factor loading gives the correlation between variables and factors. In this study, a criterion of the factor loading of 0.40 was used as a cut-off for significance. Table 9.5 shows that most of the variables weigh heavily on to one of the factors, and the loading on each factor exceeds 0.4. However, anomalous variables existed when compared to the original factor structure. Some of variables weighed heavily onto more than one factor and some variables were grouped to a factor different to the original one. The reason may be the inappropriateness of the original structure, ambiguous descriptions of variables, or the limited data collected to test the factor structure. In this study, the factor structure was revised. Some variables fell into a factor different to the original one after Factor Analysis, such as *capable client representative* and *capable design team leader* fell into the revised categorised factors of *project client experience* and *designer expertise* respectively. S*chedule for communication and information distribution* were put into the revised categorised factor, *project document management*. *Construction team updating progress and performance to others* and *contractor updating design and requirement changes to all construction team members* were put in the revised

Table 9.5 Rotated component matrix using varimax orthogonal rotation (loading)

	1	2	3	4	5	6	7	8
Design team leader: Knowledge of other disciplines	**0.8382**	0.0435	0.2339	0.0416	-0.0722	0.0303	-0.0424	0.1932
Design team leader: Communication skill	0.8013	0.1326	0.1741	0.0742	0.1686	0.0389	-0.1514	0.0536
Design team leader: Working relationship with others	0.7799	0.1914	0.0702	0.2760	-0.0018	-0.0694	0.0195	0.0826
Design team leader: Professional technical skills	0.7715	0.1561	0.1767	0.0091	0.2284	0.2862	0.0472	0.1550
Designer's ability to supply: Accurate and timely design information	0.7327	0.0888	0.0959	0.1352	0.2661	0.3365	0.1784	0.0026
Designer's ability to supply: Coordinated design information	0.7197	0.0649	0.0213	0.2560	0.1603	0.2789	0.1782	-0.1979
Design team leader: Stability of this team leader	0.6735	0.1584	0.2995	0.2103	-0.0625	-0.1772	0.1282	-0.2532
Designer's ability to supply: High buildability design information	0.6113	0.2070	0.1366	0.1061	0.1915	0.3405	0.3066	-0.1244
Client representative: Professional technical skills	0.0788	**0.8263**	0.0938	0.1869	0.0667	0.1199	0.0480	0.0548
Client: Experience and expertise in building projects	0.0882	0.7698	0.1506	0.0581	0.2664	0.2154	0.0597	0.1280
Client representative: Knowledge of other disciplines	0.1852	0.7151	0.1430	-0.0541	0.0036	-0.1708	0.3255	0.1640
Client representative: Stability of this team leader	0.1502	0.7131	0.2733	0.0082	-0.2740	0.1908	-0.1178	-0.1225
Client representative: Working relationship with others	0.1644	0.7102	0.2325	0.2422	-0.1056	0.0831	0.0607	-0.1286
Client representative: Communication skill	0.1711	0.6886	0.1772	0.2378	0.3291	-0.0561	-0.0746	-0.2095
Client: Supporting high quality of requirement information	0.0007	0.5936	0.0532	0.2184	0.5170	0.1812	0.1930	0.1205
Client: Ability to well arranged time for design and construction	0.1955	0.5830	-0.0092	0.0589	0.3975	0.2554	0.0930	0.1452
Construction project manager: Stability of this team leader	0.0956	0.0041	**0.8048**	-0.0252	0.1595	0.2423	0.0150	0.0787
Construction project manager: Engagement in the project	0.1625	0.2230	0.7502	0.0053	0.1666	0.0383	-0.0664	-0.1532
Construction project manager: Knowledge of other disciplines	0.1145	0.2079	0.7206	0.1349	-0.0322	-0.0017	0.3670	0.0440
Construction project manager: Professional technical skills	0.1940	0.2432	0.6715	0.0941	0.0601	0.1174	0.0741	0.3621
Construction project manager: Communication skill	0.1335	0.1998	0.6686	0.1561	0.3783	0.1587	0.0641	-0.0684
Construction project manager: Working relationship with others	0.1993	0.2290	0.6427	0.3186	0.2319	-0.0910	-0.1892	-0.0247
Construction project manager: A good information gatekeeper	0.2476	0.0286	0.6149	0.0797	0.0436	0.0254	0.1787	0.3248

	1	2	3	4	5	6	7	8
Interaction for developing inter-personal relationship	0.2247	0.1174	-0.0133	**0.7867**	0.1773	0.0959	-0.0246	-0.1027
Procedures for maintaining inter-organisational working relationships	0.2667	0.0257	0.1431	0.7398	-0.0296	0.0575	0.1121	0.0345
Activities for promoting committed attitudes of participants	0.1323	0.1504	0.1315	0.7373	0.1222	0.0703	0.2487	0.2271
Policies for shared work values and project objectives among participants	0.0480	0.2559	0.1787	0.5748	0.0016	0.2671	0.0748	0.2392
The document distribution structure	0.0104	0.2565	0.0062	0.5504	0.1211	0.4714	0.4134	0.1575
The communication and reporting system	0.1317	0.3685	0.0572	0.5418	0.1596	0.4861	0.1333	0.1138
Contractor: Construction work flow procedures defining scope, interfaces and sequence of activities	0.2011	0.0320	0.4567	0.0508	**0.7562**	0.1400	0.0325	0.0330
Contractor: Construction work planning and programming	0.2531	0.2849	0.4763	0.0722	0.6149	0.1615	0.2189	0.1040
Contractor: Construction team updating progress and performance to others	0.2772	0.1366	0.2771	0.3949	0.5920	0.1661	0.2431	-0.0743
Contractor: Contractor updating design and requirement changes to all construction team members	0.4400	0.1383	0.2570	0.1213	0.4951	0.2104	0.2154	0.1763
The structure of project organization	0.2719	0.1099	0.1659	0.2709	0.1719	**0.7304**	0.0136	0.0337
Participants’ understanding of organization structure	0.1373	0.1418	0.1119	0.0918	0.1021	0.7221	0.0475	0.0174
Protocols for information description	0.0944	0.1496	0.0029	0.1545	0.1160	-0.0258	**0.7578**	0.1417
Project document management system	0.0548	-0.0505	0.3139	0.3046	0.1965	0.3533	0.6248	-0.0482
Schedule for communication and information distribution	0.1686	0.3500	0.2013	0.1879	0.3269	0.3455	0.4037	0.1235
Post (effectiveness)	-0.0094	-0.0684	0.0972	0.3142	0.2949	-0.0301	0.2451	**0.6542**
Meeting (effectiveness)	0.1282	0.2010	0.3637	0.1308	-0.2457	0.3452	-0.0204	0.5137

categorised factor, *contractor expertise*. Some variables such as *the document distribution structure*, and *the communication and reporting system* still remained in the original categorised factor because the substantial meaning of the variable is more essential than the statistical analysis results.

9.2.3 Reliability test for the consistency of communication factors

Prior to using the 40 variables for further statistical analysis, there is a need to test the internal consistency of the component variables. Therefore, a reliability assessment was performed to test internal consistency of the component variables.

Cronbach's alpha was adopted to test the consistence of the 40 variables. Cronbach's alpha is a coefficient of reliability to measure how well a set of items (or variables) measures a single unidimensional latent construct. The Cronbach's coefficient alpha greater than 0.7 indicated there was high consistency among the items. The Cronbach's coefficient alpha of all included 40 variables greater than 0.7, which indicate that the 5-point Likert scale used is reliable. The Cronbach's coefficient alpha for almost all categorised factor group were greater than 0.7, which indicated there was high consistency among the variables of each categorised communication factors. The Cronbach's coefficient alpha for the categorised factors of *project communication media infrastructure* and *project document management* didn’t reach 0.7, which indicates insufficient consistent of the variables included for these two factors.

Table 9.6 Cronbach's Alpha to test internal consistency

	Cronbach's Alpha	N of Items
All 40 variables	.951	40
Project client experience	.901	8
Project communication media infrastructure	.476	2
Arrangement of organisation structure	.816	4
Project document management	.671	3
Designer's expertise	.924	8
Contractor's expertise	.877	4
Social and informal mechanisms for a collaborative working environment	.828	4
Capable construction project manager	.885	7

9.2.4 The communication factors

After a set of statistical analyses, 8 communication factors were selected for the following analysis of their impacts on the project team communication performance. Figure 9.2 and Table 9.7 show the revised factor structure which could be put into the following analysis. Eight underlying factors were established and were then fed into the following correlation analysis as independent variables. These eight factors include *project client experience, project communication media infrastructure, project document management, arrangement of organisation structure, contractor expertise, designer expertise, social and informal mechanisms for a cooperative working environment,* and *capable construction project manager*.

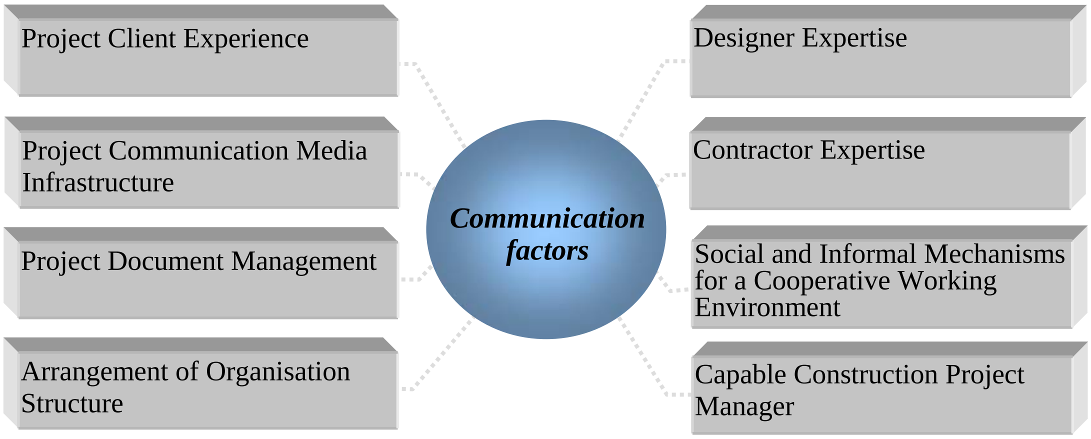

Figure 9.2 Revised independent variables: communication factors

Table 9.7 Revised factors and their included variables

Project client experience
Client's ability to well arranged time for design and construction
Client's experience and expertise in building projects
Client's supporting high quality of requirement information
A capable client representative (Professional technical skills, Knowledge of other disciplines, Communication skill, Working relationship with others, Stability of this team leader)
Project communication media infrastructure
Meeting (effectiveness)
Post (effectiveness)
Arrangement of organisation structure
The structure of project organisation
The communication and reporting system
The document distribution structure
Participants' understanding of organisation structure
Project document management
Protocols for information description
Project document management system
Schedule for communication and information distribution
Designer expertise
Accurate and timely design information
Coordinated design information
High buildability design information
A capable design team lead (Professional technical skills, Knowledge of other disciplines, Communication skill, Working relationship with others, Stability of this team leader)

Contractor expertise
Construction work planning and programming
Construction work flow procedures defining scope, interfaces and sequence of activities
Construction team updating progress and performance to others
Contractor updating design and requirement changes to all construction team members
Capable construction project manager
Construction project manager’s Professional technical skills
Construction project manager’s Knowledge of other disciplines
Construction project manager’s A good information gatekeeper
Construction project manager’s Communication skill
Construction project manager’s Engagement in the project
Construction project manager’s Working relationship with others
Construction project manager’s Stability of this team leader
Social and informal mechanisms for cooperation working environment
Procedures for maintaining inter-organisational working relationships
Policies for shared work values and project objectives among participants
Activities for promoting committed attitudes of participants
Interaction for developing inter-personal relationships

Project Client Experience

Project client experience was identified as a critical communication factor. To explore the impacts of project client experience on the communication performance, this factor was measured by the variables *client’s experience and expertise in building projects*, *client’s ability to well arrange time for design and construction*, *client’s supporting high quality of requirement information*, and a capable client representative (including 5 variables). The statistical analysis of each included variable’s impact on the project team performance showed that all include variables had a significant relationship with project team communication effectiveness.

Project Communication Media Infrastructure

Project communication media infrastructure was identified as a critical communication factor. The infrastructure of communication media in a project is set up by the different kinds of media to facilitate communication between project participants. To explore the impacts of media on the communication performance, this factor included several variables to measure the usage frequency and the effectiveness of telephone, meetings, face to face discussion, post, fax, e-mail, project intranet, and e-conference. However, the statistical analysis of each variable's impact on project team communication effectiveness showed that only two variables, the effectiveness of meetings and the effectiveness of post, had a significant relationship with the project team communication effectiveness. Most variables of this factor did not have a statistically significant relationship with the project team communication effectiveness. It may be due to the weakness of the measurement of media and the limited data collected by the empirical questionnaire.

Arrangement of Organisation Structure

Arrangement of organisation structure was identified as a critical communication factor. To explore the impact on the communication performance, the factor of *arrangement of organisation structure* was measured by four variables, which were *the structure of project organisation, the communication and reporting system, the document distribution structure* and *participants' understanding of organisation structure*. The statistical ssanalysis indicated that all included variables had a significant relationship with the project team communication effectiveness.

Project Document Management

Project document management was identified as a critical communication factor to the project team communication performance. In order to examine the impacts of this factor's impact on the communication performance, three variables were explored, which were *protocol for information description*, *project document management system*, and *schedule for communication and information distribution*. The statistical analysis showed that all the variables had a significant relationship with project team communication effectiveness.

Designer Expertise

An expert design team was critical to the project team communication performance. Their provided design information, such as drawings and specifications is the basic input information for implementing construction activities at the construction stage. The factor of *designer expertise* was measured by four variables which were *accurate and timely design information*, *coordinated design information*, *high buildability design information*, and *a capable design team leader* (measured by 5 sub-variables). The statistical analysis of each variable's impact on project team communication effectiveness showed that all the variables had a significant relationship with the project team communication effectiveness.

Contractor Expertise

Contractor expertise was identified as critical factors to the project team communication performance. To explore this factor's impacts on the project team communication performance, the factor of *contractor expertise* was described by the variables *construction work planning and programming*, *construction work flow procedures defining scope, interfaces and sequence of activities, contractor updating design and requirement changes to all construction team member*s, and *construction team updating progress and performance to others*. The statistical analysis of each included variable's impact on the project team performance showed that they all had a significant relationship with project team communication effectiveness

Social and Informal Mechanisms for a Cooperative Working Environment

The *social and informal mechanisms for a cooperative working environment* was identified as a critical communication factor. This factor included four predominant variables: *procedures for maintaining inter-organisational working relationship*, *policies for shared work values and project objectives among participants*, *activities for promoting committed attitudes of participants* and *interaction for developing inter-personal relationships*. The statistical analysis showed that all included variables had a significant relationship with the project team communication effectiveness.

Capable Construction Project Manager

Capable construction project manager was identified as a critical communication factor. This factor was measured by the variables *construction project manager's professional technical skills, knowledge of other disciplines, a good information gatekeeper, communication skill, engagement in the project, working relationship with others,* and *stability of this team leader*. The statistical analysis of each included variable's relationship with project team communication effectiveness showed that all included variables had a significant relationship with the project team communication performance.

9.3 ANALYSIS OF THE IMPACTS OF THE COMMUNICATION FACTORS ON THE COMMUNICATION PERFORMANCE

Ten factors in the communication factor framework were identified as significant by the data collected from the empirical survey. The scores of these factors were calculated by the means of the included variables. These scores were then fed into the correlation analysis to investigate their impacts on the project team communication performance.

The analysis was to determine the impacts of the communication_factors on the overall communication performance – the score of project team communication effectiveness (PCE) and each performance indicator by performing correlation analysis. The Pearson Product-Moment correlation coefficient was used to measure the strength of these impacts in this study. This correlation coefficient tests the linear relationship between two variables. The ranking of the correlation coefficients of each factor and PCE is listed in Table 9.8 which indicates the significance of the factors' impacts on the overall project team communication performance. The produced correlation matrix of the factors and the performance indicators is showed in Table 9.9. The matrix was examined to identify the three most impacted indictors of the factors based on the correlation coefficients and the significance of these coefficients .

Table 9.8 Ranking significance of the factors' impacts on project team communication effectiveness

	Project Team Communication Effectiveness (PCE)
Contractor's expertise	.506(**)
Social and informal mechanisms for a collaborative working environment	.498(**)
Arrangement of organisation structure	.442(**)
Designer's expertise	.400(**)
Project client experience	.388(**)
Capable construction project manager	.347(**)
Project document management	.341(**)
Project communication media infrastructure	.222(**)

** means the relationship is significant at the 5% level, ** means the relationship is significant at the 1% level*

Table 9.9 Correlation analysis of the factors and the communication performance indicators

	Inaccuracy	Untimeliness	Mis-understanding	Barriers	Information Underload	Information Overload	Information Distortion	Information Gatekeeping	PCE
Project client experience	***.301(**)***	.263(**)	***.354(**)***	***.320(**)***	.251(**)	0.152	.190(*)	.299(**)	.388(**)
Project communication media infrastructure	***.251(**)***	0.102	.201(*)	***.236(*)***	0.062	0.049	0.088	***.228(*)***	.222(*)
Arrangement of organisation structure	.260(**)	***.352(**)***	***.460(**)***	***.338(**)***	.223(*)	.236(*)	.311(**)	.289(**)	.442(**)
Project document management	***.324(**)***	.219(*)	***.329(**)***	.182(*)	***.249(**)***	0.179	.203(*)	.196(*)	.341(**)
Designer expertise	***.359(**)***	***.331(**)***	.255(**)	0.163	.286(**)	0.128	***.413(**)***	.228(*)	.400(**)
Contractor expertise	***.422(**)***	.371(**)	.367(**)	.261(**)	.328(**)	.219(*)	***.397(**)***	***.404(**)***	.506(**)
Social and informal mechanisms for a collaborative working environment	***.409(**)***	.347(**)	***.378(**)***	.365(**)	.278(**)	.195(*)	***.439(**)***	.333(**)	.498(**)
Capable construction project manager	***.298(**)***	***.272(**)***	.270(**)	.256(**)	0.103	0.109	.261(**)	***.351(**)***	.347(**)

** means the relationship is significant at the 5% level, ** means the relationship is significant at the 1% level*

Project Client Experience

The analysis results indicated that the factor *project client experience* was the fifth significant factor to project team communication effectiveness. This factor had a more significant relationship with the performance indicator *misunderstanding*, *barriers,* and *inaccuracy*.

Project Communication Media Infrastructure

From the statistical results, *project communication media infrastructure* is the least factor to project team communication effectiveness. The analysis result shows that the media had a more significant relationship with the performance indicator *inaccuracy*, *barriers* and *information gatekeeping*. However, communication media have been proved as a significant factor to communication by the previous study. The correlation analysis result in this study is anomalistic due to only two variables of factors included. In this study, the impacts of the communication media on the project team communication performance haven't been sufficiently explored.

Arrangement of Organisation Structure

The correlation analysis results show that the factor *arrangement of organisation structure* was the third significant factor to project team communication effectiveness. Organisation structure had a more significant relationship with the performance indicators *misunderstanding*, *untimeliness* and *barriers*.

Project Document Management

From the data analysis results, the factor *project information documentation* had a more significant relationship with the performance indicators *misunderstanding*, *inaccuracy* and *information underload*. This factor was the sixth important factor to project team communication effectiveness.

Designer Expertise

The correlation analysis results show the factor *designer expertise* had a more significant relationship with the performance indicators *information distortion*, *inaccuracy* and *untimeliness*. The results also indicates that the expertise of designers was the fourth significant factor for the overall project team communication performance.

Contractor Expertise

The correlation analysis results indicate that the factor *contractor expertise* was the most significant factor to project team communication effectiveness. From the analysis results, the factor had a more significant relationship with the performance indicators *inaccuracy*, *information gatekeeping*, and *information distortion*.

Social and Informal Mechanisms for a Cooperative Working Environment

Social and informal mechanisms for a cooperative working environment was proved to be the second significant factor to project team communication effectiveness. The correlation analysis results show that this factor had a more significant relationship with the performance indicators *information distortion*, *inaccuracy* and *misunderstanding*.

<u>*Capable Construction Project Manager*</u>

From the correlation analysis results, *capable construction project manager* had a more significant relationship with the performance indicators *information gatekeeping*, *inaccuracy* and *untimeliness*.

Because of the limited data, the analysis results show that some communication factors' impacts on the communication performance indicators were not significant and reflect anomalistic relationships. The significance of the factors' impacts on the communication performance should be further explored when sufficient data are available.

9.4 DISCUSSION OF COMMUNICATION FACTORS

The significance of the impacts of each communication factor on the project team communication performance is discussed in this section. By having an understanding of each critical factor for managing project team communication, the project participants can enhance the performance and effectiveness of communication in the future.

9.4.1 Project client experience

The client is the one who defines project requirements and sets up the project team as the project developer. The factor of *project client experience* is predominantly represented by variables of *clients' experience and expertise in building projects*, *clients' supporting high quality of requirement information*, and *clients' well arrange time for design and construction, and a capable designer representative*. In this study, the statistical analysis showed that the factor of project client experience is significantly associated with the project team communication effectiveness. It was found an experienced project client may help to achieve mutual understanding between project team members, less barriers in the communication process, and more accurate communication.

The client defines project requirements and sets up the project team as the project developer. The expert client could choose the appropriate procurement route (Thomas, 1996). The appropriate procurement routes may bring about easy and clear relations among the project participants. Appropriate procurement routes could also form good relationships which directly lead to more coordination and less barriers in project team communication. Thomas (1996) also stated that expert clients can also promptly and eagerly respond to the field requirements.

Therefore, this study concludes that an experienced client supports for implementing projects and possible impact the project team communication performance on *misunderstanding*, *inaccuracy* and *barriers*. However, the factor of client expertise is not a manageable factor and is therefore difficult to control.

9.4.2 Project communication media infrastructure

Project communication media infrastructure is the variety of media used in the project team communication process. However, data about some important media such e-mail and telephone were not explored in this study due to limited data and anomalistic results. To analyse the communication media infrastructure's impacts on the project team communication performance, only two variables were included, being *the effectiveness of document distribution through the post* and *the effectiveness of project meetings*. As the results show, an effective postal document distribution system and effective project meetings managed by the project participants have significant relationships with project team communication effectiveness. However, the statistical analysis showed that this factor was least significant factor to effectiveness of project team communication which is not consistent with the statements in previous studies. Due to the limited data, the impacts of *project communication media infrastructure* on project team communication performance have not been explored thoroughly in this study.

Communication media are essential elements in the communication process. Its importance for project team communication has been stated by many different researchers (Goldhaber, 1990 cited in Mead 1999; Guevara, 1979; PMI, 2000; Wong *et al*., 2004). Sending design drawings, progress reports, and other important project documentation among the project team members through the post is an effective and legal document delivery system (Howard and Petersen, 2001; Sievert, 1986).

Therefore, an effective postal document delivery system is an important factor for communication. The transmission of printed documents with fine details by post may often cause confusion. The needs of teams are sometime poorly served by written documentation since it could not provide the dialectic necessary to resolve misunderstandings about requirements (Curtis *et al*., 1988). Well-arranged project meetings can increase the intensity and effectiveness of the communication (Xie, 2002). Meetings offer a way to share information and understanding among a group (Gorse *et al*., 1999; Sievert, 1986; Xie, 2002). It can clarify the confusion about the documents and others' requirements (Sievert, 1986). In meetings, clarification of unclear points can also be supported with another medium (Gorse *et al*., 1999).

This study concludes that to achieve effective project communication, effective project team meetings should be frequently organised. An effective document delivery system by post should also be planned and set up at the beginning of the project.

9.4.3 Arrangement of organisation structure

The factor of *arrangement of organisation structure* builds up the communication structure for project team communication by defining the roles and responsibility relations. Four variables were designed to measure the effectiveness of *arrangement of organisation structure*, which are *the structure of project organisation, the communication and reporting system, the document distribution structure* and *participants' understanding of organisation structure*. The statistical analysis of this study showed that *arrangement of organisation structure* is the third significant factor to of project team communication effectiveness and is more significantly associated with the communication performance of *misunderstanding, untimeliness* and *barriers*. Therefore, effective procedures taken by the project participants that define the organisation structure may help to achieve improved understanding between participants, timely information, and fewer barriers to communication.

The organisation structure defines roles and relations between organisations, establishing the formal communication channels and forming a central communication system in a building project (Eisenberg *et al*., 1985; Mead, 1999; Parsons, 1951; Weber, 1947). Its importance for project team communication performance has been stated by many different researchers (Guevara, 1979; Mead, 1999; PMI, 2000; Thomas *et al*., 1998; Wong *et al*., 2004; Xie, 2002)

Carter (1993, cited in Xie, 2002) found that the problems of information omission, underload, overload and gatekeeping arose from poor organisation structure. The studies of Tecnah (1986) and PMI (2000) discovered that communication requirements and information needs are often related to the management responsibilities of each member of the project team. An ambiguous representation of the roles of project participants could contribute to a misunderstanding of requirements and a lack of essential information. A complex project organisation structure with many organisational levels may also increase the barriers or filters in the communication process and obstruct communication among the project participants (Eisenberg *et al*., 1985; Flippo and Munsinger, 1975). Without adequate controls, information may be filtered, restricted or kept while passing through these filters.

Therefore, to improve project team communication performance, a clear arrangement of organisation structure that defines roles and responsibility relations should be set up in the formal procedures. Each participant should clearly understand the organisation structure and know who to contact for the required information.

9.4.4 Project document management

Project document management defines and manages project information which needs to communicated and transmitted between project participants. This factor is predominantly presented by variables of *protocol for information description, project document management system, and schedule for communication and information distribution*. This factor was found to be significant associated with project team communication effectiveness, and more significantly impact the communication performance of *misunderstanding*, *inaccuracy*, and *information underload*. It implies that effective project document management may help to achieve improved understanding between project team members, more accurate communication, and less information underload.

Information is considered to be a critical theoretical variable in communication., The procedure to define and manage information is important for project communication effectiveness. This echoes the previous studies' proposition that an information protocol and management system is important for successful inter-organisational communication (Anumba and Evbuomwan, 1999; Eisenberg *et al*., 1985; Xie, 2002).

The factor of project documentation management impacted the *misunderstanding* and *inaccuracy*, and *information underload* of the communication performance through establishing *a protocol for information description*, *a shared project document management system,* and *schedule for communication and document distribution*

According to Pietroforte (1997) and PMI (2000), communication between different organisations is often uncoordinated because the information produced by different organisations has different interpretation frameworks, different conventions, and different types of software applications. An effective protocol for information description established at the project level could help to ensure the coordination and consistency of project information which is produced by independent organisations.

Project information is produced by project team members from different organisations. Communication of information between the project team members should cross the boundaries among these organisations. These boundaries balk participants to have all project information. The shared central project document system could allow each project team member to access needed project documents. It effectively removes the boundaries between the organisations and improves the communication between them, especially on the performance of information underload.

Timely communication could be realised by a mechanism defined in the formal procedures. *Schedule for communication and document distribution* is an established timetable which shows when each type of communication between participants will be occur and when information should be released. With an effective communication schedule, information could be transmitted to the relevant participants on time. Its effective application would benefit the *information underload* aspect of the communication performance.

This study therefore concludes that effective procedures of project document management, including a protocol for information description, a shared project document system, and schedules for information distribution and communication should be set up to achieve effective project team communication.

9.4.5 Designer expertise

An expert designer could provide high-quality information such as drawings and specifications which is the most important input for conducting construction work and is major information of communication at the construction stage. Several aspects were designed to describe *designer expertise*, which are *accurate and timely design* *information*, *coordinated design information*, *high buildability design information*, and *a capable design team leader*. The factor of *designer expertise* was found to be significantly associated with effective project team communication, especially significantly associated with the performance of *information distortion*, *inaccuracy* and *untimeliness*.

The high-quality design information provided by the expert design team is very important to project team communication performance. Xie (2002) believed that inadequate human resources and an inability to supply information can be one of the reasons for communication failure. The accuracy, coordination, buildability, and timeliness of design information are the first requirement of, and provide the major information for, constructing a building. Design information defining the implemented building serves as the common technical protocol for construction work which is conducted by main-contractors and different sub-contractors. The design information is also the basis for communication between design teams and construction teams. A capable designer representative could clearly instruct and communicate design information to the construction team. Good communication between the design team and the construction team can finally benefit the overall project team performance.

The expert designer is therefore significant to effectiveness of project team communication. It implies that the design team should have sufficient and qualified employees to ensure the high quality of the design information and a capable leader to effectively instruct this information.

9.4.6 Contractor expertise

Contractor expertise describes the level of effectiveness of construction work procedures which provided by the main-contractor. These procedures are the technical protocol of construction activities which is about how to implement and realise the expected building. The factor of *contractor expertise* is measured by the variables *construction work planning and programming*, *construction work flow procedures defining scope, interfaces and sequence of activities, construction team updating progress and performance to others,* and *contractor's updating design and requirement changes to all construction team member*. The statistical analysis showed that *contractor expertise* is the most significant factor to project team communication effectiveness, and was more significantly associated with the performance indicators of *inaccuracy*, and *information gatekeeping*, and *information distortion*. To improve project team communication effectiveness and smooth communication process, procedures for planning, managing and controlling construction work should be set up at the beginning.

An expert main-contractor is very important to project team communication at the construction stage. Construction work involves complex and interdependent activities which are implemented by different participants. Construction work scopes, interfaces and start times of different construction activities for each participant should be clearly explained. An expert main-contractor could develop an effective protocol for the coordinated construction work. By clearly outlining the work flow, sequence, scope, and interface of sub-construction work, construction procedures can help participants to effectively conduct their work. Procedures outlining the start time of the each construction activity, especially critical events should also indicate the required inputs e.g. design and requirement information from clients and designers, or materials and labour supplies from subcontractors. Previous works also stated the significance of the construction procedures, such as Thomas *et al*. (1998) who observed the importance of the formal procedure defining and coordinating work in project team communication.

Meanwhile, real time communication about all project information also could be realised by an updating mechanism defined in the formal construction procedures. All information about project progress, project performance, and design and requirement changes should be planned to timely update to all the involved participants by the main-contractor. Nowadays, the fast-tracking and complex client requirements lead to uncertain design and requirement information. Progress and performance especially emergent events of complex and dynamic construction work should also be timely informed to all involved parties. Mechanisms to ensure that changes and performance transmitted to all participants on time are very important to the overall project team communication performance.

Therefore, this study concludes that to achieve project tam communication effectiveness, a main-contractor should develop effective procedures to plan construction work, to define construction work flow and work scopes of each sub-contractors, and to set up real-time updating mechanisms for performance and changes.

9.4.7 Social and informal mechanisms for a cooperative working environment

*Social and informal mechanisms for a cooperative working environmen*t are regarded as important in the realisation of the cooperation working environment, as they apply the procedures of setting up the collaborative working relationship, setting up the common work norms, and developing friendly interpersonal relationships. This factor predominantly included the variables of *procedures for maintaining inter-organisational working relationship, policies for shared work values and project objectives among participants, interaction for developing inter-personal relationship,* and *activities for promoting committed attitudes of participants*. *Social and informal mechanism for a cooperative working environment* was found to be the second significant factor to effectiveness of project team communication. Effective *social and informal mechanisms for a cooperative working environment* more significantly related to the communication performance indicators of *information distortion, inaccurac*y and *misunderstanding* .

Social mechanisms are the factor which supports project team communication through human aspects of communication. Sonnenwald (1996) stated that the participants with different backgrounds join in project with competing interests, different perceptions of success, and different organisational constraints and priorities. Higgins and Jessop (1965) found that the main factor lying behind communications difficulties is the nature of the relationships between the communicators. Therefore, by setting up a collaborative working environment, the participant's relationships could be improved and the boundaries of different interests, perceptions and values of different organisations could be effectively synchronised. Thus, Chris (2001) concluded that when participants work in a friendly and open environment, information can smoothly flow between them; they share the information and help each other, which leads to effective communication. Xie (2002) and Eisenberg *et al*. (1985) also perceived that to achieve a collaborative working environment and improve project team communication effectiveness, a variety of flexible and effective interpersonal relationships and social linkages should be established.

This study concludes that effectiveness of project communication, especially the performance of *information distortion*, *inaccuracy* and *misunderstanding*, is greatly dependent on the collaborative working environment established by social and informal mechanisms. This social mechanism should be developed in a building project to form friendly and open working relationships, committed participants, shared work values and objectives, and an intensive social networks.

9.4.8 Capable construction project manager

Capable construction project manager plays an important role in controlling information flows, coordinating the works, and maintaining a collaborative working environment at the construction stage. The factor of *capable construction project manager* is predominantly presented by variables of *professional technical skills, knowledge of other disciplines, a good information gatekeeper, communication skill, engagement in the project, working relationship with others,* and *stability of this team leader*. In this study, the statistical analysis showed that the factor of *capable construction project manager* had a significant relationship with project team communication effectiveness, and the communication performance indicators of *information gatekeeping*, *inaccuracy* and *untimeliness*.

The construction project manager is regarded as the inter-organisational communication star (Sonnenwald, 1996), and plays an important role in the project team communication at the construction stage. The construction project manager impacted the communication performance of *information gatekeeping, inaccuracy* and *untimeliness* by managing information flows, maintaining a collaborative working environment, and coordinating the works at the construction stages. The construction project manager could act as an information coordinator, work coordinator, and social coordinator. To act as a social coordinator, a construction project manager is in charge of communication with other participants. A capable construction project manager should have a good understanding of the requirements of others. He should encourage the project team to commit to projects and maintain relationships with other professionals. Then, he might mitigate the conflicts of the project participants. A capable construction project manager should also understand the importance of project goals, rationally aligning group members’ goals with project goals, and should communicate the aligned goals to group members. To act as a work coordinator and information coordinator, a capable construction project manager represents their group in the project team communication. He controls the information transmission from and to other participants. He can smooth information flow.

This study concludes that a capable construction project manager should be assigned in order to achieve effectiveness of project communication. This project manager should have good technical knowledge, coordination skills, and information controlling skills to fulfill their roles as information, work, and social coordinator in project team communication.

9.5 SUMMARY OF THE CHAPTER

This chapter reported and discussed the statistical analysis of the impacts of the communication factors on the project team communication performance. The statistically significant variables for project team communication effectiveness were selected, which represented eight factors. These eight selected factors were then fed into an analysis of the impacts of these factors on the project team communication performance indicators. With the analysis results, the project participants can effectively manage the communication factors to enhance the performance of project team communication in the future, based on an understanding of the impacts of the communication factors.

CHAPTER 10. CONCLUSION AND RECOMMENDATIONS

10.1 INTRODUCTION

The awareness of the importance of the communication between the project participants increases. The research has been designed to identify and investigate critical factors for managing communication between project participants particularly at the construction stage in a building project. A comprehensive literature review, two rounds of questionnaire surveys, and some interviews were conducted to investigate the project team communication performance criteria, the critical factors for managing project team communication, and the impacts of these factors on the project team communication performance. In this chapter, the conclusions of this research are summarised, followed by a presentation of the significance of this study. Finally, potential areas for further study are discussed.

10.2 REVIEW OF THE OBJECTIVES OF THIS STUDY

As identified in Chapter 1, the primary aim of this research was to identify critical factors for managing project team communication at the construction stage which influence the performance of communication between project participants. The specific objectives were to understand the communication process between the project participants at the construction stage in a building project; to identify communication performance indicators for assessing project team communication performance; to indentify communication factors which are critical factors for managing project team communication and examine the significance of the factors for building up a communication factor framework; to further investigate the impacts of the communication factors on communication performance, as well as to examine the communication performance and the effectiveness of the communication factors in practice. The ultimate goal is to provide project participants with valuable information on how to manage project team communication at the construction stage.

10.3 GENERAL CONCLUSION

Complex project team communication is "*the transmission and interchange of project related information among building participants in order to coordinate and accomplish construction work, and to achieve the common project goals*". In this context, the functions of project team communication at the construction stage include information transmission, work coordination and relationship maintenance.

Effective project team communication is important for project success. However, little improvement has been made in the effectiveness of project team communication in building projects. Research gaps associated with communication in construction include little progress in improving and measuring communication effectiveness, little research into communication at the construction stage, little research considering inter-organisational communication in specific organisational settings, little research undertaken to explore complex factors influencing communication performance, and few quantitative studies to examine the impacts of various factors on communication performance. To achieve communication effectiveness, it is important to successfully manage team communication. Various factors influence team communication. This research seeks to develop a framework of critical factors for managing team communication at the construction stage and to examine the factors' impacts on project team communication performance.

The *factors* are *critical factors for managing project team communication at the construction stage and could impact the effectiveness of team communication in a building project*. These critical factors are called *communication factors* in this study. To explore the communication factors' impacts on project team communication performance, the project team communication performance should be assessed first. In this study, *variables* which are *used to assess the performance of team communication on a project* are called *communication performance indicators.*

Although the performance of project team communication is reflected in many aspects, eight typical indicators to examine this performance have been identified based on a literature review in this study. The eight communication performance indicators are: *inaccuracy*, *misunderstanding*, *untimeliness*, *barriers*, *information underload, information overload*, *information distortion*, and *information gatekeeping*. These eight communication performance indicators form the basic means for analysing the impacts of the communication factors on the communication performance in this study. They can also be used to identify communication problems in practice.

The survey results revealed the different frequencies of each communication problems in practice. *Information underload* was the most frequent communication problem in Hong Kong building projects, which was followed by *untimeliness*, *inaccuracy*, *barriers*, and *misunderstanding*. *Information gatekeeping, information distortion,* and *information overload* were the three least appeared communication problems in Hong Kong building projects. In Beijing building projects, *information underload* was also the most frequent communication problem, which was followed by *barriers*, *inaccuracy*, *information gatekeeping*, and *misunderstanding*. *Untimeliness, information overload*, and *information distortion* were the three least frequent communication problems in Beijing building projects. It was also found that a significant difference existed between Hong Kong and Beijing projects in all the communication performance aspects except the communication problem of *barriers* and *information gatekeeping*. This indicates that building participants in Hong Kong and Beijing faced different project team communication problems.

Although many factors influencing the effectiveness of project team communication, the critical factors for managing project team communication have been systematically identified from both theoretical and practical points of view in this study. Through a comprehensive literature review and a brainstorming session, 11 preliminary communication factors were identified. The significance and meanings of these 11 factors was further investigated in the pilot questionnaire survey. The factors were then developed into a comprehensive framework of the communication factors based on the responses from construction professionals. This framework consists of the 13 critical factors for managing project team communication which have impacts on the performance of project team communication at the construction stage in a building project. These factors include *project complexity, project client experience, project information technology (IT) applications, project organisation management approaches, project communication media infrastructure, project information documentation, arrangement of organisation structure, schedule for communication and information distribution, design information with high-quality content, effective procedures for construction work, expertise and background of staff, social and informal mechanisms for a cooperative working environment, and capable project manager*. This communication factor framework can be used by project participants to manage project team communication at the construction stage.

The impacts of the communication factors on the project team communication performance in practice were also explored. The impacts of the communication factors were examined by employing several sets of statistical analysis methods to analyse the data collected in the empirical questionnaire survey. Forty variables of communication factors which had significant relationships with project team communication effectiveness were selected from sixty original variables. Reliability and validation of the factors and their associated variables were further tested by calculating the Cronbach's Alpha and applying Factor Analysis. Eight selected and revised communication factors were put into correlation analysis process to explore their impacts on the project team communication performance indicators.

The revised categorised communication factors were proved to impact project team communication effectiveness by analysing relationships between each factor with the overall performance score of project team communication effectiveness (PCE) (Table 10.1). The top 3 factors which significantly associated with project team communication effectiveness were *contractor's expertise*, *social and informal mechanism for a cooperative working environment*, and *arrangement of organisation structure*.

Table 10.1 Ranking significance of the revised categorised factors

Ranking of significance	**The revised communication factors**
1	Contractor's expertise
2	Social and informal mechanisms for a collaborative working environment
3	Arrangement of organisation structure
4	Designer's expertise
5	Project client experience
6	Capable construction project manager
7	Project document management
8	Project communication media infrastructure

Each revised categorised communication factor were also analysed the relationship with each communication performance indicators in practical building projects. The results are listed in Table 10.2.

Table 10.2 The revised categorised factors and their impacted performance indicators

Factors for managing project team communication	**The impacted performance indicators**
Project client experience	* Misunderstanding * Barriers * Inaccuracy
Project communication media infrastructure	* Inaccuracy * Barriers * Information gatekeeping
Arrangement of organisation structure	* Misunderstanding * Untimeliness * Barriers
Project documentation management	* Misunderstanding * Inaccuracy * Information underload
Designer expertise	* Information distortion * Inaccuracy * Untimeliness
Contractor expertise	* Inaccuracy * Information gatekeeping * Information distortion
Social and informal mechanisms for a cooperative working environment	* Information distortion * Inaccuracy * Misunderstanding
Capable construction project manager	* Information gatekeeping * Inaccuracy * Untimeliness

Project Client Experience

The client as the project developer is the one who defines project requirements and sets up the project team. It was found that an experienced project client had significant relationship with effective project team communication. An experienced client could help to achieve mutual understanding between project team members, fewer barriers to communication process, and more accurate communication, This study concluded that the experience of the client will influence their supports for implementing projects and impact project team communication performance. However, the factor of client expertise is not a manageable factor and is therefore difficult to control.

Project Communication Media Infrastructure

Project communication media infrastructure is the variety of media used in the project team communication process. As the results shown, an effective postal document distribution system and effective project meetings managed by the project participants was significantly associated with project team communication effectiveness. However, the result of the impacts of the communication media on the project team communication performance was anomalistic. The impacts of some important communication media, such as e-mail, informal conversation, telephone, etc. were not explored in this study due to the lack of the data and the limitation of measuring questions.

Arrangement of Organisation Structure

The factor of *arrangement of organisation structure* builds up the communication system for project team communication by defining the roles and responsibility relations of the participants. It was found that effective procedures defining the arrangement of organisation structure taken by the project participants was the third important factor to effective project team communication. It could help to achieve improved understanding between participants, timely receiving needed information, and fewer barriers during communication process. Therefore, to improve project team communication, clear arrangement of organisation structure defining role and responsibility relations of participants should be set up in formal procedures. At the same time, each participant should clearly understand the organisation structure, and know who to contact for the required information.

Project Document Management

Project document management defines and manages project information which is needs to be communicated and transmitted between project participants. It was found that effective procedures and system for managing project information and documents is important to effective project team communication, improved understanding between project team members, more accurate communication, and less information underload. This study concluded that the procedures of project document management, including a protocol for information description and a shared project document system, and a schedule for communication and information distribution should be set up at the beginning of the project.

Designer Expertise

An expert designer could provide high-quality information such as drawings and specifications which is the most important input for conducting construction work and is major information of communication at the construction stage. The survey results show an expert designer is the important factor to project team communication effectiveness. An expert designer could help to achieve little information distortion during transmission, more accurate communication, and timly having needed information. It implies that design teams should have sufficient and qualified employees which could ensure the high quality of the design information and a capable leader to effectively instruct this information.

Contractor Expertise

An expert contractor could provide effective procedures for planning and controlling construction work. Effective procedures are the technical protocol of construction activities. These procedures define the construction planning, the construction work flow, the performance and changes updating mechanisms. It was found that the factor of *contractor expert is the most important factor to* effectiveness of project team communication. An expert main-contractor could smooth communication process and help to achieve more accurate communication, little information gatekeeping, and few problems of information distortion. Therefore, main-contractor should develop effective procedures to plan construction work, to define construction work flow and work scopes of each sub-contractors, to set up updating mechanisms for performance and changes.

Social and Informal Mechanisms for a Cooperative Working Environment

Social and informal mechanisms are regarded as important in the realisation of a cooperative working environment, as they apply the procedures of setting up friendly and open working relationships, promote commitment to projects, form shared work values and objective, and develop an intensive social network. It was found that social and informal mechanism for a cooperative working environment is the second important factor to effective project team communication. Effective and appropriate social mechanisms could help to achieve little information distortion, better communication accuracy and improved understanding between participants. Therefore, to realize project team communication effectiveness, social mechanism should be established for a cooperative working environment.

Capable Construction Project Manager

A capable construction project manager plays a very important role in controlling information flows, coordinating the works, and maintaining a collaborative working environment at the construction stages. It was discovered that a capable construction project manager involved in a building project may help to improve effectiveness of project team communication, and mitigate the problems of information gatekeeping, inaccurate communication, and untimely communication. This study concludes that in order to achieve effectiveness of project team communication, a capable construction project manager should be assigned. This project manager should have experienced capacity to fulfil his information, work, and social coordination roles in project team communication.

Based on an understanding of the impacts of the factors on the project team communication performance, the project participants can effectively manage the factors to enhance the performance of project team communication.

10.4 SIGNIFICANCE AND CONTRIBUTION OF THE RESEARCH

This study contributes to the knowledge development of the discipline of communication between project participants at the construction stage. Some researchers have studied project team communication and discussed communication performance indicators and their influential factors. However, few have focused on the construction stage and investigated factors for managing project team communication to improve project team communication performance.

A framework of critical factors for managing project team communication has been built up from both theoretical and practical points of view in this study. The understanding of the identified communication factors provides a framework for project participants to develop strategies for improving communication effectiveness at the construction stage.

The impacts of the factors on the communication performance in practical building projects were also explored in the empirical questionnaire survey. The variation of the effectiveness of the critical factors can lead to the variation of the indicators of communication performance. Therefore, understanding the impacts of these factors can help to improve the communication performance indicators by applying needed actions to the related impacting factors. This understanding provides further benefits to both individual project team members and the objectives of the whole project.

Meanwhile, the current typical communication problems at the construction stage in building projects were identified by assessing the communication performance indicators in practical projects. The identified communication performance indicators can be used to compare the communication performance between different projects.

10.5 LIMITATION AND RECOMMENDATION FOR FUTURE STUDIES

During the course of this research, several areas were highlighted as potential areas for further study, as follows:

a. This study has systematically investigated the critical factors for managing team communication during the implement of construction work. However, each critical factor could be explored further, such as specific approaches for improve communication effectiveness and how these factors impact on the communication process. Further studies could be given on examining specific methods and approaches for improving communication effectiveness based on understand the factors. To explore the ways in which critical factors influence the communication process, the relationship between the critical factors and each key elements of the communication process can be analysed further.

b. The research findings are mainly dependent on the perceptions of invited respondents and are subjective in nature. Therefore, there is a need to develop a more objective method of quantifying interval-level measurement criteria for dependent and independent variables, which can reduce human bias and improve the effectiveness of the relationship analysis.

c. In this study, the data collected for analysis of the factors' impacts on the communication performance indicators were only from limited cases in two major cities. Limited data impacted the significance of the analysis results. More data should be collected in the country-wide cities, which could lead to more significant relationships and strong conclusions for project team communication.

d. Further study should detail the communication process between project team members through the project life cycle, examine the attributes of each element of the communication process and their situations in building projects.

e. This study is limited to overall team communication at the construction stage in which all communication interfaces were considered. Further studies could be given to examine specific communication interfaces between participants, for example the communication between main-contractors and designers.

f. A non-traditional procurement system and innovative management approaches, such as Design and Build, partnering, value management and so forth, have recently been progressively adopted in the construction industry. The effectiveness of these innovative measures on project team communication performance still needs further observation. It is therefore worth conducting further research concerning other types of procurement system and some innovative management skills.

g. This study is limited to the construction stages of a building project. The constraint of time has precluded the inclusion of the longitudinal study on the variation of the significance of the factors as the project developed and team members became more familiar with each other.

h. The data for this study was mainly collected from projects whose participants were from the same country, meaning that they were carried out in a more stable and simple social environment. Further research can be done to focus on projects whose participants are from different countries, as their different cultures and environments may lead to a different set of determining factors.

The study samples collected in this study are on general building projects. It is recommended that the research methodology adopted for this study be applied to other specific construction projects, such as civil projects, infrastructure projects, and so forth.

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APPENDIX A

SAMPLE OF COVER LETTER

FOR THE POLIT QUESTIONNAIRE SURVEY

Managing Director
<Company Name>
<Address1>
<Address2>
Hong Kong

Dear Sir/Madam,

Good project information exchange and communication includes the need to ensure timely and appropriate generation, collection, dissemination, storage, and ultimate disposition of project information. Effective inter-organisational communication is essential to the successful completion of the construction projects.

We are conducting a research project aiming to improve the effectiveness of information exchange and communication between the project participants at the construction stage of the project.

The enclosed questionnaire is a part of the research to explore the major factors influencing information exchange and communication effectiveness and other issues related to communication in construction. The survey will provide important insights into the information exchange and communication between the construction project participants and will help to enable an effective managerial strategy for information communication.

This questionnaire seeks representatives from the every participant organisation during the construction phase of projects to provide opinions on information exchange and communication issues. The views from the managers or professionals in your organisation are very important to the fulfillment of our study. PLEASE COULD YOU PASS THE QUESTIONNAIRE TO ONE OF THE PROJECT MANAGERS IN YOUR ORGANISATION TO COMPLETE.

The questionnaire is designed to preserve your anonymity. We promise you that all data will be kept strictly confidential and used solely for academic research purposes. We will provide you the main research findings when they are available if you indicate that you would like to know.

It will take you 5-10 minutes to complete the questionnaire. I thank you very much indeed in advance for taking the time to participate in the survey. PLEASE COULD YOU RETURN THE QUESTIONNAIRE DOCUMENT ON OR BEFORE FRIDAY ***data***.

Yours sincerely,

Ms. Yan LIU
PhD Candidate,
The Department of Building & Real Estate
The Hong Kong Polytechnic University
Kowloon, Hong Kong
Tel: ****** Fax: ******

Cc: Prof. Professor Andrew N. Baldwin, Prof. LY Shen

If you would like a summary report of the results of this questionnaire survey, please write down your contact information below. (Alternatively attach your business card to the survey document.)
Also, we promise that the information will be solely used for the purpose of sending the report.
Thank you again for your kind participation.

Name: ______________________________
Email: ______________________________
Corresponding address: ____

Enclosures: Questionnaire

APPENDIX B

SAMPLE OF THE POLIT QUESTIONNAIRE

Research into Project Team Communication at the Construction Stage
Department of Building & Real Estate

The Hong Kong Polytechnic University

This research project aims to improve the effectiveness of communication between the participants of building projects. The enclosed questionnaire will assist the researchers to explore the critical factors influencing communication effectiveness. Your view is very important to the fulfillment of our study and we hope that you will be able to find the time to complete and RETURN THE QUESTIONNAIRE DOCUMENT ON OR BEFORE FRIDAY ***date***. Thank you in advance for your participation.

SECTION 1 - INFORMATION ON YOUR ORGANISATION

Instruction:
Please select the option that most closely meets your organisation using "√" or write down information in the blanks.

1. What is the primary business of your organisation? (your role in the construction projects)
   ☐Client ☐Designer ☐Contractor ☐Consultant
   ☐Subcontractor ☐Supplier ☐________ ☐________

2. What was the turnover of your organisation in the last financial year? (HK $)
   ☐Less Than 100 M ☐100M-500M ☐500M-1.5B ☐More Than 1.5B

3. What is the number of permanent staff in your organisation?
   ☐Less Than 50 ☐50-100 ☐100-500 ☐More Than 500

4. How many years has your organisation been in existence?
   ☐Less Than 5 ☐5-20 ☐20-50 ☐More Than 50

5. What is the business region of your organisation?
   ☐Hong Kong ☐Hong Kong and Mainland ☐Hong Kong and Asia ☐Overseas

6. What is your business scope of your organisation?
   ☐Building projects ☐Civil projects ☐Both ☐_________

7. What is the percentage of the each type of work according to your organisation's records? (enter %)
   Building projects _____% Civil Eng. projects _____% Other projects _____%

8. What is the maximum size of construction project recently undertaken by your organisation? (HK$)
   ☐Less Than 10M ☐10M-100M ☐100M-1B ☐More Than 1B

9. How many construction projects are concurrently undertaken by your organisation?
   ☐Less Than 5 ☐5-10 ☐10-20 ☐More Than 20

10. What is your position in your organisation?
    ☐Director ☐ Senior manager ☐Project Manager ☐Manager

11. How many years experience have you had in the construction industry?
    ☐1-10 ☐11-20 ☐21-30 ☐Over 30

SECTION 2 - FACTORS INFLUENCING THE EFFECTIVENESS OF COMMUNICATION BETWEEN PARTICIPANTS AT THE CONSTRUCTION STAGE

Instruction:
For each of the factors listed in this questionnaire. Please indicate according to your experience its level of importance in effective communication between the project participants at the construction stage. The importance is scaled as follows:

1 – unimportant 2 little importance 3 – neutral 4 – important 5 – extremely important

For example, for factor F1 – If you believe the project location has an extremely important influence on the communication effectiveness between project participants please tick box 5. If you believe that it is unimportant tick box 1.

2.1 PROJECT CHARACTERISTICS FACTORS

	Unimportant ◄- - -► *Extremely important*
1. The project location, i.e. the physical location of a project site	1 – 2 – 3 – 4 – 5 ☐ ☐ ☐ ☐ ☐
2. The size of the construction project, with respect to GFA, contract cost etc.	1 – 2 – 3 – 4 – 5 ☐ ☐ ☐ ☐ ☐
3. The type of construction project, i.e. commercial buildings or residential etc.	1 – 2 – 3 – 4 – 5 ☐ ☐ ☐ ☐ ☐
4. The complexity of the project, with respect to its design and construction	1 – 2 – 3 – 4 – 5 ☐ ☐ ☐ ☐ ☐
5. The number of companies involved in the project, i.e. how many participants	1 – 2 – 3 – 4 – 5 ☐ ☐ ☐ ☐ ☐
6. The timescale for completion of the project, i.e. time constraints for design and construction work	1 – 2 – 3 – 4 – 5 ☐ ☐ ☐ ☐ ☐
7. Specific constraints on the project, e.g. the required completion time from client	1 – 2 – 3 – 4 – 5 ☐ ☐ ☐ ☐ ☐
Other Factors (PLEASE STATE)	1 – 2 – 3 – 4 – 5 ☐ ☐ ☐ ☐ ☐

2.2 MANAGEMENT MEASURES FACTORS

	Unimportant ◄- - -► *Extremely important*
8. The financial investment in information management, i.e. the applied information technologies in a project	1 – 2 – 3 – 4 – 5 ☐ ☐ ☐ ☐ ☐
9. The computer applications software used by the project team, i.e. kinds of application in different participants	1 – 2 – 3 – 4 – 5 ☐ ☐ ☐ ☐ ☐
10. The computer hardware used by the project team, i.e. kinds of application in different participants	1 – 2 – 3 – 4 – 5 ☐ ☐ ☐ ☐ ☐
11. The type of procurement method used on the project, i.e. organisation management approaches e.g. Traditional Contract, Design and Build	1 – 2 – 3 – 4 – 5 ☐ ☐ ☐ ☐ ☐
12. The medium used to convey the information, i.e. written documents by post, by telephone, by meeting, by bulletin, by email or by intranet, which included in a project	1 – 2 – 3 – 4 – 5 ☐ ☐ ☐ ☐ ☐

◄- - -►

	Unimportant ◄- - -► *Extremely important*
13. The format of the information i.e. written document, drawing photograph, or different type of soft document, which prescribed by formal provisions	1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐
14. Clear classification of the information, i.e. storing information and easy for retrieval	1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐
15. The project organisational structure, i.e. role and responsibility of participants and their relations	1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐
16. How familiar the participants are with the type of contract, i.e. participants' understanding on project organisation structure	1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐
17. A formal and visible communication system i.e. clear organisation structure for document distribution	1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐
18. The Person is responsible for producing and sending the information to the project participants, i.e. information distribution coordinators	1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐
19. The timing of the communication, i.e. when the information is distributed relating to the construct process, which defined in formal procedures	1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐
20. The quality of the information content, i.e. high-quality information supplied for implementing construction	1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐
21. The good spirit and trust between the parties, i.e. inter-organisational collaborative working relationships	1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐
22. The project group culture, i.e. established participation attitudes of project group members	1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐
23. The alignment of the objectives of the participant organisations, i.e. establishing common project goals and values	1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐
24. The relationship between the participant organisations prior to the commencement of the project, i.e. previous cooperation experience	1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐
25. The contribution of the project manager, i.e. capable project manager with respect to communication skills and professional knowledge etc.	1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐
Other factors (PLEASE STATE)	1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐

2.3 OTHER FACTORS AND COMMENTS

Are there some other factors influencing the effectiveness of communication between participants at the construction stage of a building project? Please list them below; please use the back of the page if necessary.

____

____

____

____

SECTION 3 - OTHER ISSUES RELATED TO COMMUNICATION BETWEEN PROJECT PARTICIPANTS

Please indicate your view using "√" or write down an answer in the blanks.

1. In your experience who are most difficult to communicate with?

☐clients	☐designers	☐contractors	☐subcontractors	☐others	☐no view

Please explain why:

2. Who should be the centre of communication at the construction stage of a project?

☐clients	☐designers	☐contractors	☐subcontractors	☐others	☐no view

Please explain why:

3. In what stage of a building project are there most frequent communication problems between participants?

☐Brief	☐Schematic design	☐Development design	☐Construction documents	☐Bid/Negotiation	☐Construction

Please explain why:

4. About what topics are there the most frequent communication problems between participants at the construction stage?

☐Financial	☐marketing	☐Design	☐technological	☐ Construction Process	☐others

Please explain why:

5. In what management areas at the construction stage are there most frequent communication problems between participants?

☐time management	☐cost management	☐quality management	☐human resource management	☐ procurement management	☐ health and safety management

Please explain why:

6. Are there specific types of contract or contract arrangements that you believe result in effective project communication? (Please explain why)

THANK YOU FOR COMPLETING THE QUESTIONNAIRE – PLEASE RETURN TO THE SENDER IN THE ENVELOPE PROVIDED.

APPENDIX C

SAMPLE OF COVER LETTER

FOR THE EMPIRICAL QUESTIONNAIRE SURVEY

The Hong Kong Polytechnic University
香港理工大學

DEPARTMENT OF
BUILDING & REAL ESTATE
建築及房地產學系

Date

To front-line managers in each organisation in project team

Dear Sir/Madam:

<u>Re</u>: A Survey for Examining Communication Effectiveness between Building Project Participants at the Construction Stage

I am writing to invite you to participate in our survey which is intended to identify and analyse the critical factors to improve communication effectiveness among client, construction team and design team at the construction stage in building projects.

With the effective communication system linking the project participants, accurate technical information will be quickly communicated and consensus decision will be easily achieved. It will improve information quality and team work, and then reduce conflicts and reworks.

In this questionnaire, you are asked to provide your perception on the performance of communication mechanism and project management in a particular building project which you are mainly involved in now. The communication problems and their reasons in your project will be analysed and compared to the established CII projects benchmark and other projects in Hong Kong. We hope this work could benefit your company and the outcomes will be sent to you when available.

I would be mostly grateful if you or one of the project managers to complete the attached questionnaire and kindly return it to me in the enclosed envelope or fax ****** on or before ***date***. It will take you 15-20 minutes to complete. Please feel free to copy the enclosed questionnaire for completion by other colleagues. You can be assured that your response will be treated with absolute confidentiality and no respondents or projects will be identified. It will be used only for research purpose. Should you have any question, please feel free to contact me.

Thank you in advance for your contribution and look forward to receiving your reply.

Yours sincerely,

Miss Yan LIU

PhD Student
Department of Building & Real Estate
The Hong Kong Polytechnic University
Phone: ******
Fax: ******
Email: ******

Encl.
A copy of questionnaire
An addressed and freepost envelope

Cc: Prof. Andrew N. Baldwin, Prof. LY Shen

The Hong Kong Polytechnic University 香港理工大學　DEPARTMENT OF BUILDING & REAL ESTATE 建築及房地產學系

致：建设项目团队各参与方的项目负责人

建设项目施工阶段各参与方沟通与信息交流的研究

尊敬的先生/女士：
您好！

我们正在做一项提高建设项目团队间沟通和信息交流的研究，研究对象是工程施工阶段的甲方、监理、设计、总包商和分包商之间的信息交流情况。项目各参与方之间有效的信息交流和沟通，可以使技术信息迅速准确地传递到各个需要的组织，可以促使各方能够迅速达成一致意见，是保证项目成功的必要条件。

在这份问卷中，我们邀请您对项目团队间的信息交流的实际情况发表您的看法。通过此问卷，我们会分析您所在的项目的团队沟通的问题以及他们产生的原因。同时，我们会将您所在的项目的团队沟通的表现和美国建造业研究协会（CII）的项目以及我们在北京地区采访的其它项目做出比较。分析出当采用不同的合同方式、组织模式、信息系统和交流方式时，所得到的不同的沟通效果。我们希望本项研究可以帮助您的企业选择信息系统，合同方式及管理措施等，从而进一步提高项目的团队沟通表现。

在此，我们邀请您或您项目的项目经理，选择一个您正在参与的工业与民用建筑项目完成此问卷。我们郑重地承诺，您的宝贵意见仅用于学术研究。调查资料将会严格保密，研究结果只展现地区整体情况，不会涉及任何个人或项目信息。

在此，特别感谢您对于本课题的大力协助。

此致

敬礼

刘妍　博士研究生
香港理工大学, 建筑与房地产学系
电话: ********　　（北京）********　（香港）
传真: ********　（香港）
电子信箱: ********

抄送：
安德鲁・布尔文教授
申立银教授

附件：
调查问卷

APPENDIX D

SAMPLE OF THE EMPIRICAL QUESTIONNAIRE

INSTRUCTION

Please answer all questions in the context of ***inter-organisational communication at the construction stage*** for information exchange, working coordination, and decision making etc. with reference to ***one building project you are mainly involved in now or just finished***. Pleases be aware that your responses will be kept in strict confidence.

1. Project Profile

1. Your position in this project:______________________

2. Type of organisation you are working in:
   - ❑Client ❑Engineering consultant ❑Supplier
   - ❑Architect ❑Q.S. consultant ❑Sub-contractor (please specify)_________________________
   - ❑Main Contractor ❑Project management consultant ❑Others (please specify)________________________________

3. The approximate turnover of <u>your company</u> in 2005: (in HK$ M: million; B: billion)
   - ❑<50M ❑50-100 M ❑100-500 M ❑500M-1B
   - ❑1-2.5B ❑2.5-5B ❑5-10B ❑>10B

4. Project location: ❑Hong Kong ❑Macau ❑Mainland ❑Overseas (specify)_________

5. Function of Building: ❑Residential Building ❑Commercial Building ❑Public Works
   ❑Office ❑Industrial Building ❑Others (specify)___________

6. Type of construction: ❑New work ❑Redevelopment ❑Others (specify)___________
   ❑Extension ❑Maintenance/refurbishing

7. The procurement system: ❑Traditional Procurement ❑Design & Build
   ❑Construction Management ❑Others (please specify)________________________________

8. Type of tendering methods: ❑Open tendering ❑Selective tendering
   ❑Negotiated tendering ❑Others (please specify)________________________________

9. Original total contract sum at tender award of this project: HK$___________Million, Gross floor area (GFA):_________m^2

10. Construction performed by subcontractors: ________________% of total cost

11. The extent of design at construction start:_______% designed

12. The total scheduled construction duration:________months, the current stage in construction process:__________________

13. Please indicate the level of complexity of this project

	very simple ↔ very complex
1) Complex building functions leading to difficulty in design	1 – 2 – 3 – 4 – 5
2) Complex design buildability leading to difficulty to construct	1 – 2 – 3 – 4 – 5

14. What particular management techniques were used or are being used on this project which have improved communication between participants? (you can choose more than one item)
    - ❑Partnering/alliances ❑Formal team building ❑Joint Venture
    - ❑Concurrent Engineering ❑Total quality management ❑Others(please specify): _______________________

15. What kinds of IT systems were used or are being used on this project which have facilitated communication between participants?

	being used	Considering for future using
1) Email	❑	❑
2) Project intranet	❑	❑
3) 3-D design drawing	❑	❑
4) 4-D simulation construction	❑	❑
5) Video conference	❑	❑
6) On-line chat system	❑	❑
7) Others (please specify):________________________________	❑	❑

2. Management Measures

1. How often do you use the following media for communication with other parties in this project? Please also indicate their effectiveness in communication for problems solving, work coordination and information exchange etc.

Media	never ↔ always	not effective ↔ very effective
1) Hard copy distribution or post	1 2 3 4 5	1 2 3 4 5
2) Access to networked project database/intranet	1 2 3 4 5	1 2 3 4 5
3) Meeting	1 2 3 4 5	1 2 3 4 5
4) E-mail	1 2 3 4 5	1 2 3 4 5
5) Fax	1 2 3 4 5	1 2 3 4 5
6) Telephone	1 2 3 4 5	1 2 3 4 5
7) Face to face discussion	1 2 3 4 5	1 2 3 4 5
8) Video-conference, Tele-conference	1 2 3 4 5	1 2 3 4 5
9) Others (please specify):____________________	1 2 3 4 5	1 2 3 4 5

2. Please indicate your opinions on the following statements on inter-organisational relations in this project.

	highly disagree ↔ highly agree
1) I am familiar with other parties' roles and responsibilities.	1 2 3 4 5
2) Roles, and responsibilities of each party in this project are clear defined by the formal procedures (e.g. Contract Arrangement etc.).	1 2 3 4 5
3) Communication linkages and reporting lines with other parties are well described by established inter-organisational chart in formal procedures e.g. Contract Arrangement	1 2 3 4 5
4) The document distribution structure clearly formed for releasing and distributing documents among project parties.	1 2 3 4 5

3. Please assess the effectiveness of the information and document management procedures applied on this project for facilitating communication between project participants:

	not effective ↔ very effective
1) Project document management system: clear classification of collected information	1 2 3 4 5
2) Protocols for information description and used IT to define congruent formats and communication etiquette	1 2 3 4 5

4. Please assess the effectiveness of procedures about communication schedules applied on this project for facilitating communication between project participants:

	not effective ↔ very effective
1) Schedule for communication and information distribution along with production flow	1 2 3 4 5
2) Mechanisms applied by main-contractor for being aware of and updating design and requirement changes to all construction team members in advance and controlling document versions	1 2 3 4 5
3) Mechanisms applied by main-contractor for timely updating all parties the project progress and performance, as well as informing required inputs	1 2 3 4 5

5. Please indicate your opinions on the following social aspects for inter-organisational communication on this project

	highly disagree ↔ highly agree
1) Good cooperative working relationships among different parties established by formal procedures. People in different organizations trust and help each other.	1 2 3 4 5
2) Organisational work values and objectives are aligned to shared values and objectives by project culture and policies.	1 2 3 4 5
3) Committed attitudes of participants developed by some organised activities. People are happy to be involved in the project.	1 2 3 4 5
4) There are many social interactions between the project parties. Therefore, good inter-personal friendships and affinity with other parties are formed.	1 2 3 4 5

6. Please indicate your opinions on the competency of the project team leaders in this project:
Remarks: *Please also evaluate your own group. If you lack information on some aspects of others' performance, please leave that item blank.*

	Construction team leader weak ↔ strong	Client's representative weak ↔ strong	Design team leader weak ↔ strong
1) Professional technical skills	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
2) Knowledge of other disciplines	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
3) A good information gatekeeper to control information flow	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
4) Communication skill	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
5) Early and continued engagement in the project, always available to contact	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
6) Working relationship with others	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
7) Stability of this team leader	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5

7. Please indicate your opinions on the capacity of the client organization in this project:

	very weak ↔ very strong
1) Experience and expertise in building projects	1 2 3 4 5
2) Supporting high quality of requirement information	1 2 3 4 5
3) Ability to well arranged time for design and construction	1 2 3 4 5

8. Please indicate your opinions on the performance of the main-contractor organization in this project:

	very weak ↔ very strong
1) Ability to develop effective procedures of construction planning and programming outlining work flows and sequence	1 2 3 4 5
2) Ability to develop effective procedures defining construction work scopes and interfaces of each construction team member	1 2 3 4 5

9. Please indicate your opinions on the performance of the design/consultant team organisations in this project:

	very weak ↔ very strong
1) Knowledge of construction, outputting high buildability design	1 2 3 4 5
2) Ability to supply high quality of design information, good controlling design changes	1 2 3 4 5
3) Ability to supply coordinated design information	1 2 3 4 5

3. Project Communication Performance

1. Please indicate the frequency of the **following problems** you experience when you communicate with other parties at the construction stage in this project:

	always ↔ never
1) Misunderstanding what information other parties expect from you	1 2 3 4 5
2) Receiving conflicting information from others	1 2 3 4 5

	always ↔ never
3) Poor communication or lack of coordination with other parties	1 – 2 – 3 – 4 – 5
4) having less information than you need	1 – 2 – 3 – 4 – 5
5) Too much information than you can efficiently use	1 – 2 – 3 – 4 – 5
6) Haven't been kept current with design changes	1 – 2 – 3 – 4 – 5
7) Haven't been kept current with schedule changes	1 – 2 – 3 – 4 – 5
8) Information changed in meaning or lost in some contents during the dissemination	1 – 2 – 3 – 4 – 5
9) Information withheld during its dissemination by ones who control information flow	1 – 2 – 3 – 4 – 5
10) Inadequate accessing to the information sources (information provider or information database) Please indicate barriers______(1-interpersonal issues, 2-accessibility, 3- logistic issues, 4-others (specify)____	1 – 2 – 3 – 4 – 5

2. Overall, how effective do you think communication between project participants is at the construction stage <u>on this project</u>?

not effective ↔ very effective

1 – 2 – 3 – 4 – 5

3. How often do you experience communication problems with other parties at the construction stage in this project? (please tick which is your company in the front box and also assess)

	always ↔ never
❑ Client	1 – 2 – 3 – 4 – 5
❑ Architect	1 – 2 – 3 – 4 – 5
❑ Engineering Consultants	1 – 2 – 3 – 4 – 5
❑ Main-contractor	1 – 2 – 3 – 4 – 5
❑ Key Sub-contractors	1 – 2 – 3 – 4 – 5
❑ Key Suppliers	1 – 2 – 3 – 4 – 5
❑ Others (please specify): __________________________	1 – 2 – 3 – 4 – 5

4. How often do you experience communication problems with other parties in the following aspects at the construction stage in this project?

	always ↔ never
1) Design and requirement information	1 – 2 – 3 – 4 – 5
2) Cost management	1 – 2 – 3 – 4 – 5
3) Time management	1 – 2 – 3 – 4 – 5
4) Quality management	1 – 2 – 3 – 4 – 5
5) Safety management	1 – 2 – 3 – 4 – 5
6) Environment management	1 – 2 – 3 – 4 – 5
7) Contract management	1 – 2 – 3 – 4 – 5
8) Material and procurement management	1 – 2 – 3 – 4 – 5
9) Risk management	1 – 2 – 3 – 4 – 5
10) Others (please specify): __________________________	1 – 2 – 3 – 4 – 5

5. What do you see as the primary barriers to effective communication <u>on this project</u>?

____

____

6. How could communication between the project participants be improved from the practice <u>of this project</u>?

____

____

♦The End. Thank you for your contribution and time! ♦

Return Slip

If you would like a summary report of the results, please write down your contact information below. (Alternatively attach your business card to the survey document.) We promise the information will be solely used for sending the report.

Name:

Organisation:

Address:

Telephone number:

Email:

说明:
这是一份关于施工阶段项目各参与方之间的沟通和信息交流的调查文卷，请您参考您正参与的一个在施或刚刚竣工的工业与民用建筑项目，协助我们回答下列所有问题，这大概需要您20分钟。您所填写的信息我们会严格保密。

1.项目基本情况

1. 您在项目中所担任的职务____________________

2. 您所在的团队在本项目中的角色：
❑业主 ❑建筑设计 ❑结构或机电设计
❑工程造价咨询 ❑项目管理咨询 ❑分包商或供应商(请注明分包内容)__________________
❑监理 ❑总包商 ❑其他(请注明)__________________

3. 2005年贵公司的营业额约是多少（以人民币记）：
❑<5000万元 ❑ 5000万元～1亿元 ❑ 1亿元～5亿元 ❑5亿元～10亿元
❑10亿元～25亿元 ❑25亿元～50亿元 ❑50亿元～100亿元 ❑>100亿元以上

4. 项目所在城市： ❑北京 ❑其它城市(请注明)____________ ❑海外(请注明)__________

5. 建筑类型: ❑住宅 ❑商场 ❑公共建筑：如学校、医院等(请注明)______________
❑写字楼 ❑厂房 ❑其它(请注明)__________________

6. 工程类型 ❑新建工程 ❑改建工程 ❑其它(请注明)__________
❑扩建工程 ❑维修工程

7. 承包方式 ❑传统方式(设计→招标→建造) ❑设计-建造(D&B模式) ❑建设-移交(B&T模式)
❑项目管理(CM模式) ❑其它(请注明) __________________

8. 招标方式 ❑公开招标 ❑邀请招标
❑单独议标 ❑其它(请注明)__________________

9. 工程总造价： RMB________万元， 总建筑面积：____________平方米

10. 分包工作量占： __________%工程总造价

11. 施工开始时，设计已经完成了____________%

12. 总工期为：__________月， 现在工程进展到____________________阶段

13. 请指出本项目本身的复杂程度

	很简单		↔		很复杂
1) 建筑功能导致设计工作的复杂程度	1	2	3	4	5
2) 设计图纸易建性，即设计导致施工的难易程度	1	2	3	4	5

14. 您认为本项目采取的什么管理措施可以帮助提高项目参与者之间的沟通和信息交流的效果？（可以多选）
❑伙伴关系模式或联合体 ❑正式项目团队建设 ❑共同风险制 （融资建造）
❑并行工程 ❑全面质量管理 ❑其它（请注明）________________

15. 您认为本项目采用的什么IT信息系统可以帮助提高项目参与方之间的沟通和信息交流的效果。

	正在使用	考虑将来使用
1) 电子邮件系统	❑	❑
2) 基于项目的内联网	❑	❑
3) 三维可视化建筑设计	❑	❑
4) 四维模拟施工	❑	❑
5) 电视会议	❑	❑
6) 网上即时聊天系统	❑	❑
7) 其它（请注明）____________________________	❑	❑

2. 管理措施

1. 请您指出在与其他项目参与方进行沟通时，使用下列方法的频率，同时请指出不同交流媒介对于交流信息，解决问题，达成共识的效果如何：

媒介	从不使用 ↔ 经常用	效果很差 ↔ 非常有效
1) 分发或邮寄材料	1 2 3 4 5	1 2 3 4 5
2) 访问在线项目数据库，项目内联网	1 2 3 4 5	1 2 3 4 5
3) 会议	1 2 3 4 5	1 2 3 4 5
4) 电子邮件	1 2 3 4 5	1 2 3 4 5
5) 传真	1 2 3 4 5	1 2 3 4 5
6) 电话	1 2 3 4 5	1 2 3 4 5
7) 见面讨论	1 2 3 4 5	1 2 3 4 5
8) 电视电话会议	1 2 3 4 5	1 2 3 4 5
9) 其它 (请注明):_____________________	1 2 3 4 5	1 2 3 4 5

2. 请指出您对本项目组织结构的看法：

	非常不同意 ↔ 非常同意
1) 我熟悉其他参与方的职责和角色，清楚如何得到需要的支持和帮助	1 2 3 4 5
2) 项目有正式的文件明确界定各参与方的职责和角色 (如：合同安排)	1 2 3 4 5
3) 项目有正规的程序清楚规定信息交流的渠道，或者通过图表来表明项目各参与方之间的职能交接关系	1 2 3 4 5
4）项目建立了畅通的资料传递结构，可有效地进行报告和传递资料（比如有专人来负责与其他参与方传递信息和资料）	1 2 3 4 5

3. 请指出您对本项目各参与方之间关系的看法：

	非常不同意 ↔ 非常同意
1) 有效的管理措施在参与方之间建立起了有良好的工作关系，大家可以互相信任和帮助	1 2 3 4 5
2) 各参与方的工作理念和目标能够很好的符合已经建立起的项目文化和总目标	1 2 3 4 5
3) 有组织的培训使得各参与方都积极参与项目和团队工作	1 2 3 4 5
4) 项目参与方之间经常有社交活动，不同公司的同事之间关系紧密	1 2 3 4 5

4. 请您评价本项目在各参与方之间信息交流时所采用的以下信息管理措施的表现：

	效果很差 ↔ 非常有效
1) 项目文档管理系统，进行信息的收集和分类	1 2 3 4 5
2) 项目信息格式及信息交流协议（包括IT使用的协议和规定）	1 2 3 4 5

5. 请您评价本项目管理信息交流时间所采用的以下措施的效果：

	效果很差 ↔ 非常有效
1) 信息交流时间表即伴随施工过程的信息交流的时间安排	1 2 3 4 5
2) 变更通知和版本更新机制，总承包方对设计和需求变更前瞻性的管理	1 2 3 4 5
3) 项目的实时反馈机制，总承包方及时通知项目的进程和表现，并得到各参与方的配合工作	1 2 3 4 5

6. 请您评价本项目中各参与方的领导的能力：

备注：请评价各方在项目中的表现（包括贵公司）。如果您不了解其他参与方的某些的信息，可以留下空白。

	施工单位项目经理 弱 ↔ 强	甲方代表 弱 ↔ 强	设计代表 弱 ↔ 强
1) 专业技术能力	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
2) 其它专业领域的相关知识	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
3) 控制信息流的能力	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
4) 沟通能力	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
5) 积极投入项目工作，大部分时间驻施工现场，随时可以被找到	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
6) 与他人的工作关系	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
7) 项目领导的稳定性	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5

7. 请您评价本项目甲方的表现

	很弱 ↔ 很强
1) 工程项目建设方面的经验和专业知识	1 2 3 4 5
2) 可以提供高质量的设计和施工要求的信息	1 2 3 4 5
3) 适当的安排设计和施工的时间	1 2 3 4 5

8. 请您评价本项目总承包商的表现

	很弱 ↔ 很强
1) 可以制定详细有效的施工组织计划来安排施工的顺序和流程	1 2 3 4 5
2) 可以制定有效的措施来界定和管理各参与方的工作范围和工作交叉节点	1 2 3 4 5

9. 请您评价本项目主要的设计单位的表现

	很弱 ↔ 很强
1) 掌握了一定的施工知识，使项目的设计容易施工，提供易建性高的设计	1 2 3 4 5
2) 提供高质量的设计信息，很好控制设计变更	1 2 3 4 5
3) 提供相互兼容，各专业交圈对口的设计文件	1 2 3 4 5

3. 项目信息交流和沟通表现

1. 施工阶段中，您在与项目其他方沟通和交流信息时，请指出遇到的下列问题的频率。

	经常 ↔ 从不
1) 没有正确理解其他参与方的信息需求	1 2 3 4 5
2) 从其他参与方那里得到相互矛盾的信息	1 2 3 4 5
3) 沟通困难，其他参与方不协调工作	1 2 3 4 5
4) 缺乏信息，所需要的信息不能充分收集到	1 2 3 4 5
5) 信息量太大以至不能有效使用	1 2 3 4 5
6) 没有即时获得设计变更的通知	1 2 3 4 5
7) 没有即时获得进度变更的通知	1 2 3 4 5
8) 在信息传递过程中，需要的信息部分内容被改变或丢失	1 2 3 4 5

	经常	↔			从不
9) 在信息传递过程中，信息被信息管理者留滞	1	2	3	4	5
10) 不能充分接触信息源（信息提供者或时信息库） 请指出原因_________（1-人际障碍, 2-访问权限, 3-等级权限, 4-其它(请指明)	1	2	3	4	5

2. 总体来说，您认为本项目施工阶段各参与方之间的沟通和信息交流的表现如何？

	表现不好	↔			非常有效
	1	2	3	4	5

3. 请指出您所经历的和其他参与方的沟通问题的频率 （请在前边的❑选择出那个是您所属的组织并评价）

	经常	↔			从不
❑ 业主	1	2	3	4	5
❑ 监理	1	2	3	4	5
❑ 建筑师	1	2	3	4	5
❑ 结构，机电工程设计师	1	2	3	4	5
❑ 总承包方	1	2	3	4	5
❑ 主要的专业分保商	1	2	3	4	5
❑ 主要的供货商	1	2	3	4	5
❑ 其他(请指明) ______________________	1	2	3	4	5

4. 施工阶段中，在以下管理方面，您所遇到的与其他参与方的沟通问题的频率：

	经常	↔			从不
1) 设计和建筑功能要求	1	2	3	4	5
2) 成本管理	1	2	3	4	5
3) 时间进度管理	1	2	3	4	5
4) 质量管理	1	2	3	4	5
5) 安全管理	1	2	3	4	5
6) 环境管理	1	2	3	4	5
7) 合同管理	1	2	3	4	5
8) 材料和采购管理	1	2	3	4	5
9) 风险管理	1	2	3	4	5
10) 其它(请指明)______________________	1	2	3	4	5

5. 您认为在本项目中什么是项目团队间最大的沟通障碍？

____

____

6. 在本项目中，项目团队间的沟通和信息交流是如何提高的？

____

____

♦ 结束， 再次感谢您的参与！♦

若您能留下关于该项研究和问卷调查的宝贵意见我们将不胜感激！

如果您想获得一份此次调查问卷的结果，请填写您的姓名及联系方式。我们郑重承诺您所提供的信息只用于邮寄研究报告。

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