PROBLEMS AND BARRIERS OF ICT UTILIZATION ON IRANIAN CONSTRUCTION SITES: CASE STUDY ON THE SUCCESSFUL USE OF ICT IN REMOTE CONSTRUCTION SITES

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SUMMARY: *To clarify the current situation of ICT utilization in the Iranian construction industry, twelve semi-structured interviews were conducted with highly-experienced construction practitioners and ICT developers in the Iranian construction industry from 2009 to 2010. Interviews were qualitatively analyzed and a narrative interpretation was developed. Results obtained during this survey included identifying the barriers for ICT utilization in the Iranian construction organizations. The problems and barriers were divided into three groups: barriers for ICT usage in construction sites, barriers for ICT usage in head offices and common barriers of ICT usage in construction sites and head offices. This paper will discuss the barriers for ICT usage in construction sites. Some of the interviewees mentioned their company advances in ICT application and overcoming the barriers and problems. This paper focuses on a case study of a successful construction firm in the ICT utilization and overcoming the barriers of ICT adoption on remote construction sites. A study on ICT application in construction projects of this company can draw a pattern for other similar construction firms in Iran and.*

KEYWORDS: *case study, construction project, ICT barriers, ICT utilization, Iran.*

INTRODUCTION

Extensive advances in information and communication technology in recent decades have affected all industries. Construction industry also has been influenced by the information technology. ICT plays important roles in design, management and execution of construction projects. It has provided easy storage and fast access to accurate and updated information for construction organizations and made heavy calculations possible. Modern communication tools enable construction practitioners to have widespread connections between construction site and head office. In order to stay competitive, construction organizations use ICT in all processes related to construction.

Harris F. (2001) believes that besides acting as a mean for general management and processing of project and company information, there are other ways in which ICT has been taken on by construction. These developments affect the construction process itself and can be categorised into four main areas. They are standardisation (examples include the use of Electronic Data Interchange (EDI) and bar coding), visualisation (comprising Computer-Aided Design (CAD), Virtual Reality (VR) and Augmented Reality), communication (including video/data conferencing and Intranets), integration (employing infobases and project specific data bases).

To clarify the current situation of ICT utilization in the Iranian construction industry, twelve semi-structured interviews were conducted with highly-experienced construction practitioners and ICT developers of Iranian construction industry from 2009 to 2010.

This paper explains the current situation of ICT utilization in the Iranian construction industry with focus on the barriers and problems of ICT application in construction sites. The problems and barriers of ICT adoption in construction sites were extracted from the semi-structured interviews which were conducted with twelve practitioners from different companies involved in construction projects in Iran. After twelve interviews, the most successful construction firm in ICT adoption among all interviewees was selected for the case study. The way this company utilize ICT can be a insightful story that provides a pattern for other construction firms which are going to enhance the level of ICT utilization in their projects.

1. PREVIOUS RESEARCH

Information Technology in Construction (ITC) can be defined as the application of decision support tools, which uses electronic machines and programs for processing, storage, analysis, control, transfer and presentation of construction information data during the whole life cycle of a construction project (El-Ghandour and Al-Hussein 2004).

Revard H. et al. (2004) studied the use of information technology in the Canadian construction industry. They interviewed with professionals included architects, engineers, general contractors, and owners from eleven case studies which cover architecture, engineering, construction management, and specialized contractors. These case studies define an initial compendium of Best Practice in the use of information technology (IT) in Canada. The following issues were identified: the electronic distribution of documents is more efficient and cheaper; the short time-line and the tight budgets make it difficult to introduce new technologies on projects; the industry is locked in one CAD system and it is difficult to introduce new ones; it is costly to maintain trained CAD and IT personnel; and companies that lag behind reduce the potential benefits of IT. Still, the industry could achieve substantial benefits from the adoption of IT if it would be more widespread.

Peansupap et al. (2006) studied on Information Communication Technology (ICT) implementation constraints in the Australian construction industry. The Constraints at the personal level include limited budget for ICT investment, commitment from other project participants, issues of ICT standardization, and security problems. At the organizational level, constraints include basic levels of computer experience, time available to learn and the identification of clear benefits of ICT use. Constraints at the group level include time available to share information, quality of personal contact and geographical distance.

Hewage et al. (2008) believes that the Construction Industry lags behind other industries in its acquisition and use of modern technology. They investigated current status and challenges of IT usage in Alberta's building projects in Canada. Their research presents the views of three different construction industry stakeholders, namely, construction workers, construction managers and technology providers regarding the possibilities and opportunities in using Information Technology in construction project to improve communication and worker

satisfaction. Their paper ends up with a set of recommendations for enhancing the usage of IT tools and systems on construction projects as: use of a communication device/system to capture information of different parties and deliver efficiently to the construction site level, provide a portable communication device such as a personnel digital assistant (PDA) to field level managers such as field engineers and foreman, provide better (two-way) radios for all the construction workers, comprehensive analysis of construction industry needs of IT usage and system integration, create a "meeting place" for all the construction stakeholders to discuss their IT needs, expectations, and abilities, a third party participation in pilot testing potential information technologies for construction industry use, develop/conduct modern information technology related training courses for both workers and managers, detailed modern information technology related skills assessment of each and every construction worker in construction job sites and delegate responsibilities to use IT accordingly, more funding for third parties such as universities to conduct field work/pilot testing related to information technologies in construction and develop industry-wide standards for the use of IT.

El-Saboni et al. (2009) investigated the use of modern electronic communication management systems, and how these systems affect the success of construction projects in the United Arab Emirates (UAE). They found that benefits of ICT implementation in UAE client organization are transparency, governance and enhanced capability of decision making. For project management firm benefits include better control and more effective documentation. For consultant firms benefits like organized flow of work and quality assurance are achievable and for contractor benefits include tracking of submittals and timely approvals.

Ahuja et al. (2009) believes that effective and real time communication among all project members can be achieved through adoption of information and communication technology (ICT). Their study in India indicated that Small and Medium Enterprises (SME's) with higher turnover have higher adoption of ICT. They identified issues that need to be addressed at site office as following: systems should be periodically upgraded, software should be periodically upgraded, key site staff should be more IT aware and proficient, faulty telephone connection in far-off project sites, connectivity through internet is poor in remote project sites, download times are very high and data security issues need to be addressed.

Ahuja et al. (2009) identified issues that require action at the levels of industry, organization and people. For example personal meetings are still preferred by construction professionals over teleconferences and other e-meeting solutions for managing building construction projects. This issue requires action at the level of organization and people or "IT infrastructure at project sites and IT capability of site staff is an important factor and needs improvement in Indian construction industry" requires action at the organization level.

Alaghbandrad et al. (2010) explained how Iranian firms utilize ICT in administrative affairs and described trends and patterns of the Iranian organizations towards administration ICT application. The results showed that the Iranian construction organization acquire ICT facilities based on their needs and functionality of the facility. The paper also explains that important sections of a typical automation system in construction in Iran are archiving, personnel management and communication.

2. RESEARCH METHODOLOGY

This research has used the qualitative methodological approach. This approach helps the researcher to investigate the current status of ICT adaption in the Iranian construction industry by getting help from highly-experienced practitioners involved in construction projects in Iran. The qualitative approach helps the research to be focused on personal histories, perspectives, and experts′ experiences of construction industry (Bryman and Bell, 2003).

At the first step relevant literature related to ICT adaption in construction industry of different countries were reviewed. The aim was to understand problems and barriers that have been identified by previous researchers to provide a context for this research.

After reviewing the literature, twelve semi-structured interviews were conducted with construction practitioners and ICT developers in Iran during the period of 2009 to 2010. The aim was to clarify the current situation of ICT utilization in the Iranian construction industry. Naoum (2007) expressed that selected sampling is the most appropriate sampling method for qualitative interviewing. To gather enough data, twelve interviewees were selected among construction practitioners who have four specifications: a) to have work experience as a senior manager in a construction company, b) to have ten or more years of experience in construction, c) to be completely familiar with the culture and environment of construction industry in Iran, and d) to apply a minimum level of ICT in their organizations (to have personal computer, CAD/CAM (Computer-Aided Manufacturing) software, Microsoft Office, and access to internet). Ten interviews were conducted with professionals working in construction firms (contractors and consultants) using IT. Also, to gain better

understanding of the role of ICT developers in construction, two interviews were carried out with the senior managers of two local software developers companies. Two software developers were selected to interview based on recommendation of seven interviewees who use the software products of one of these two developers in their firms.

The goal of this research is to better understand the current situation of ICT usage in the Iranian construction industry. To achieve this goal, a semi-structured questionnaire was designed to be used in interviews. The semi-structured interview provided an open environment which allow for focused, conversational, two-way communication between the researcher and the respondent. Unlike the questionnaire framework, where detailed questions are formulating ahead of time, semi structured interviewing starts with more general questions or topics. Semi-structured questionnaire means that not all questions are designed and phrased ahead of time. The majority of questions are created during the interview. However, to make the interview process more organized the questionnaire divided into four sections.

The first section investigated the usage of some specific ICT tools like PC, GPS, GIS, Wireless facilities, bar code, email, Internet/Intranet, video conference, etc. The interviewees were asked whether they use these tools and what is the advantage and disadvantage of them. At the second section, they were asked about the current situation and experience of their companies in ICT utilization. Third section identifies the barriers and problems of ICT utilization in the construction firms and in the fourth section, the future ideal and expectation from ICT from respondent's point of view was studied.

Interviewing had been continued up to the point that desired level of data saturation was achieved. That was the point that the interviewer understood responses are being repeated by new interviewees and critical and sensitive information could not be received from them anymore.

To identify the barriers and problems of ICT utilization in the construction firms, three main questions were asked in the third section:

1. What are the barriers and problems of ICT utilization in your organization?
2. What are the risks of ICT utilization in your organization?
3. What are the problems of utilizing ICT in construction sites?

After gathering enough data, qualitative data analysis was undertaken using NVivo. Coding was the main qualitative data analysis method utilized in this study. It is a process for categorizing qualitative data and describing the implications of these categories. Based on the analysis a comprehensive interpretation was developed to reveal the hidden problems and barriers of ICT utilization on construction sites. Wherever it was suitable, the participants' direct quotes are cited anonymously to make the interpretation more meaningful.

It should be explained that it is an explanatory research that aims to collect knowledge about underlying process of ICT application in construction organization and its problems and barriers. Thus, instead of validity checking, which is usually used for quantitative research, two alternative measures of qualitative study is adopted: credibility and transferability. Since the purpose of qualitative research is to understand a phenomenon of interest from the participant's point of view, the participants are the only ones who can legitimately judge the credibility of the results. Hence, to make the research credible, the result of data analysis was presented to three interviewees and their beliefs, concerns and comments were considered. In terms of transferability, it should be expressed that the results of this study are restricted to the participants' experiences and their viewpoints and cannot be generalized in wider contexts. In other words, the result may not be the whole reality as in social studies like this there may be multiple realities. Hence, transferring the result to the wider or different context should be done by considering assumptions and limitation of the sample.

3. QUALITATIVE DATA ANALYSIS

During the analysis, it was revealed that barriers and problems of ICT utilization in the construction firms can be classified in two groups:

- Barriers and problems of ICT utilization in head office.
- Barriers and problems of ICT utilization in construction site.

This paper will focus only on barriers and problems of ICT utilization in construction site. During the data analysis it was understood that some Iranian construction projects were properly managed and equipped by ICT tools and study on ICT application in these construction projects as case studies is valuable.

Based on data collected from interviews, barriers and problems of ICT utilization in construction sites in Iran can be described in seven categories as shown in Fig. 1.

Problems and barriers of ICT utilization in construction sites:

- Poor ICT infrastructure

- Unfamiliarity of local personnel with ICT in remote construction sites

- No financial justification for ICT training of personnel in small construction sites

- Lack of feeling transfer in some electronic communication tools like video conference

- Inapplicable software outputs

- Complicated administrative process for ICT development

- Poor back up system in remote construction sites

FIG. 1: Problems and barriers of ICT utilization in construction sites.

3.1 Poor ICT infrastructure

Without a widespread and high quality ICT infrastructure, it's not possible to exploit ICT power completely. Some respondents believe that Iran's ICT infrastructure does not allow them employ their ICT tools with full capacity. For example internet speed is not enough to have online meeting by video conference, however, they are ready to have video conference if the internet speed be better. In addition, in some remote construction sites which are out of urban areas, there is not access to internet. Therefore, some pioneer construction companies in ICT who have huge projects in remote regions, have to invest on ICT infrastructure only for that project and this matter imposes a surplus cost to them. One of the respondents stated "We are driving on the ICT road. It's not possible to drive fast on a stony road. If we have decided to pass this way, we should pave the road".

3.2 Unfamiliarity of local personnel with ICT in remote construction sites

The personnel who are working in construction sites are usually in lower level of specialty compared with office employees and this matter is severe for remote construction sites because finding local experts is not always possible. Therefore, the company have to pay more to send experts to remote construction sites. This issue is not cost effective for small projects because a small project usually has a small profit margin and it is not justified to invest a lot for sending skilled personnel to remote construction sites for a small profit.

3.3 No financial justification for ICT training of personnel in small construction sites

Educated personnel are capital for a company. The construction firms usually attempt to maintain their educated and experienced staff. As it was expressed, skilled local personnel are not usually available to employ in remote

construction sites. Training the local personnel is a solution only for huge construction projects, because the local trained personnel of small projects will be unemployed in that region after project completion and usually the obtained profit is less than cost of education.

3.4 Lack of feeling transfer in some electronic communication tools like video conference

People express their purpose with words. The words are pronounced differently in different cases. Each pronunciation contains a specific feeling and purpose. One of the disadvantages of electronic communication tools is lack of feeling transfer. Video conference is a communication tool that is very beneficial for those construction firms that are executing remote construction projects. Online meeting can reduce travelling cost of personnel between head office and construction site. However, one of the respondents expressed that their company has the needed facility for video conference, but the personnel don't welcome this ICT tools. He believes that it has a human reason. He said "When the people are together, have more realistic feeling about meeting than when they are in their home. They have more action and reaction and interference when they are together".

3.5 Inapplicable software outputs

Engineering judgement is a key factor in design process of every construction project. In the design phase it's needed that experienced and knowledgeable engineers design or supervise the design process. Their experience enables them to have an excellent engineering judgement about applicability of design software outputs. One of the software developers believes that even if he consider building codes in their software as much as he can, but if the user had not sufficient technical knowledge, he/she cannot use the software correctly.

It can be inferred that in the remote construction projects that designers are working in head office and far from construction site, applicability of software outputs will be decreased if the designers did not have enough experience and imagination from execution of the outputs and if they want to visit and supervise the construction site, it will cost a lot to commute between head office and construction site.

3.6 Complicated administrative process for ICT development

As it was expressed, in some cases, to improve the poor ICT infrastructure, construction firms have to invest on ICT infrastructure only for a particular project. During the interviews, it was revealed that the administrative process of getting permission to develop some ICT infrastructure like internet is very complicated. An interviewee mentioned that "our company may be involved several months to get permissions". The interviewees believe that it will cost less for the government to develop ICT infrastructure in remote construction sites because the development cost will be distributed among all construction firms using these facilities. Otherwise, each company has to invest separately on a specific project.

3.7 Poor backup system in remote construction sites

In the remote construction projects, the company has to establish two separate organizations, one in the head office and another in the construction site. Connecting and integrating these two organizations is a crucial task. During the analysis stage, it was understood that one of the construction managers' concerns is the backup system. Due to lack of an integrated system between head office and construction site the backup system will be separated. One of the respondents said "we send the plans to the construction sites in format of computer files. If these files be available for contractor and supervision system without any limitation, everyone can make change on them deliberately or unintentionally and these changed files can be considered as the original plans".

4. CASE STUDY

After twelve semi-structure interviews, the best company in adoption of ICT among all interviewees was chosen to study more. Kayson which is a leading Iranian construction company was chosen for the case study. Kayson by employing more than 650 personnel and utilizing well-equipped construction machinery is involved in different sectors of construction industry including oil and gas, industrial building, transportation, water structures and general building. This private firm has carried out projects in Iran, the Persian Gulf area, Eastern

Europe, India and South America. Some of the current and previous notable projects can be mentioned as: Parand New City 40,000 unit housing project (Iran), 10,000 unit housing project (Bolivarian Republic of Venezuela), South Pars Gas Field Development (phase 12: onshore facilities liquid processing and utilities) (Iran), Imam Khomeini International Airport (Iran), Siah-Bishe pumped storage project upper and lower Dams (Iran), multifunctional hotel, business centre and Shopping Mall (Minsk, Republic of Belarus). (Kayson Co., 2011). Their head office is located in Tehran (Iran) and the construction sites are located in different regions in Iran and overseas. This company was chosen because it is assumed that management of these remote construction sites in an international scale is not possible without having effective utilization of ICT tools. An interview was conducted with Quality & Business Excellence Director of this company, Mr. Hemmati who is responsible for improving the performance of the company. He has about 30 years of senior management experience in Kayson and is a key manager in planning for ICT use in the firm. After discussing problems and barriers of ICT utilization in construction sites in Iran which were identified through twelve interviews, Mr Hemmati was asked to explain how his company has overcame these barriers and problems.

4.1 INVESTMENT ON INFRASTRUCTURE

The interviewee confirmed that local ICT infrastructure is weaker than needed level of their projects and his company establishes the required infrastructure both in small and huge construction projects. He justified this policy by mentioning these factors: Social Responsibility, Company Reputation, Transfer ICT facilities, Mobile ICT tools (Fig. 2).
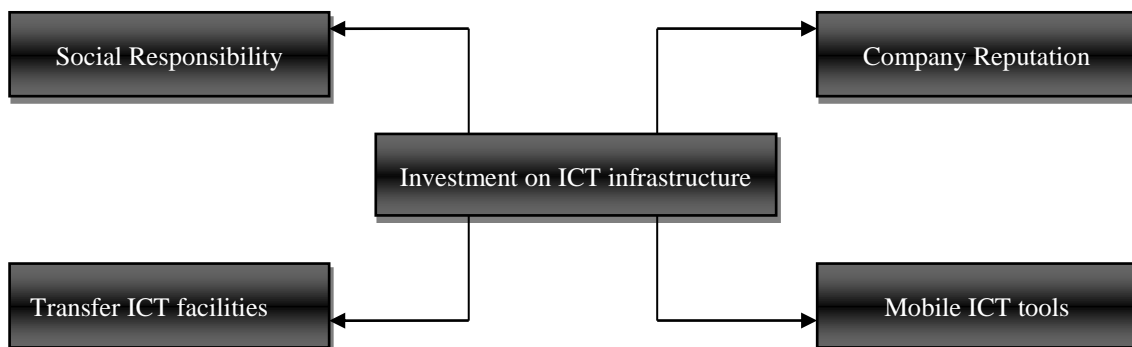

FIG. 2: Justifier factors for investment in ICT infrastructure in remote construction sites

4.1.1 Social Responsibility

This construction firm considers ICT as a basic need. In addition to benefit from ICT infrastructure for the company, new infrastructure improves the ICT facilities of project's region. This can be considered as part of the firm's social responsibility.

4.1.2 Company Reputation

The interviewee believes that some benefits obtained from investment in ICT infrastructure are intangible. These benefits may appear over the long term and even the investment return may be negative for small projects. However a construction firm whose projects are equipped with high quality ICT infrastructure can satisfy the client better and this satisfaction brings reputation for the company. This reputation causes more demand for this

construction firm. As a result, this company can attract more projects and more benefit. In addition, it is a fact that lack of suitable ICT infrastructure imposes hidden costs to the project.

4.1.3 Transfer ICT facilities

The company establishes some part of the ICT infrastructure for permanent use. After project completion some part of ICT infrastructure can be used for maintenance of the project or for other uses in that region. Therefore, if the construction firm foresees the required ICT infrastructure after completion of project and build them for permanent use, these facilities can be transferred and sold to the local authorities or operators of the projects and some part of the investment will be returned to the company.

4.1.4 Mobile ICT tools

Some parts of ICT tools can be used as mobile facilities. These facilities will not be installed in a certain place permanently and can be replaced after project completion and can be applied in other projects. It is an economic policy to avoid fixed and permanent ICT infrastructure.

4.2 HIERARCHICAL TRAINING OF PERSONNEL

As mentioned, training of local personnel may not be economic in small projects because the obtained profit is less than cost of education. However this problem can be adjusted by hierarchical training of personnel. In this case study, the company policy is training the most experienced and qualified staff of head office. This specialized central team, is employed in head office, but their duty is training of native personnel of remote construction sites only to a certain level that they need. Based on this method, the education costs will be optimum. In addition, the native educated personnel of a project, will remain as a capital for that region. This people demand for a new job after project completion. Hence, the local authority tries to create job for this unemployed experts by defining a new project. The first option for new projects will be the previous construction firm that has executed the last project successfully. Therefore, new opportunities will be created for the company because of new demands for job and successful performance.

4.3 ENCOURAGEMENT AND COMPULSION FOR USING ELECTRONIC COMMUNICATION TOOLS

We can mention video conferencing as one of the most important electronic communication tools in construction projects. This communication tool may not be welcomed from personnel sometimes because a video conference meeting may be boring due to lack of body language. In the remote construction sites video conference is a requirement for communication between head office and construction site because it's not feasible for personnel and managers to commute a long distance regularly. In the case study, the encouragement and compulsion policy was considered.

4.3.1 Encouragement

Senior manager and top leaders of company should be pioneer in using of video conference. This behaviour will encourage other staff to use this ICT tool. Preparing high-speed internet will increase the quality of video conference. Also some unofficial behaviour like smiling, joking, etc, will break official and boring atmosphere of this electronic meetings. Then the personnel will be accustomed with video conference gradually.

4.3.2 Compulsion

If the management consider the video conference as a compulsive communication tool and the company regulation be adapted with using video conference, the practitioners will consider this issue seriously.

4.4 NETWORK CONNECTION FOR DESIGNERS

The interviewee believes that it is not economic to send top designers and expensive experts to the remote construction sites. Also the number of them is less than number of projects. To overcome this problem, his construction firm has found a solution by getting help from ICT. The design process is distributed between head office and construction site. Top designers work at head office and there is a design unit in construction site. The high level designs and kind of designs which can be done in head office, will be designed in head office. Those kinds of design which the designer needs be present at the construction site will be duty of construction site design office. These two design offices are connected by network and top designers will support the construction site office performance.

4.5 JUSTIFICATION FOR REDUCING ADMINISTRATIVE PROCCESS

The interviewee mentioned that they have to justify some ICT organizations to provide ICT for their national and international projects. However, this issue is justified in some other countries. He believes that attitude towards ICT varies among different countries. In third world countries, the administrative process doesn't facilitate the use of ICT.

4.6 COMPREHENSIVE DOCUMENT MANAGEMENT SYSTEM

A strong document management system can prevent any unwanted change or missing documents. This construction firm controls document management through an excellent integrated back up system and an intelligent procedure of document approval. To avoid unwanted changes and missing documents, an integrated back up system is developed among all projects and head office. Also every change in documents needs to be approved through an electronic signature procedure. Every activity within this document management system will be saved daily, weekly, monthly, and yearly.

5. CONCLUSION

This paper presents part of a qualitative study on ICT adoption in the Iranian construction industry. The focus of this paper is only on barriers and problems of ICT utilization on construction sites and the specific approaches of a successful Iranian construction firm on ICT adoption on remote construction sites is described as a case study. Based on data collected from interviews, barriers and problems of ICT utilization in construction sites in Iran can be described in seven categories: poor ICT infrastructure, lack of local personnel familiar with ICT systems in remote construction sites, no economic justification for ICT training of personnel in small construction sites, lack of feeling transfer in some electronic communication tools like video conference, inapplicable software outputs, complicated administrative process for ICT development, and poor back up system in remote construction sites. The main factors which were important for this construction firm to overcome these barriers and problems include: investment on infrastructure, hierarchical training of personnel, encouragement and compulsion for using electronic communication tools, network connection for designers, justification for reducing administrative process, comprehensive document management system. A study on the ICT application in construction projects of this company can draw a pattern for other similar construction firms in Iran and other countries. The result of this study is limited to the participants' points of view and quantitative research should be conducted to confirm findings. The future research may be focused on identifying strategies for dealing with obstacles in ICT utilization in construction sites by conducting more case studies.

6. ACKNOWLEDGEMENT

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