PERCEPTIONS AFFECTING ICT ADOPTION FOR BUILDING PROJECT MANAGEMENT IN THE INDIAN CONSTRUCTION INDUSTRY

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ABSTRACT

Building project management requires effective communication between all project team members and small and Medium Enterprises (SMEs) constitute the majority of businesses in the building construction sector. A research was recently conducted with respect to SMEs to study their perceived barriers, associated enablers and benefits of effective adoption of information and communication technologies (ICT), in order to improve the management of building projects. A questionnaire survey was carried out in India to assess the importance of each identified perception. Data analysis shows that the industry and organization level barriers and associated enablers are perceived to be very important. Thus, the study identifies strategic actions to be taken by the managers at the industry and organization levels for increasing effective adoption of ICT for building project management. Analysis results have also been utilized for scenario building for ICT adoption within the building industry.

Key Words: perceptions, ICT, building, project management, SME

INTRODUCTION

Building construction project teams typically comprise multiple and geographically separated organizations of different sizes. The team structure is strongly decentralized with a weakly

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integrated environment. Also at any time, each construction organization could be involved in more than one project and could be a part of more than one supply chain (Dainty et al., 2001). This unique nature of the building industry requires that the communication protocols are adopted by the industry as a whole and do not remain project specific.

Collaboration and coordination can be achieved through the use of Information Communication Technologies (ICT). But, compared to other sectors, the building industry has been slow in the adoption and embracing of IT tools and techniques (Love et al., 2004; Opfer, 1997). Effective use of ICT by the organizations and its diffusion in the industry is required to be properly managed to better prepare for future ICT applications adoption (Peansupap and Walker, 2005). The issues of slow response and proper management of ICT applications warrant further study.

Building professionals, who are a part of different project team organizations, manage projects and the project team organizations, are a part of the construction industry. Thus, holistic study is required at the levels of industry, organization and the people. The issues that require study are technical, managerial, cultural and socio/political due to differing perceptions of the project team members. IT research in construction till now has predominantly had a technical focus rather than a managerial nature such as investment justification, strategy and strategic information systems planning (Love et al., 2004). Also, to date, a methodology has not been developed to examine the potential contributions of information management strategies in reducing overall project schedules and cost (Back and Moreau, 2000). Thus, perception based analysis is relevant in the context of ICT adoption for construction project management, since extent of ICT

adoption on construction projects is primarily defined by the perceptions of the project managers (Peansupap and Walker, 2005).

In construction industry, majority of the construction organizations can be categorized as Small and Medium enterprises (SMEs) and the communication management research is required to address management and communication processes adopted by SMEs. Also, by virtue of the number of organizations, greatest strategic scope exists at this level (Betts, 1999) and strategic adoption of ICT by the construction industry is defined by the strategic and operational requirements of SMEs. These issues can be addressed by global research, but also require clear understanding of the management and communication processes followed by the SMEs of each distinct regional area or country. Against this contextual backdrop, this paper studies the perceptions of SMEs in the Indian construction industry regarding barriers, associated enablers and benefits of effective ICT adoption for building project management.

The paper first discusses the research methodology adopted for data collection and analysis. Further, it discusses the identified perceived barriers, associated enablers and benefits of effective ICT adoption for building project management. The elements of findings come from the combined literature review and survey of building professionals. Specific requirements of SMEs, and data analysis through scenario building are discussed for the present status of ICT adoption for building project management in the Indian building industry. Perceptions and issues that require further action at the levels of industry, organization and people are also revealed.

RESEARCH METHODOLOGY

Literature review and discussion with the experts led to the identification of perceived barriers, associated enablers and benefits of effective adoption of ICT for building project management. Perceived barriers for effective adoption of ICT were studied at the four levels, i.e. industry, organization, projects, and technology levels (Table 1). Identification of the perceived barriers at each level led to the identification of perceived enablers of that level, since enablers are required to mitigate barriers and assist in enhancing ICT adoption in the industry (Table 2). But, some of the industry related barriers could also be addressed through strategic decisions taken at the project level for administration and increasing team collaboration. Perceived benefits were grouped under measures of project success, effective team management, effective use of technology and increased efficiency of the organization (Table 3). Fig.1 shows the groups in which perceived barriers, enablers and benefits were studied and their inter-relation.

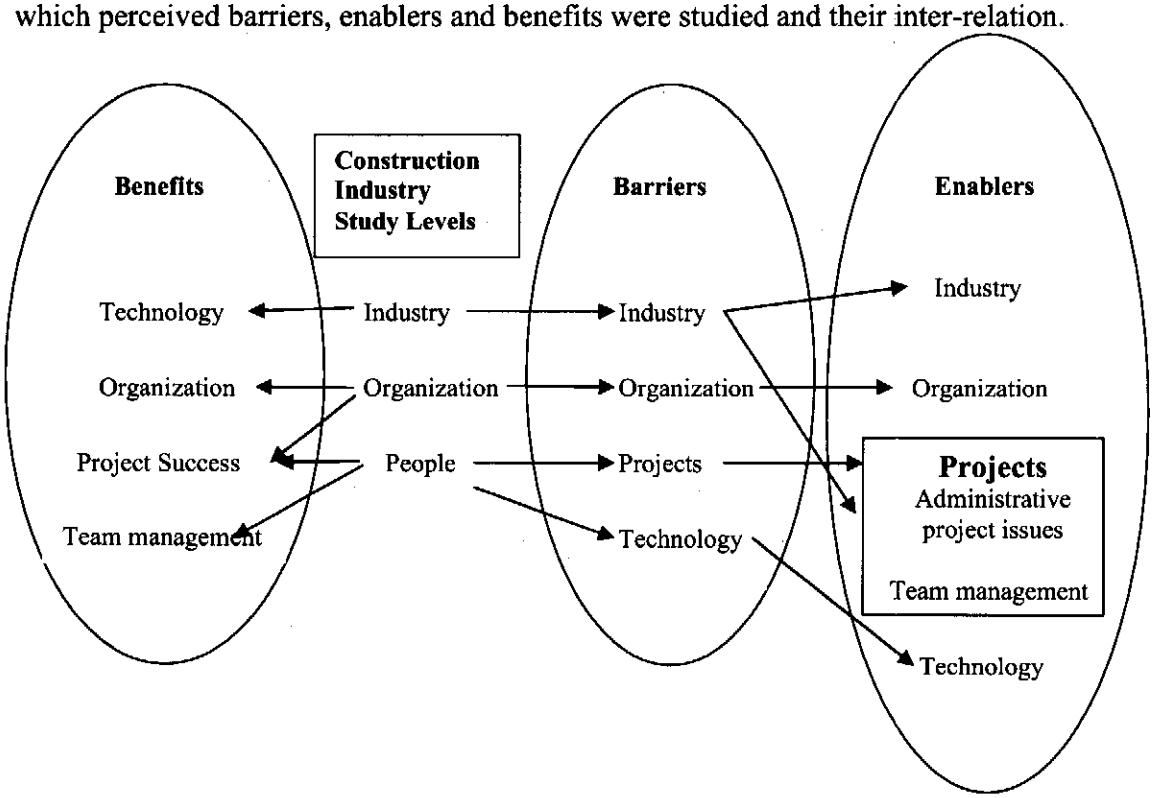

Figure 1: Relation between the Groups in which the Perceptions are studied

Table 1: Descriptive Statistics – Perceived Barriers

Rank	Barriers	Group	Mean	Std. Deviation
1	Poor supply-chain management of contractors, sub-contractors, specialists and suppliers in the construction projects	Industry	3.72	1.23
2	The separation of the process of design, construction and operation and maintenance of buildings	Industry	3.70	1.23
3	Lack of strategic direction within the industry in terms of standards and protocols that would inform any ICT investment decision	Industry	3.62	1.01
4	Fragmented construction industry having several different organizations big and small, having different set of requirements and different level of ICT knowledge	Industry	3.59	1.14
5	Cost of keeping up to date with the technological developments in hardware/software	Organization	3.58	1.11
6	Initial cost of ICT infrastructure installation	Organization	3.54	1.33
7	Non-availability of critical mass of organizations/projects in the industry that adopt ICT	Industry	3.47	1.10
8	The construction industry does not work on absolute standards or is not dominated by one strong leader, as is the case like IBM in computers or Ford in automobiles.	Industry	3.46	1.07
9	Cost of training the staff for technological developments in hardware/software or hiring new staff for the updated technology	Organization	3.44	1.19
10	Lack of technical standards for communication interface between different software	Technology	3.42	1.12
11	Security of data	Technology	3.41	1.19
12	Senior construction professionals unwilling to adopt ICT	Organization	3.19	1.51
13	Uniqueness of each construction project	Projects	3.15	0.87
14	High staff turnover in construction organizations	Organization	3.03	1.35
15	Non-dependability of IT Infrastructure	Technology	2.87	1.18
16	Information overflow because of use of Internet as a communication tool	Technology	2.74	1.13
17	Uncertainty of benefit from use of IT based communication	Organization	2.52	1.36

A questionnaire survey was conducted in the Indian construction industry to assess the importance of each perceived barrier, enabler and benefit as perceived by the organizations involved in managing building projects. The unit of analysis for the survey was an organization managing building projects and the sample population was SMEs in the Indian construction industry. Based on the literature review, for the research study, an SME was defined as an organization with staff upto 250. Survey was conducted across India to minimize the regional bias. Survey sample was selected from the Yellow Pages and the Notified lists of Professional bodies and falls under the group of Purposive Sampling. Three groups of organizations were

included in the sample: builders, including contractors who construct and manage their own projects; PM consultancy organizations, which are formally appointed as project managers on building projects; and architectural organizations, which manage small to medium size building projects, as project managers are not formally appointed on many such projects. Targeted respondents were the senior level executives in the organizations. Respondents' response for each identified perception was rated on a five-point Likert scale. On this scale, 1 and 5 corresponded to 'not important' and 'most important' respectively, whereas 3 corresponded to 'moderately important'. Descriptive analysis was conducted for the data collected for each group of the perceptions and the perceptions were ranked based on the mean responses. Some of the perceptions had high standard deviation and responses for these perceptions were studied individually. t-test of significance was also conducted for data analysis of perceived benefits. It was found that there is a relation between the perceptions and the size of organization as well as the extent of ICT adoption by the organization.

Content validity of the questionnaire was supported by an extensive literature review, discussions with experts from the industry and academics and pre-test of the questionnaire through a pilot survey. 149 usable responses were received for a response rate of 40%. Out of the 149 responses received, 75 (50%) were from Builders, 49 (33%) from Project Management Consultancy organizations (PMCOs) and 25 (17%) from Architectural organizations. For postal surveys in the construction industry, 30%-40% response rate is considered satisfactory (Liberatore et al., 2001; Love and Smith, 2003).

Table 2: Descriptive Statistics – Perceived Enablers				
Rank	**Enablers**	**Group**	**Mean**	**Std. Deviation**
1	Information flow planned in standardized formats	Projects	4.44	3.43
2	Improved IT support to construction site processes	Projects	4.30	0.78
3	Development of a realistic and reliable electronic database in the organization	Organization	4.26	0.83
4	All project team members use the same IT systems for the project	Projects	4.25	0.87
5	Education of the users for effective use of ICT and its Benefits	Industry	4.23	0.89
6	Systems for better communication between office and project sites	Projects	4.23	0.87
7	Each project to have a champion for adoption of ICT and acting as the team leader. It could be the Project Manager/owner's project representative	Projects	4.19	0.90
8	Senior management should create an environment for adoption of ICT within the organization	Organization	4.17	0.90
9	Project scope requiring use of ICT	Projects	4.16	0.94
10	Adequate and dependable conditional access systems to be provided for the automated system	Technology	4.14	0.81
11	Shared use of common databases by project team members	Projects	4.13	0.88
12	Project information seamlessly transferred between all the phases of a building project.	Projects	4.13	0.84
13	Standardized drawing formats for presentation and content.	Technology	4.12	0.93
14	Equal attention to be given to associated managerial issues while conducting technical implementation	Organization	4.11	0.81
15	ICT Training to be more accessible and less costly	Industry	4.09	1.04
16	Increased use of 3D visualization techniques as a communication tool	Technology	4.08	1.12
17	Education of the users that ICT does not increase isolation but enhances team working	Industry	4.08	0.91
18	Widespread adoption of ICT in the construction industry	Industry	4.08	0.93
19	Measuring benefits accrued by utilization of IT based communication	Organization	4.05	0.96
20	Collaboration between research and practice	Industry	4.03	1.00
21	Better collaborative maturity or trust between team members for sharing information	Projects	3.97	0.88
22	Use of standardized information classification systems	Technology	3.95	0.98
23	Periodicity and alternative methods of communication for each process finalized at the start of the project	Projects	3.95	0.80
24	Industry data and information bases maintained by professional bodies and government agencies	Industry	3.93	1.15
25	Software to be more user friendly and flexible	Technology	3.93	0.95
26	IT communication systems developed within organizations to be business driven	Organization	3.90	1.00
27	Organization structures to be reengineered for use of ICT	Organization	3.89	1.01
28	Use of common internet services by project team members	Projects	3.88	1.08
29	Using web based systems also as a workspace	Projects	3.84	4.22
30	Subcontractors and suppliers to be integrated formally into communication and reporting structures	Projects	3.83	1.02
31	Development of data communication and exchange standards	Technology	3.81	0.87
32	Time and cost scheduling software with increased capability for risk management	Technology	3.74	1.07

33	Development of interaction communication protocols, information policies, and meeting structures for online meetings.	Projects	3.65	1.13
34	Flexible/scalable systems that would help in meeting changing demands	Technology	3.64	0.99
35	Better interface between PM/scheduling software and software utilized for other processes	Technology	3.63	0.65
36	Availability of indigenously developed software incorporating the specific construction industry requirements of the country	Technology	3.60	1.26
37	Availability of more multilingual software and web portals	Technology	2.74	1.27

Each organization's data was studied for the cumulative responses of perceived barriers and benefits. Relation between these cumulative responses helped in scenario building for present status of ICT adoption for building project management in the industry with respect to the perceptions.

This research methodology comes under the realm of Interpretive research, as the perception based data has been interpreted for results formulation. Interpretivist approach tries to understand the process and delves deeper to offer second order explanations for the process and the context of observed phenomenon is of extreme importance (Srivastava and Teo, 2006).

LITERATURE STUDY

Barriers and Enablers

There is poor supply-chain management in the construction industry and communication is one of the technologies considered relevant to meet this challenge. But, researchers have identified that organizations consider initial cost and cost of keeping up to date with the technological developments in training and hardware/software as an important barrier for effective utilization of ICT (Mitropoulos and Tatum, 2000; Root and Thorpe, 2001). Root and Thorpe (2001) have also linked it to the lack of strategic direction within the industry, both in terms of overall direction and the standards and protocols that would inform any IT investment decision. Thus,

identification of organizational changes required for effective use of ICT (Froese, 1996; Mitropoulos and Tatum, 2000) and measuring benefits accrued by utilization of it are important enablers for its effective utilization (Mitropoulos and Tatum, 2000).

Table 3: Descriptive Statistics – Perceived Benefits

Rank	Benefits	Group	Mean	Std. Deviation
1	Effective communication management between project team members	Team management	4.54	0.61
2	Project completion as per the estimated time	Projects	4.50	0.82
3	Project information obtained in real time	Projects	4.45	0.83
4	Project completion as per the estimated budget	Projects	4.35	0.82
5	Greater management control	Team management	4.29	0.78
6	Client satisfaction	Projects	4.28	0.78
7	Improved capability of the system to cross reference to other correspondence	Technology	4.27	0.73
8	Effective collaboration and coordination between project team members	Team management	4.26	0.70
9	Reduced risk of errors and rework on projects	Projects	4.25	0.88
10	Multilocational availability of information	Technology	4.23	0.91
11	"One-source" documentation archive maintained for clients	Projects	4.19	0.93
12	Useful information compiled and disseminated to other projects	Organization	4.17	0.75
13	Better information assessment and management within the organization	Organization	4.15	0.98
14	Richer information is made available to managers	Projects	4.15	0.84
15	Effective concurrent construction management	Projects	4.13	0.93
16	Increase in overall organizational efficiency	Organization	4.05	0.96
17	Effective contract management	Projects	4.01	1.00
18	Effective joint decision making	Team management	4.00	0.87
19	Effective change management	Projects	3.99	0.97
20	A complete log of all communications maintained for tracking purposes	Projects	3.99	0.85
21	Ease of retrieval of information	Technology	3.99	0.99
22	Project managers can spend more time on managerial work	Projects	3.99	0.99
23	Flow of accurate information	Technology	3.98	1.11
24	Less time spent in query and approval process	Projects	3.91	0.95
25	Increased information portability in the ICT environment	Technology	3.86	0.94
26	Effective material procurement and management	Projects	3.85	0.94
27	Life cycle concept becomes a competitive factor	Projects	3.83	0.89
28	Reduced hard copy filing/storage of documents/drawings	Technology	3.81	1.21
29	Project completion as per the specifications	Projects	3.70	1.08
30	Motivation of the workforce	Team management	3.66	1.25
31	Reduced administrative costs of document handling and distribution to multiple parties	Projects	3.56	1.33

In collaborative working, benefits of any technology come through widespread adoption of the technology. The lack of critical mass of construction projects requiring use of ICT has resulted in organizations being unwilling to make technological advances, especially with respect to communication technologies (Root and Thorpe, 2001). But, widespread technological change would require a good level of awareness of the technology throughout the industry, understanding of the technology and how to work with it (Froese, 1996). Project scope should also require use of ICT (Root and Thorpe, 2001). Also, CEOs and top managers' perception of importance of use of IT helps to align IT strategies and goals with those of the company as a whole. Equally important, it sends a strong signal throughout the company that IT is taken very seriously (Bawden and Blakeman, 1990).

Organizations need a realistic and reliable knowledge base which needs to be transmitted in the organization at a fast pace and made easily and instantly available to engineers/managers at all levels (Pandit and Munshi, 1999). But, SMEs do not see justification in spending money on large databases in isolation and require help from large organizations and government bodies for the same.

Communicating information in standardized formats supports integration of different project phases. Also, effective information sharing could be achieved through use of common Internet services or shared use of common databases (Construct IT for Business, 2000a). ICT support to construction site processes is also important and inter-organization integrated document control and management systems are required to be developed.

Effective communication, training, education and organization structure are identified as important cultural characteristics impacting upon the utilization and exploitation of IT for teamworking (Egbu et al., 2001). Construction program graduates schooled in ICT technologies will increase its use in the industry. In part, contractors have adopted computerized cost estimating and other systems due to the fact that college-educated construction graduates were familiar with these tools (Opfer, 1997).

As per Desai (Desai, 1999), Barbour report had identified software incompatibility and lack of user education as an important barrier for transition from paper to electronic record keeping. Standardization of information transfer is very important at national as well as international level (Vera Programme Report, 2000) and can be achieved by industry level initiatives.

Technology related barriers for effective ICT adoption have also been identified. In a survey, it was found that most of the respondents agreed that the quality of IT equipment and infrastructure made available to them was a major factor in ensuring that they used it (Egbu et al., 2001). So, inappropriate and inadequate ICT infrastructure is a barrier for its effective adoption. Also, while using ICT, organizations have a fear of data security (Root and Thorpe, 2001). A project web site provides a centralized, commonly accessible, reliable means of transmitting and storing project information. But, people need a road map to integrate the project web sites as a tool into their work on a daily basis (O'Brien, 2000).

Liberatore et al. (2001) have identified following issues as enablers of effective ICT adoption and areas of future research: Integrating PM software with other software packages and with

enterprise wide systems for such activities as materials management and financial control; Increased flexibility of PM software; Ease of use issues including making the software more user friendly and making training more accessible and less costly; Improved software capabilities to communicate project information with field sites; Increased capabilities to handle project uncertainty/risk and improved methods to forecast activity duration.

At the organization level, all IT development in an organization should be business driven and should play a part in and be integral with construction activities and business processes of the organization (Construct IT for Business, 2000a). At the project level, ICT adoption requires a champion i.e. individuals that are committed to the change and that are in a position to influence their organizations (Froese, 1996) or project teams. The champion could be the project managers or clients.

In the context of Indian construction industry where questionnaire survey was conducted for data collection, it is seen that India has a large population using English efficiently, but still majority in India cannot use this language. Web sites, web portals and software have been launched in regional languages by IBM, Microsoft and other IT agencies. Availability of multilingual software could be considered as an enabler for effective ICT adoption in the Indian construction industry.

Benefits

Benefits of ICT adoption for managing construction projects and improving overall organizational efficiency have been discussed in the literature. Some of the identified benefits

are: Richer information to aid decision making; Project information obtained quicker; Improved communication; Closer relationships; Improved information flow and greater management control (Construct IT for Business, 2000b; Love et al., 2004; Root and Thorpe, 2001). Desai (1999) has reported that Barbour Report has identified following benefits of ICT adoption: Increased speed of communication; Easier than paper communication; Ease of coordination; Lack of filing/storage and accuracy of information.

Egbu et. al. (2001) have discussed that in a survey, the majority of interviewees regarded IT as speeding up communication and enabling greater dissemination of written data. It was generally agreed that it is important for overall organizational efficiency and increased motivation among the team members. Various business models have evolved which draw upon links between the use of the Internet to perform project management and to improve an organization's internal processes in their road to achieving excellence (Alshawi and Ingirige, 2002).

ICT adoption for increased collaboration between project team organizations has been discussed in the literature (Back and Bell, 1995; Villagarcia and Cardoso, 1999). Use of ICT allows for a large number of options, products and solutions to be considered, appraised and included in minimum time. It also allows project teams to function more efficiently, particularly under concurrent construction arrangement. The net result is significant savings in project time and cost as well as improved realization of project value and goals (Jaafari and Manivong, 1998).

Benefits of using Internet as a communication tool and workspace for managing construction projects have been widely discussed (Alshawi and Ingirige, 2002; Chan and Leung, 2004;

Ruikar et al., 2005). Benefits of web based systems have been identified as: Reduced manual distribution costs; Integration of project information; Simple management of access rights; Document storage & archiving; Continuous access to project information and minimal software requirement (Construct IT for Business, 2000b).

Theoreticians and researchers universally agree that the key to enhance organizational efficiency, productivity and quality through DSS is to integrate the information flow and decision making processes vertically and horizontally, in order to coordinate and manage conflicts amongst various sub-units of the system (Pandit and Munshi, 1999).

Effective implementation of ICT within projects, as well as the entire industry would improve the communication processes by an order of magnitude, and would thus benefit the delivery of all phases and functions on projects (Jaafari and Manivong, 1998).

Small and Medium Enterprises (SMEs)

In construction, where 97% of the organizations employ less than 20 persons, a typical organization is an SME (Katranuschkov et al., 2001). It is a heterogeneous sector encompassing small, unorganized enterprises as well as modern and more organized ones. One of the most important issues that hinders the growth of SMEs in a globalised scenario is that of access to appropriate technology when technology upgradation is the key to facing global competition (Balsubramanian, 2006).

The projects can require involvement of a great number of small and large enterprises with varying collaborations (Goodman and Chinowsky, 2000). Larger organizations view the contract organizations as an extension of their facility and it is usual for them to ensure that the operational procedures and quality standards of their contract organizations are compatible with theirs (Huin, 2004). So, when the SMEs are managing the projects as contract organizations, their ICT adoption is determined by the requirements of large organizations. In the manufacturing industry, an SME would primarily be an extension of a large organization as its contract organization. *But, in the construction industry, an SME may also be independently managing the building projects. In such a situation, the extent of ICT adoption would be determined by the ICT capability of the SME and its staff.*

ANALYSIS

Perceived Barriers

Table 1 shows the mean and standard deviation for identified perceived barriers. Study of the ranking of the perceived barriers and enablers shows that Industry related barriers are among the top 50% barriers. Organization related barriers are in the middle and lower levels. Technology related barriers are among the last 40% barriers. There is only one project related barrier and it is in the middle level.

Highest ranked barrier is 'Poor supply-chain management of contractors, sub-contractors, specialists and suppliers in the construction projects'. This barrier has been considered as an

Industry related barrier instead of Project related barrier, because this issue is required to be strategically addressed at the industry level and would provide benefits in the projects. Barriers related to basic structure of the construction industry in terms of 'fragmentation', 'lack of strategic direction' and 'separation of the process of design, construction and operation and maintenance of buildings works' are also ranked high. 'Initial cost' and 'cost of upgrading ICT infrastructure' related barriers are the next. But, barriers related to 'cost of training the staff or hiring staff for new technology' have lower ranking.

This is so because training of the staff is not prevalent in most of the construction organizations and staff salaries in the construction industry are defined primarily by the technical expertise of the staff and not by their ICT capability. Barrier related to 'initial cost of ICT infrastructure' has high standard deviation of 1.33, which indicates that varied responses have been given by the organizations for this barrier. After studying the responses it was found that for organizations with higher turnover it is not an important barrier.

Barriers related to 'non-availability of critical mass of organizations/projects in the industry that adopt ICT' and 'not having an industry leader or defined industry standards' have middle level rankings. These barriers affect setting up or defining the benchmark practices for ICT adoption in the industry. Technology related barriers, such as: 'lack of technical standards for communication interface between different software', 'security of data', 'non dependability of ICT infrastructure' and 'Information overflow due to use of Internet' are not perceived as very important barriers, even though primarily standalone software are used for discrete applications. The barrier related to 'senior construction professionals unwilling to adopt ICT' is also low in

ranking, and this fact in itself is an enabler. Mean ranks of the barriers 'high staff turnover in construction organizations' and 'uncertainty of benefit from use of IT based communication' are low. But, their standard deviation is highest at 1.35 and 1.36 respectively, indicating varied perceptions for these barriers. After studying the responses individually, it was found that the perception of these barriers is influenced by the size of the organization. These barriers are not very important for organizations with high turnover. Case study analysis of some of these organizations showed that due to proactive HR policies, staff turnover is not an issue in these organizations. Also, these organizations conduct subjective evaluation of benefits of ICT adoption, thus they are uncertain about its benefits.

Analysis shows that available Technology in terms of ICT infrastructure is found primarily adequate by the organizations, and high ranked barriers are Industry related barriers or Organization related barriers. These require strategic initiatives at the industry and organization levels.

Perceived Enablers

Table 2 shows the mean and standard deviation for the identified perceived enablers. Study of the ranking of perceived enablers shows that Industry and Organization related enablers are primarily at the top and middle levels. Technology related enablers are in the middle and bottom ranks. Projects related enablers are distributed at all the levels.

The project related administrative enabler of 'planning information flow in standardized formats' is at the highest rank, but it has a high standard deviation of 3.43, which indicates varied perceptions. Very low importance has been given to this enabler by the organizations that have low ICT adoption. Other project related administrative enablers like 'Improved IT support to construction sites', 'project team members using same IT systems', 'each project to have a champion for adoption of ICT and acting as the team leader' etc. are ranked high.

'Project scope requiring use of ICT' is at the middle level and team management related enablers like 'Better collaborative maturity or trust between team members for sharing information', 'Shared use of common databases by project team members' etc. are at the middle and bottom levels. 'Using web based systems also as a workspace' is a low ranked enabler but has a high standard deviation of 4.22 as most of the respondents are not aware of the web based systems and hence do not consider it important, but organizations with higher use of ICT consider it important.

Organization related enabler 'Development of a realistic and reliable electronic database in the organization' is ranked high. Other organization related enablers are related to strategic planning at the organization level by the senior management and are ranked at the top and middle levels. The organizations look at the professional bodies, academicians and large organizations to take the initiatives and to educate the users for effective use of ICT and its benefits. Other industry related enablers are ranked at the middle level.

'Security of data' has been rated as a middle ranked barrier and 'adequate and dependable conditional access systems to be provided for the automated system' has been rated as a middle

ranked technology related enabler. It indicates that data security is an issue that needs consideration. Enablers related with 'standardized information systems' and 'increased use of 3D visualization techniques' are at the middle level. Technology related enablers addressing requirement of 'better interface of different software' and 'indigenously developed software' are at the bottom. This was also validated through separate analysis which showed that primarily international level standard software are being utilized in the industry.

Analysis shows that it is important for the clients to include use of ICT in the project scope. Some of the industry related barriers can be addressed while planning and setting up systems at the project level. But, these systems are required to be set up by a team member who takes the lead in defining the ICT adoption in a project. Such a champion of adoption of ICT should also address the issues that improve team management collaboration. All the project team organizations should develop strategic plans aligning the adoption of ICT with their business plans and maintaining a reliable electronic database in the organization. It is also important that at the industry level, education and training are provided to the construction professionals for adopting ICT.

Perceived Benefits

Table 3 shows the mean and standard deviation for the identified perceived benefits. Descriptive statistics showed that all the groups of benefits have been considered equally important and overall it is perceived that the adoption of ICT leads to significant benefits. t-test of significance was conducted and the results were found significant.

'Effective communication management' is considered as the most important benefit. 'Project completion on time and as per the estimated budget' are also high ranked benefits, 'project completion as per the specifications' is ranked low, because it is perceived that there are other factors also that drive this benefit. Adoption of ICT also leads to 'client satisfaction'. Benefits related to 'greater management control', 'effective joint decision-making' and 'change management' are also important. 'Effective contract management' benefit is medium ranked, since adoption of ICT partially drives this benefit. 'Flow of accurate information' is ranked in the middle, but it has high standard deviation since some respondents were of the view, that, even if ICT is adopted, accuracy of information cannot be achieved unless input data is accurate, which further stresses the requirement of training and education.

The majority of the respondents perceive that adoption of ICT does not lead to substantially 'reduced hard copy filing/storage of documents/drawings for the projects' and 'reduced administrative costs of document handling and distribution to multiple parties'. This analysis was also validated through separate analysis which showed that almost all the surveyed organizations keep hard copy backup of documents along with the electronic copy, and all good for construction documents and drawings have to be delivered at site as signed hard copies. But high standard deviations of these benefits show that some organizations do perceive these benefits as important.

In the context of ICT adoption for building project management, effective adoption of ICT can be defined by the extent to which ICT adoption reduces human resources, time and cost for

managing information for building project management processes. As per the results discussed above, time of communicating information is perceived to have reduced. But, since hard copy storage of data has not reduced, human resources cost and time related with managing information have not reduced.

Scenario Building for the Industry

Each organization's data was studied for the cumulative responses of perceived barriers and benefits. Based on these cumulative responses, scenario building has been done for the level of ICT adoption for building project management in the industry with respect to the perceptions.

The study included 17 identified barriers and importance of each barrier is rated on a 5 point Likert scale with scores 1-5. Thus, cumulative score of the barriers for any organization could range from 17-85. Considering equal range grouping, cumulative scores of 17-39 are considered as low, 40-62 as medium and 63-85 as high. The study included 31 identified benefits and cumulative scores of benefits for any organization could range from 31-155. Considering equal range grouping, cumulative scores of 31-72 are considered as low, 73-113 as medium and 114-155 as high. The matrix in Fig. 2 shows the distribution of the surveyed organizations for low, medium and high perceptions of the barriers and the benefits and results of the scenario building. The definition of high and low ICT adoption is in reference to ICT adoption by SMEs in the Indian construction industry where the questionnaire survey was conducted.

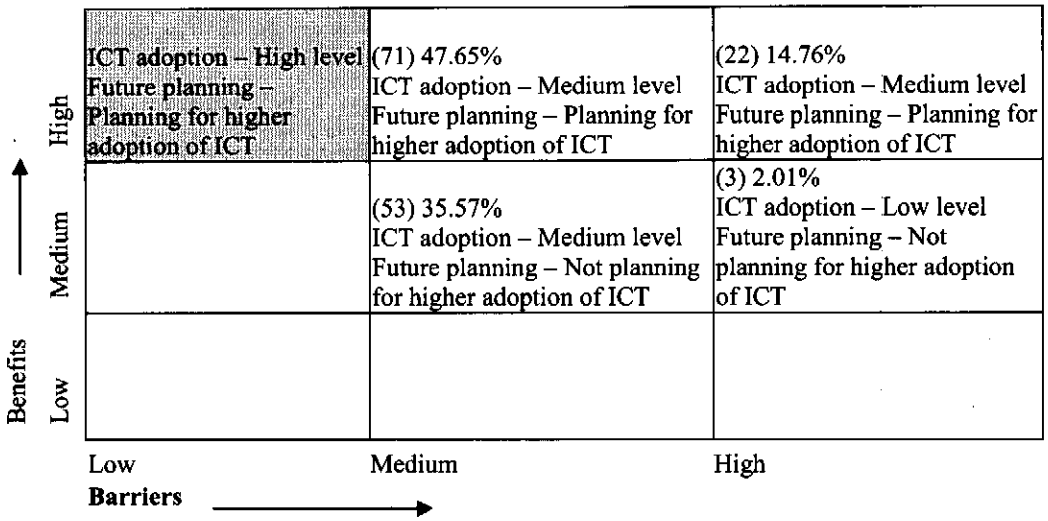

Fig. 2: Matrix with the Distribution of Organizations for Different Levels of Perceptions of Barriers and Benefits and Results of Scenario Building

53 (35.57%) organizations perceived medium level barriers and benefits. Thus, if not driven by the industry requirements, these organizations would be medium level adopters of ICT. They would also not be planning for high level adoption of ICT, as they perceive only medium level benefits. 3 (2.01%) organizations perceived high barriers and medium benefits. By default, ICT adoption in these organizations would be low. 71 (47.65%) organizations perceived high benefits and medium level barriers. ICT adoption in these organizations would be in the middle level, but these organizations would be planning for the further increased use as they perceive high benefits. 22 (14.76%) organizations would like to increase the ICT adoption in their organizations because they perceive high benefits, but perception of high barriers would define their present use and future planning for ICT adoption.

There are no organizations in the survey that perceived low barriers or low benefits of effective adoption of ICT for building project management. The scenario building results can be summarized as given below.

An organization's ICT adoption for building project management would be of high level, only if the senior management perceives low barriers and high benefits of ICT adoption.

DISCUSSION

Questionnaire survey was conducted at the organization level. But the survey was conducted across India. Thus, the results can be generalized at the industry level. Above discussed analysis led to the identification of issues that require action at the level of industry, organization and people.

- **Strategic initiatives are required to be taken by the professional bodies and large organizations in the industry.**

Study of data regarding perceived barriers and enablers shows that strategic initiatives are required to be taken by the professional bodies and large organizations in the industry: to address administrative and managerial issues; to provide training and education to the construction students and executives; to create an atmosphere in the industry for collaborative maturity or trust between the project team members for sharing information; to prepare electronic databases which should be available for the SMEs within the industry; to develop integrated systems for information sharing in the industry; and to initiate standardization of data etc.

Action required: Industry level

- **Large organizations and professional bodies are required to take a pro-active approach and establish benchmark practices for ICT adoption for building project management.**

At present there is increased construction activity in the country driving high ICT adoption and there is also increased involvement of geographically separated agencies. As per data analysis, construction executives perceive that Industry level initiatives are very important. This analysis and literature review identifies that this is the scenario in which benchmark practices for use of ICT should be established.

Action required: Industry level

- **Cost of IT infrastructure is perceived high by SMEs.**

Majority of the organizations consider high cost of ICT infrastructure and the cost of upgrading for latest software/hardware as an important barrier for effective adoption of ICT. This affects collaborative work required for the construction projects. Thus, cost of IT infrastructure should be made affordable for SMEs through incentives

Action required: Industry level

- **Strategic initiatives are required to be taken by clients, individual organizations and project managers**

In a construction project, clients should include use of ICT in the scope of work. Project managers or the client should take the lead and plan the use of ICT for the project. It should be combined with communication management plans for the project, defining formats and

periodicity of reports, meeting schedules and communication methods to be used for each process. Construction sites should have appropriate ICT infrastructure and ICT trained staff.

Organizations should strategically plan for future use of ICT by their organizations. The plans should be aligned with their business plans. Methodologies need to be developed for quantifying benefits of use of ICT. Senior management should champion the cause of use of ICT in their organization.

Construction professionals are primarily satisfied with the technology available. But, security of data is a barrier of medium rank and professionals would like to have improved conditional access systems. Standardization of data representation in the software and use of information classification systems is important.

Action required: Organization and People level

While the research was conducted in an Indian context, the research outcome is envisaged to be widely applicable in other countries. Factors affecting ICT adoption for building project management or the research variables were identified after extensive literature survey. Thus, these research variables could be generalized for other countries with due considerations, specifically for countries where the construction industry is similar to Indian construction industry in terms of working methodologies, and social and cultural factors or for large countries.

There are factors other than perceived benefits and barriers that affect ICT adoption for building project management. These factors also formed a part of the research and were studied through separate analysis and are discussed in other papers.

CONCLUSIONS

Building construction projects require collaboration by all involved organizations and people, or project teams, which are typically geographically separated, are of different sizes and professional backgrounds, and represent specific interests and preferences. Effective communication between all project team members is an essential ingredient to project management success and in present scenario it can be achieved by adoption of ICT. But, research indicates that adoption of ICT in the industry has been slow and it has not been adopted effectively. Issues for slow adoption are technical, managerial, cultural and socio/political and this is due to differing perceptions of project team members. Utilizing interpretive research methodology, the research discussed in this paper studies perceptions of SMEs in the Indian building construction industry regarding perceived barriers, enablers and benefits of effective use of ICT for building project management. Data for the study was collected through a questionnaire survey conducted in the Indian construction industry and data analysis shows that technology is not perceived as an important barrier. But, Industry and Organization related barriers and associated mitigating enablers are perceived at the top and middle levels respectively. Thus, the study concludes that if strategic issues are addressed at the industry and organization levels and project managers respond to administrative and team management issues

at the project level, benefits of ICT adoption would be accrued at all the three levels of industry, organization and projects, thereby increasing effective ICT adoption in the industry.

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