

## **Application of Information and Communication Technology in the Architecture, Engineering and Construction (AEC) Industry in Hong Kong**

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### **Abstract:**

Since we are living in the Information and Communication Technologies (ICT) era, the use of ICT has been widely penetrated into our workplaces and daily lives. Organizations from different industry have been investing in ICT for the purpose of improving productivity and efficiency. There is growing demand for ICT in the AEC industry in Hong Kong. However, the usage of ICT in the AEC industry has been slow until recent years. Also the impact of applying ICT on AEC industry in Hong Kong has not been documented. The objective of this paper is to examine and document the current adoption of ICT and the trends of ICT development in AEC to provide a clearer insight of current usage of ICT in the industry by reviewing literatures and journals; and by questionnaire surveys. The conclusions of this study can assist stakeholders involved with the ICT adoption process in the industry including managers, service providers, consultants and end-users.

### **Keywords:**

Information and Communication Technology (ICT), Construction Industry, ICT adoption.

### **Citation:**

Lau, Wing Hong; Woo, Fleming; Application of Information and Communication Technology in the Architecture, Engineering and Construction (AEC) Industry in Hong Kong *senario* (2015); Journal of Business & Management (COES&RJ-JBM) Vol.3, No.1, pp.324-334.

## 1 Introduction

Nowadays, Information and Communication Technology (ICT) is important to every aspects including both industries and daily lives (Europa.eu, 2009; Massachusetts Institute of Technology, 2001; Dataware Technologies, 1998; Aguila-Obra & Padilla-Melendez, 2006;

Ahlering, Eichel, Chou, & Skarecky, 2005). The revolution in the information technology has ushered in many technologies, systems, procedures and structures that have benefitted the business domain. Becerik (2004) added that construction industry in particular also is gearing up to the increasing demand of business complexities and involving different stakeholders. ICT has invaded the work space as a boost to the business productivity with a huge investment. The purpose for which ICT is being used is more strategic in nature, especially for achieving business objectives and gain competitive advantage (Bouchlaghem, Shang, Whyte, & Ganah, 2005). Thus ICT based solutions should be business specific and difficulties to align the ICT module to capture business problems are the key towards the first stage. Growing demand can be seen for the use of ICT in the Architecture, Engineering and Construction (AEC) in Hong Kong. Nonetheless, the literature has not been widely published especially on materials relevant to the local context, thus the current research would devoted to provide insights to the development of local ICT application in AEC. This paper is aim to explore the issues of application and find out the efficacy of ICT in the AEC industry of Hong Kong. The research objectives being achieved are:

- i. To identify the role of ICT in the business domain
- ii. To evaluate how the ICT benefits the AEC industry and current trends in Hong Kong
- iii. To understand the challenges and barriers for ICT implementation and application in AEC industry in Hong Kong

## 2 Literature Review

In the literature review, publication on the usage, development and adoption of ICT in AEC would be assessed; the related materials would be focused on the local context so as to support the following discussion.

### 2.1 Local Development of ICT

In Hong Kong, apart from the isolated development of ICT in individual organizations, it was also driven by the Hong Kong Government. Starting from the twentieth century, the government of Hong Kong had started their intention on attaining the full potential of the ICT so as to benefit the community and industry so as to keep the leading position for the application of information technology (GovHK, 2014). In fact, five major areas of ICT have been included (Digital 21 Strategy, 2000):

1. Facilitation to the digital economy
2. Promotion of the advanced technology and innovation
3. Development of Hong Kong as an information hub for the technological trade and cooperation.
4. Enabling of the public services of next generation
5. Building an inclusive and knowledge-based society

From the above, it can be seen that the first three items would be directly affecting the development of the AEC industries, and the discussions below would focus on these aspects.

### 2.2 ICT in Local AEC Industries

From the traditional definition, AEC refereed to a single industry, while it actually includes three separate but related players - architecture, engineering and construction in this project.

With the seamless integration of those entities, the architects, engineers and contractors can work together effectively in achieving success in large numbers of construction projects (Gammon Construction Limited, 2012). In fact, some of the parts for the related industries

have been impacted by technology as well as ICT (Bass, 2014; Saks, 2004; Sunindijo, 2009; Trigo, Varajão, Figueiredo, & Barroso, 2007).

AEC industry in Hong Kong is actively involved in planning, design, construction on site which works on certain constraints of quicker project due to space limitation within city limits. Thus knowledge based software models are used by larger engineering construction firms due to the cost factor. They design on tried and tested software which are shared with project stakeholders for faster integration and decision making across teams. Pre-fabricated castings are manufactured as per the specifications of the 3D modelling done by software to avoid any anomaly (Eastman, Sacks, & Lee, 2002) The total project is processed on BIM and tracked from start to finish that is organized approach to AEC in Hong Kong (Cerovsek, 2011). AEC industry in particular also has braced itself and is gearing up to the increasing demand of business complexities which involves different stakeholders (Grilo & Jardim-Goncalves, 2011). AEC industry in Hong Kong follows the global trends and their key intention is to leverage technology for stakeholder integration for integrating construction industry for achieving measurable benefits (Ku & Mahabaleshwarkar, 2011).

### *2.3 Usage and Benefits of ICT in Hong Kong AEC industry*

The business challenges in AEC industry are varied with cross teams working on different projects across locations (Chi, Kang, & Wang, 2013; Halfawy & Froese, 2005). The most vital element of ICT technology is knowledge sharing and the ability to do construction or engineering modelling (Kubicki, Guerriero, & Johannsen, 2009). The use of ICT starts from the conceptual design and the computer simulation of the erection of the proposed construction building. Integrated POP design which is virtually enables the stakeholders to be in sync and discuss issues regarding cost, forecasted finishing timeline, track the progress (Chen & Rankin, 2006). This reduces the cost and with modelling techniques, the software helps to analyze the risks by 3D visualizing explicitly. ICT also enables to do each component design and enable them virtually to do process modelling where 3D Computer Aided Design (CAD) allows AEC to do accurate projection of estimates. It automatically calculates the days required, materials, manpower required along with cost estimation to finish the total construction using the CPM (critical path method) (Davis & Songer, 2009; Lankhorst, 2009). Thus information is asset which is exchanged by ICT based applications across locations in real time basis for quicker knowledge sharing to enable faster decision making in AEC companies.

### *2.4 Barriers to successful implementation of ICT in Hong Kong AEC industry*

The software which are used for modelling in AEC are mostly pre-programmed and have limitations of not able to scope so much of data, modules, client interactivity, desired output. Authors (Shen & Tam, 2002) argued that AEC industry in Hong Kong is actively involved in planning, design, construction on site which works on certain constraints of quicker project completion due to space limitation within city limits. However, knowledge based models are implemented that enable the completion of project in real time. Other authors (Lee & Jeong, 2012) confirmed that pre-fabricated castings are made as per the specifications of the 3D modelling to avoid any anomaly. The total project management is processed as per completion date on software as well on site that is an organized approach to AEC in Hong Kong (Mukherjee & Muga, 2010). According to (Pauwels, De Meyer, & Van Campenhout, 2010), although usage of application in AEC projects overall reduces the cost and wastes, however, adoption of software tools in themselves can be a limiting factor as they can be very expensive.

The software which is used for modelling in AEC is mostly pre-programmed and have limitations embedded in them while the projects executed are typically suffering from the following challenges. It generally lacks the availability of knowledge across teams on real

time basis, which aids in understanding specifications, project progress of one stage affecting other and amount of funds available for each stage (Rezgui, Hopfe, & Vorakulpipat, 2010).

Further, according to (Ugwu, 2006), the overall cost of adoption of ICT in AEC industry is quite high, which can limit the overall uses of ICT within the industry.

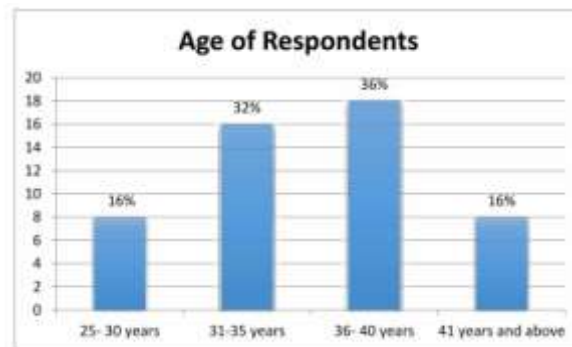
### 3 Research Methodology

This paper evaluates the different ICT strategies for their efficacy undertaken by the AEC firms in Hong Kong through Qualitative research questionnaire. There were a total of 50 respondents, who were selected using the stratified sampling to selecting four types of stakeholders i.e. managers, consultants, service providers and end-users were subjected to open-ended semi-structured questionnaire.

The respondents were chosen from the AEC industries respectively, and have been interviewed separately in order to collect their opinions on the impacts arising from the application of ICT (Ghobakhloo, Sabouri, Hong, & Zulkifli, 2011; Attar & Sweis, 2010).

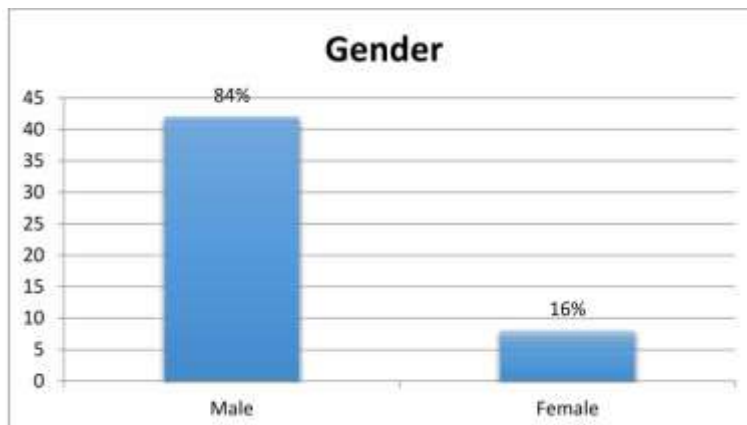
### 4 Results & Discussions

The survey conducted amongst the managers of AEC firms, independent consultants, with a sample size of 50 shows the actual scenario. The response profile shows the breakup of total respondents.



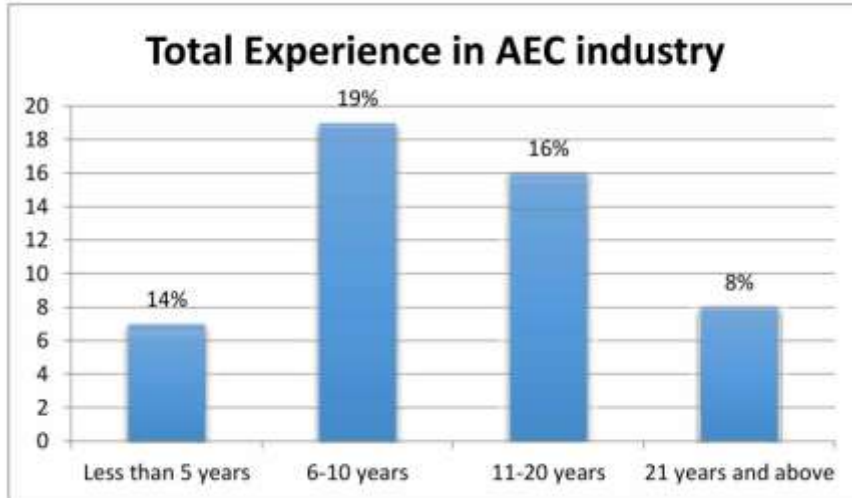
**Figure 1**

It shows that (25-30) years have 16%, (31-35) years at 32%, (36-40) years at 36%, (41 years and above) at 16% indicates that most of them are more experienced in this field. It has varied age groups and has more tenured people in the AEC industry.



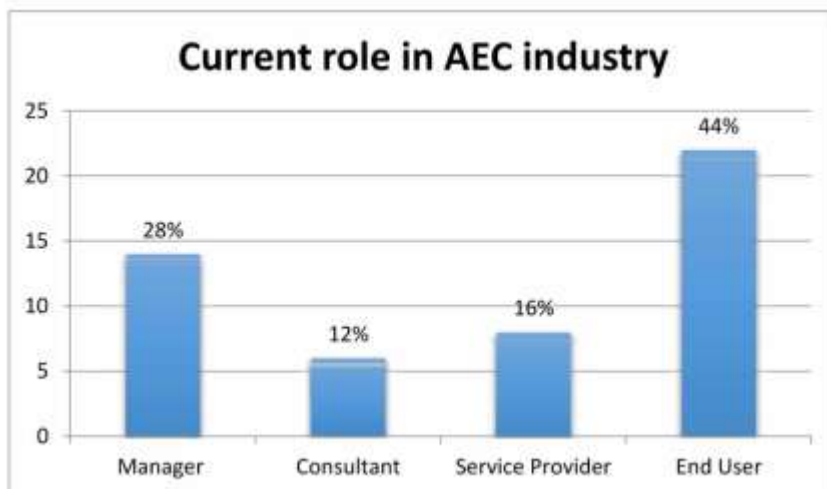
**Figure 2**

The respondent category has a predominance of male gender which shows that AEC industry comprises a skewed representation. Thus the respondents are more males voicing their opinion from AEC industry that shows the industry employability factor for the gender.



**Figure 3**

The responses indicate that most of the respondents have 21 years or above experience in AEC industry with 8% respondents confirming it, which is followed by (11-20) years tenure having 16% representations, (6-10) years with 19% respondents, and less than 5 years at 14% representations. This is a key indicator for the responses as more experience in the same domain is actually beneficial for much more accurate description of the current trends prevailing.



**Figure 4**

The responses show respondents profile and the categories of the total respondents their role in AEC industry with managers leading the group at 28% representations. It has 12% consultants, 16% service providers, and 44% end users that make up the total profile. The respondent group has more managers who are working in various capacities in AEC industry and they have more applied knowledge in actual industry setting that will enrich the questionnaire output.

Responding to role of ICT, 86% of the surveyed managers stated that the revolution in the information technology has ushered in many new technologies, systems, procedures and structures that have benefitted the business domain. ICT has invaded AEC work space specially project management which has aided business productivity but comes with a huge investment. Managers stated that the purpose of ICT is more strategic in nature, especially for achieving deadlines, project costs, reduce waste and gain competitive advantage. ICT based solutions align are designed to capture business problems, communicate with stakeholders on real time and also share knowledge based models across locations which are enabling AEC industry towards better integration and accuracy in delivering projects.

With respect to properly documented, ICT Strategy, 86% of the AEC stakeholders in this industry indicated that they have adopted ICT which is predominantly a top management decision to automate conceptual design, define stages of project, and design components for precise fabrication and also to calculate project cost and a realistic deadline. Also, 86% of the surveyed respondents stated the lacking of written ICT strategy though it is a part of agenda. This includes agenda of AEC firms to adopting different application software to better equip themselves to provide solutions to their clients in a most accurate way to avoid

project over run costs which is most common. A high number of surveyed managers (86%) stated that there is no documented strategy but the broad framework do exist which lay down the general rules of phases involved. The documented ICT strategy would be: “*application based strategy*” that explores the ICT to fullest potential for collaboration within and with external bodies for an effective solution.

In terms of ICT which are currently available i.e. information sharing is one of the most important tools which enable information transfer on real time basis within AEC industry, the design drawings are also shared to different stakeholders on real time basis involved in a project. Previously it was done in 2-dimensional (2D) that had limitations in translating the concept to design challenge but more recently 3-dimensional (3D) has enabled to be precise with minute details that are enabling their functions.

In terms of how ICT has benefitted the AEC industry in Hong Kong respondents indicated that companies have adopted BIM (building information modeling), that includes both private and public client mostly in real estate sector. With all surveyed consultants responded that it has caught up with the major construction firms that are into commercial projects in Hong Kong while the medium and smaller ones are on the verge of accepting it in their work procedures. All surveyed managers added that apart from project end to end solution they are also utilizing it for the facility management system. The managers also stated that working within constraints of project, material planning and requirements is done which helps to avoid overshooting deadline that increases cost, and legal clauses, the ICT applicability is leveraged to make multiple AEC projects successful. Consultants added that the business challenges in Hong Kong AEC industry are sharing information with cross teams working on different projects across locations that leads to cost saving and reduction in waste.

Thus, agreeing with research findings of (Shen, et al., 2010) information is asset which is exchanged by ICT based applications across locations in real time basis for quicker knowledge sharing to enable faster decision making in AEC companies.

Investments towards integration of ICT involve several factors starts from the conceptual design of the intended construction project and the computer simulation of the erection of the proposed construction building (Peansupap & Walker, 2006). So the factors according to different considered before Integrated POP design which is virtual enables the stakeholders to be in sync and include issues regarding cost, forecasted finishing timeline and also track the progress. Consultants explained that this reduces the cost and with modelling techniques, the software helps to analyze the design challenges by 3D visualizing explicitly. ICT also enables to do each component design and integrate them virtually to do process modeling where 3D CAD allows AEC to do accurate engineering projection of estimates. It automatically calculates the days required, materials, manpower required along with cost estimation to finish the total construction project using the Critical Path Method (CPM) technique. Senior managers stated that the cost of each type of software varies and since they are substantial investment the appropriate choice for a particular AEC firm depends on the scalability of the project (Pektas & Pultar, 2006). They evaluate the benefits and constraints of each type of functions like using advanced geometry, the quantity of building materials required and cost estimate, systems and assembly functions and lastly the sequencing of process flow integration in the whole project. This is in sync with the findings of (Rankohi & Waugh, 2013) who indicate that AEC industry is also in interested additional key functions like the software be able to identify conflict, interference and collision detection that are intelligent functions built in the software.

Problems related to programming in software were reported by the respondents as one of the major barrier to implementation of ICT. Consultants stated that absence of this has been found in most AEC site offices, and hence it is a barrier for project completion. The software itself may have limitations in terms of scoping the project from conceptual framework to 3D modelling. It may have reliability and hardware compatibility problems, while implementing such software all locations is a huge cost the parent company (Shin & Dunston, 2008). Consultants added that leadership and employees not motivated enough to graduate from physical drawings to computer based 3D modeling is a serious impediment for the AEC firm and the project. Senior project managers retorted that ability to handle queries from different teams, non-existence of capability to capture project information, business processes and even software technology obsolescence can also happen which may derail the project. Inability of calculating the economic cost, non-detection of the risk components and analysis will hinder the AEC functions substantially in terms of client commitment, project completion and commissioning and incur huge legal costs (Takim, Harris, & Nawawi, 2013).

All surveyed managers Project managers opined that streamlining mundane and repetitive tasks are easily tamed through ICT technology which is generally efficient in low level task computation. Communication has enabled AEC firms as there are high level process and low level computing requirements. Consultants added that the mapping requirements and planning process, modeling and engineering analysis are critical functions that form the backbone of the ICT technology and serves AEC purpose. Senior managers explained that ICT technology enabling the commercial aspect of billing a client, supplier, and vendor also forms a vital part of the project. They added to say that the man hours used on daily basis on the project are all integrated functions are a boost to the project analysis domain which relates to project tracking and resource utilization capability index. The ability to achieve the project toll gates in each phase and the final completion and commissioning is a critical part of AEC industry norms, and hence use of ICT has gradually enabled proper utilization of time, resources. The concept to design and modelling with stakeholder integration has thus equipped the AEC

firms to counter the project based challenges. This has overall impacted the growth of the AEC industry in a positive way.

### **5 Summary of Findings**

ICT as indicated by the respondents is seen as a value adding resource in the overall business strategy. The key areas where it is set to play a strategic role is that it helps in achieving deadlines, reduce overall project costs, reduce waste and enables gain of competitive advantage. Although 98% of the organizations do have a system for the adoption of ICT technologies, however documented strategy is missing and do have broad framework which includes rules related to each phase involved in the process. Among the technologies which are currently available, 3D detailing techniques, Building Information Modelling are commonly used. Knowledge based models within ICT have been used in the AEC industry of Hong Kong in order to fast track construction, and also reduce the cost, and time taken to implement decisions. 75% of respondents indicated that they follow technological developments advancements when making decisions regarding investments. Investments are made only after the evaluation of tools on the basis of set parameters. Further business needs also play an important role in devising strategy related to investment and adoption in ICT industry.

Barriers related to successful implementation and management of ICT as indicated by the respondents were mostly infrastructural problems, and inefficient use of software. Also, lack of vigor among the employees to shift from currently available tools to ICT was also indicated by the respondent as an important barrier. Further inability of detect risks attached with adoption of new tools was also indicated.

Adoption of ICT tools has obviously eased out AEC operations and improved the overall businesses processed and capabilities within the firm. However, the respondents indicated that if project feasibility can also be improved then adoption would increase the suitability for the upcoming opportunities in this area.

### **6 Conclusion**

The overall theme which broadly emerged from the managers, consultants is that the ICT technology is beneficial but the cost involved is too high which is related to the projects at hand. The usability of the ICT should enable to harness the business processes and its capabilities in the fullest that will enable to optimize process, functions, resources utilization against time. This aspect is the key to achieve project feasibility in design phase to meet the outcomes during project closure phase on time to avoid the legalities. The challenges though many are challenging the sector, the firm and the kind of project coupled with the type of software used is a major hurdle which managers, consultants and other stakeholders needs to overcome. Hong Kong in particular can benefit with quicker conceptualizing and commissioning of medium to large scale construction projects with ease provided it uses an apt visionary AEC company which is capable of understanding the whole picture. Thus leveraging the ICT technology enables to counter the potential risk factors, and the scoping and suitability opportunities that plague the construction and engineering industry at large.

To conclude, it can be seen that with the government policy of facilitation to the digital economy, promotion of the advanced technology and innovation, and development of Hong Kong as an information hub for the technological trade and cooperation. The relevant elements have been included in the AEC industry (Andresen, et al., 2000). For example, the information exchange system from construction industry is linked to the digital economy as all industries needs for the information exchange, while the unified protocol would facilitate the communication. Also, the application of CAD and BIM would promote the advanced technology and innovation in Hong Kong, while the use of information exchange system



would fulfill the requirement of developing Hong Kong as an information hub for the technological trade and cooperation (Onyegiri, Nwachukwu, & Jamike, 2011).

In fact, apart from the individual development of the related technology, government should consider to introduce relevant ICT policies to the AEC industry to facilitate the sharing of similarities. Also, it is advisable for the cooperation of the company in coordinating the development of the industry specific software so as to benefit to the whole business without the duplication of efforts. It is hoped that more resource can be devoted to these aspects so as to yield the maximum performance and productivity in the industries (Kretschmer, 2012).

Finally, although the findings of the current study are not comprehensive, the most important function of the current work is to trigger the attention for the ICT application in the local AEC industry. Consequently, it is hoped that fellow researchers can provide more insight and research efforts in the related aspects so as to further benefits to the local community and industry.

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#### **Appendix I: Questionnaire for AEC Industry Respondents**

The Application of Information and Communication Technology in the Architecture, Engineering and Construction (AEC) industry in Hong Kong

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