A Survey of the Potential for I-Build Technology in Improving the Effectiveness of Construction Management in the Taiwanese Construction Industry

Hung-Ju Chien

Abstract - i-Build technology is a state-of-the-art business integration tool, which includes all the functions of construction management for the enterprise and its partners. i-Build applications include electronic document management (EDM), customer relationship management (CRM), subcontractor management (SCM), e-Procurement and financial management (FM) etc. The aim of this paper is to examine the current awareness of i-Build and to identify its potential for improving the effectiveness of construction management in the Taiwanese construction industry. This paper reports on the findings obtained from a questionnaire survey conducted between November 2009 and January 2010, with contributions received from 50 organisations representing Taiwanese main contractors, construction companies, architects, engineering companies and clients. The results revealed that 5% of Taiwanese construction professionals have experience of using i-Build. It also indicated that applications of i-Build offered significant potential in improving the effectiveness of construction cost management (CM), project information management (PIM), electronic document management (EDM) and programme management (PM).

Keywords: Construction Management, Information and Communication Technology, i-Build Technology.

I. INTRODUCTION

Construction is usually a temporary multi-organisation process, which is heavily dependent on the exchange of large complex data and information. The successful completion of the project depends on the accuracy, effectiveness and timing of communication and the exchange of information and data between the project team (Tam, 1999; Rojas & Songer, 1999; Akinsola et al., 2000; Barker, 2001). According to research by Professor Hans Bjornsson (2001), former director of Stanford University USA, 65% of mistakes in the construction industry are due to a misunderstanding among architects, contractors and subcontractors over information. A further study carried out by Coopers & Lybrand (2001) showed that 15% of all documents are misplaced and 7% are lost for good. In the study, the average cost of the search for the missing documents was £85 per item in staff time / salary equivalent. Great strides have been made over recent years to improve productivity through the design and construction process. The introduction of non-adversarial approaches such as ‘lean thinking’ and ‘partnering’ has contributed significantly to cutting down on wasted time and money, making the UK construction industry far more efficient.

Construction Best Practice Programme (CBPP, 2003) as an example, stated that during 2002 construction organisations that engaged in Best Practice increased profitability by £56 million, an average of £15,000 per company. Companies implementing Best Practice have seen profits increase by 50% relative to those not applying these principles. A key contributor to this process improvement is the sharing of project information. Huge savings can be made simply by ensuring that all members of the project team receive accurate drawings and everyone is working to the same, up to date, information (Kernon, 2000). This paper investigates the extent of the current use of i-Build by Taiwanese construction professionals. It also reports on the findings obtained from the questionnaire survey conducted by the authors between November 2009 and January 2010, with contributions received from fifty respondents representing Taiwanese main contractors, construction companies, architects, engineering companies and clients.

1) Aim Of This Research

The aim of this research is to explore the potential for i-Build technology in the Taiwanese construction industry which will enable companies to improve their corporate business performance.

2) Rational for the hypothesis

As previously mentioned there could be potential improvements in the construction industry through the implementation of the i-Build technology. Such improvements have only recently come to the attention of the Taiwanese construction industry because ICT implementation is changing construction in many ways as part of a general drive towards best practice. It improves the capability and efficiency of many aspects of the construction process. Integration of the construction process through the Internet and effective information exchange is not widespread at present but it is a major area of opportunity waiting to be exploited. The following hypothesis is based on this rationale.

3) Hypothesis

The Taiwanese construction companies utilising i-Build will improve communication, extend information support and enhance business performance.
II. CHALLENGES FACING PROJECT MANAGEMENT NOW AND IN THE FUTURE

Traditional project management practices have evolved over time as the requirements for managing and controlling construction projects unfolded. However, with the advances of management techniques and Information and Communication Technology (ICT), traditional practices have proven to be insufficient in meeting the new project requirements (Alshawi & Ingirige, 2002, p.5). Indeed, productivity analysis by Howarth (2002) has concluded that the industry, on average achieves less than 50% productivity. At present the UK government, industry and clients are all seeking to bring about change in the construction industry to improve quality, competitiveness and profitability and finally increase value to clients (Alshawi & Ingirige, 2002, p.2). Implementation is carried out through initiatives such as the Strategic Forum for Construction (2002), the activities of the Construction Best Practice Programme (CBPP) and the Movement for Innovation (M4I). These initiatives are seeking to secure a culture of co-operation, teamwork, and continuous improvement in the performance of the industry. According to the report, ‘Project Management and Computers in the Year 2010’ Froese and Waugh (1991), argue that there are three major roles relating to future trends in computers for project management. These are a supplier of more and better information, a tool for multimedia communication, and an advanced decision support and information-processing device. They conclude that: “Since the computer technology to support these roles will undoubtedly exist, the challenge facing the industry is to develop the information technology foundations – such as representation standards and project models.” In the report, 85% of the respondents believed that in 2010, the success of companies offering project management services would depend on their computer and information technology capabilities. In fact 92% of respondents believed that everyone in the project management team would be using a computer in 2010. Another similar survey carried out by Froese et al. (2001) revealed that almost all respondents (96%) believed that information technology will be more important for project managers in 2020 compared with today (two-thirds said ‘much more important’). A further 94% of respondents responded that new computer technologies would have a positive impact on the market potential/competitive advantage and the effectiveness in managing projects. From the two survey results, it is easy to accept the fact that ICT will have a vital role to play in the execution and management of projects in the future. The changing project management environment is also influenced by other factors. Alshawi & Ingirige (2002, p.6) identified these factors as:

- Increases in project complexity; project complexity has increased due to their being much wider scope, and fragmented parties around the world are having to communicate with one another for efficient project execution.
- The need to achieve faster results with the given resources; this factor places severe time pressures on the entire project team.
- New procurement practices; the emergence of new procurement practices change the way the team members are interrelated. For example procurement schemes such as Private Finance Initiative (PFI) and partnering have impacted upon construction project management.
- Client sophistication; this has become a major driver for productivity improvements in construction.

One of the real challenges in implementing change in the construction industry is the highly fragmented nature of the industry that results in a large number of participants, even on a small construction project. The transition of the construction industry to the computer-integrated era requires the development and acceptance of collaboration technologies for all phases of a construction project from design, through the construction process planning, and project execution and management (Veeramani et al., 1998).

III. LIMITATIONS OF THE CURRENT PROJECT MANAGEMENT PRACTICES

1) Lack of Adequate Communication

Construction is one of the most information-dependent industries. Timely and accurate information is therefore important for all project participants as it forms the basis on which decisions are made and physical progress is achieved. Scanlin (1998) points out that communication consumes about 75% to 90% of a project manager’s time and Biggs (1997) lists communication problems as the root cause of most project failures. Deng et al (2001) further points out that the extensive physical distance between project participants, extending over national boundaries is the main communication barrier to achieve timely and accurate information transfer. Thus, improving communication among project participants is always the key factor leading to the success or failure of a construction project. The inefficiency of the current communication practice has become a barrier to the innovative construction processes that have been developed for the industry over the past four decades (Akinsola et al., 2000). Dennison (2000), consultant for Druid commented, “There is so little communication between the different elements of the construction process. Even internally between regional offices, everybody is doing things a different way.” Communication problems typically lead to additional project expenditure due to reworking. According to Egan (1998) up to 30% of construction is rework. The problems of reworking occur due to conflicting information and information not received in time to the parties concerned. The main cause is the lack of consistency in the flow of information between the
different parties involved in the construction project (Alshawi & Ingirige, 2002, p.7).

E-mail is now a popular tool of communication in the construction industry, so most professionals will be familiar with using it for sending messages and attaching drawings and documents. A survey carried out by the Construction Confederation (CC, 2001) revealed that the majority of contractors make full use of e-mail with 100% of companies that employ over 250 employees using it. The survey also predicts that by 2002 all companies with over 30 employees will use it consistently. However, it does have its limitations, first of all, e-mail is not ideal for sending large documents or drawings as there is no guarantee that the whole thing will be delivered intact. Secondary, e-mail messages sit on a server belonging to a third party - the Internet Service Provider (ISP) - before they are collected, so there is also the potential for a security breach (Kernon, 2000).

2) The Duplication of Project Information

The construction professionals that participate in the project all have specific functions to carry out a number of discrete activities. Examining the activities carried out by various members of the project team lead to the conclusion that different entities often deal with similar information (Table 1). Project information therefore needs to be passed along the project chain from one member to others. This is often done in practice by paper transfer of, for example, drawings and reports etc. Recently, information has started to be transferred electronically (Murray et al., 2001). On examining table 1 it can be seen that very similar items of information are used by most of the role players during the project cycle; the two, which stand out are drawings and cost data. Table 1 for example also illustrates how both the quantity surveyor and the contractor need to prepare priced bills of quantities; these professionals may, however, use different and incompatible software for taking off quantities, preparing a bill, pricing the bill and for calculating interim and final measurements. The duplication of information here is evident.

3) Lack of Collaborative Design and Construction

The current practice of design and construction in industry can be described as a stage controlled process. The life cycle of a project is divided into many isolated stages such as design, tender, construction, maintenance, etc. Each stage has a predefined output that is considered to be the main input for the next (Alshawi & Faraj, 2002). This can result in several disadvantages. Veeramani et al. (1998) identified such disadvantages as:

- Firstly, some problems with the facility design may not be recognised until the actual construction of the facility has begun. This can lead to redesign or design modifications during the construction stage, and this not only impacts upon the productivity but also the cost and completion lead-time of the project.
- Second, since a lesser amount of design flexibility is available once the construction phase has begun, this can result in less-than-optimal design changes in order to overcome the construction problem. For example, a typical building consists of several types of subsystems that may need to be accommodated within the available space. The current practice of design of these subsystems is typically
performed by separate groups of people within an organisation or by different organisations. This can often lead to conflicting space requirements or difficult-to-construct configurations for certain subsystems. Due to the expense associated with delaying construction projects, the typical tendency is to make local modifications to the affected subsystems so that they can be made to fit within the spatial constraints. But this can create longer-term problems for maintenance and upgrade of these subsystems.

Table 1: Information – role player matrix for a typical project chain

<table>
<thead>
<tr>
<th>Information</th>
<th>Role Players</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>P  PM  A  QS  E  C  S  FM  LA  B  L</td>
</tr>
<tr>
<td>Drawing</td>
<td>o  o  i  o  o  i  o  o  o  o</td>
</tr>
<tr>
<td>Specifications</td>
<td>o  o  i  o  i  o  o  o  o  o</td>
</tr>
<tr>
<td>Bills of quantities</td>
<td>o  o  i  i  o  o  o  o  o  o</td>
</tr>
<tr>
<td>Budget</td>
<td>o  o  o  i  o  o  o  o  o  o</td>
</tr>
<tr>
<td>Contracts</td>
<td>o  o  o  i  i  i  o  o  o  o</td>
</tr>
<tr>
<td>Planning</td>
<td>i  o  i  i  i  i  o  o  o  o</td>
</tr>
<tr>
<td>Personnel control</td>
<td>i  i  o  i  i  i  o  o  o  o</td>
</tr>
<tr>
<td>Materials control</td>
<td>i  i  o  i  i  i  o  o  o  o</td>
</tr>
<tr>
<td>Equipment control</td>
<td>i  i  o  i  i  i  o  o  o  o</td>
</tr>
</tbody>
</table>

Key:  
- Initiation  
- Information  

P – Promoter  
PM – Project Manager/principal agent  
A – Architect  
QS – Quantity Surveyor  
E – Engineers  
C – Contractor  
FM – Facilities Manager  
LA – Local Authorities  
B – Bankers  
L – Lawyers  

Source: Murray et al., 2001, p. 39-4

4) Projects Still Rely On Hard Copy Documentation To Complete The Endorsement Procedure

Although many construction organisations are using ICT to improve specific processes/applications, the construction industry still traditionally continues the practice of issuing hard copy documentation as against electronic forms for auditing and record purposes (Alshawi & Ingrigge, 2002, p.7). Multiple copies of these documents of course would be printed off and distributed using mail or courier services. Every time a drawing gets revised - however simple the revision - new sets of the full drawing have to be printed and dispatched around the country to various members of the project team (Kernon, 2000). Deng et al. (2001) argue that communication in the construction industry is complicated by its structural problems. They conclude that: “When drawings are amended, the revised drawings or instructions need to be in hard copy form confirmed with the architect’s chop (authorisation stamp) or signature and the receipt of the drawings be acknowledged by the contractors in writing. Therefore, sending project information in an electronic form cannot complete the endorsement procedure.” Indeed, the mixing of electronic and hard copies in projects makes it difficult for project managers to process the right information as and when required.

5) Lack Of Standard Processes For Project Management

Projects are normally managed according to the experience of the project managers who are specifically appointed for this task. Each project manager, even within the same organisation, prefers to follow his/her own experience, which has been developed over a long period of time. These practices lead to large variations in management practices and therefore can create a significant impact on the capability of coordinating and controlling project information (Hunt, 1995).

IV. FEATURES AND FUNCTIONAL REQUIREMENT OF THE I-BUILD

i-Build can have four main constituent parts that are needed to run a successful construction business (See Figure 2).

1. Process management  
2. Document management  
3. Electronic commerce  
4. Security
With i-Build, information can be aggregated from multiple sources, consistently analysed and then communicated.

The opening view is a project directory or an individual project web site depending upon how the service is provided (Graig, 2006). i-Build allows a single point of access for managing multiple documents and programmes. All information pertaining to the users’ role will be delivered to their computer. It also indicates whether users have documents for review in their associated projects. For a single project, the access will be controlled at a project Web page or beneath it. For example, the project web site could have a public side on which general information about the project can be viewed by anyone. (See Figure 3)

The Internet makes companies more vulnerable simply because it allows more entry points to their business. Using i-Build is also the case. ICT security is becoming an increasingly important issue since no system can be 100% secure (Hamilton, 2002a). There can be a number of security levels to guard against unauthorised third-party access to sensitive information. For example, every user has a unique username and password (Figure 4). For added security, Secure Socket Layering (SSL) can be added. All of the data is held on servers in physically secure premises, data is backed up regularly and servers monitored constantly for hackers, viruses and overall performance.

Figure 2: i-Build framework
Source: Hogan, 2001 (adapted by the authors)

1) Opening Viewing

2) Security
3) **Requests For Information (RFI)**

The RFI facility can be used to raise and answer questions, resolve issues of request information (BuildOnline, 2002). Individual users should need the appropriate permissions from the construction company to create an RFI. The construction company may also be able to configure routing rules for resolution, review, information and forwarding (Hamilton, 2002b, Figure 5). The actual workflow routing used for RFI and submittals is likely to vary with the delivery model. For example, in the design-build model, there may be only isolated cases where it is necessary to route an RFI or a submittal through an owner (Graig, 2006).

![Figure 5: Requests for information](source: i-Build, 2009 with permission)

4) **Document Management**

A significant amount of information is exchanged between various members in a construction supply chain. Poor communication and co-ordination, resulting in misunderstanding, misinterpretation and ignorance of information may seriously affect the performance of the project in terms of quality, time, cost and value (Cheng et al., 2001). Document management provides all the features needed to allow the construction company to share and collaborate on project related documents as well as being able to route them to the right project participants for action and follow-up. Document management also allows the construction company to upload, download and revise documents as well as view and redline online. All activities are audited so that the enterprise is aware of all the history relating to a document (Figure 6).

![Figure 6: Document management](source: i-Build, 2009 with permission)

5) **Contracts Management**

The contract section manages multiple prime contracts, subcontractor contracts and professional service agreements. The contract profile can be used to create the actual contract and display it within the i-Build system to authorised users. Change orders, purchase orders, back-charges, work orders and contract closeout documents can all be prepared and managed in the i-Build system (Graig, 2006). Furthermore, contractor invoices can be issued from the i-Build, just using a customised workflow process (Figure 7).

![Figure 7: Contracts management](source: i-Build, 2009 with permission)

6) **Cost Management**

Today, Internet enabled customers have more information and more choice than ever. The one-size-fits-all days are gone, customers have high expectations and are increasingly demanding more tailored and customised services to suit their specific needs. Cost management provides all the features needed to allow the construction company to assess their cash flow. It also simultaneously issues the daily report of ‘cash-in’ and ‘cash-out’ of the project. Therefore, the enterprise could assess the cash flow of the project at any time (Figure 8).

![Figure 8: Cost management](source: i-Build, 2009 with permission)

7) **Management Reports**

The management report within the i-Build system includes management reports and field reports. In general, the primary contract requires these features to keep the client and other members of the team apprised of the overall status of the project including schedule budget, significant issues, photographic progress and other items (Figure 9).
In the traditional supply chain, buying and selling materials means establishing long-term relationships with suppliers, distributors and retailers, with multiple distribution centres, long lead-times and fixed margins. Now, all of the business activities are being re-innovated. Companies can buy and sell across a wide Internet-enabled marketplace – the virtual marketplace. Conditions such as challenging time-to-market, service response times and product lifecycles – are all factors that are key to market success. i-Build e – procurement solution offers another model for efficient Internet purchasing. With e – procurement, enterprises can streamline entire purchasing operations from item selection through to approvals to payment and offers real-time interactivity with trading partners, dramatically reducing purchasing costs, and boosting efficiencies to realise a rapid return on investment.

Furthermore, e – procurement also offers flexible functionality to cater for the different needs of first time, repeat and power users, allowing the user to select based on the user’s business model. e - Procurement was therefore designed to:

- Provide new, industry leading search capabilities, which include text search, parametric search and categorisation, and perform as people think (Figure 10).
- e – Procurement also provides a ‘Smart Search’ for supplier link-outs, so users can more easily find and link out to these external supplier sites.
- e – Procurement caters for frequent or experienced users, so they can complete their transactions quickly and handle checkouts in one step.

V. RESEARCH METHODOLOGY

The aim of this research is to explore the potential for i-Build technology in the Taiwanese construction industry which will enable companies to improve their corporate business performance. To determine the current use of state-of-the-art i-Build technology by Taiwanese Architectural, Engineering and Construction (AEC) companies, a questionnaire was conducted, which was designed and based upon a review of current literature and the research objective. In addition, this questionnaire was also used to test the veracity of the hypothesis: The Taiwanese construction companies utilising i-Build will improve communication, extend information support and enhance business performance. A number of stages were involved in questionnaire survey process; these are:

- Sample selection;
- Questionnaire design;
- Pilot questionnaire;
- Questionnaire main distribution and analysis.

1) Sample Selection

Once the technique has been decided for collecting data, selecting the research sample is very important and great care must be taken in order to provide representative and reliable evidence. Naoum (1998, p.60) suggests that there are two main criteria that need to be taken into account when selecting the research sample. First, what do you want to know? Second, about whom do you want to know it? Following the general recommendations provided by Naoum, this questionnaire was sent to a wide range of
professionals within the Taiwanese construction industry. A total of 50 construction professionals were selected as the sample for the questionnaire survey. The name and contact information of the sample respondents were obtained from the authors’ network of contacts and also from organisations such as the Taiwan Construction Research Institute (TCRI), Chinese National Association of General Contractors (CNAGC), Construction Magazine and Contractor Development Foundation (CDF). Although some of the sample respondents were obtained from the author’s network of contacts, not all free random selection. However although they can in no way be considered to representative of the industry as a whole they do provide important indications.

2) Questionnaire Design

Two types of questions were used in the questionnaire; closed-ended questions and open-ended questions. Almost all the questionnaires have closed-ended questions to ensure consistency of respondent feedback. As it is not possible to design all questions as closed-ended, some questions were left open-ended, to obtain numerical data or to solicit some written comment. A total of 10 multiple-choice questions were included in the questionnaire. From the above hypothesis, the author constructed the questionnaire with five sections as shown below:

1. General information
2. Build applications
3. The appropriate level of cost and charging structures
4. The noticeable benefits that have been gained from using i-Build
5. The barriers that discourage the construction industry from utilising i-Build

3) Pilot Questionnaire

Before the main survey was undertaken, a draft version of the questionnaire was piloted with one Taiwanese construction company (turnover between TWD 2 – 5 billion (USD 61- 305 million)) and one Taiwanese engineering company (turnover between TWD 2 – 5 billion (USD 61- 305 million)). This pilot study was intended to elicit responses that would help to test the wording of the questionnaire, identify ambiguous questions, and also provide an indication of the time to complete the questionnaire. Some of the comments and suggested amendments from the pilot study respondents were used to amend the questionnaire prior to its final distribution.

4) Questionnaire Main Distribution

During November 2009 and January 2010, the authors conducted 50 telephone interviews with potential users of i-Build technology. Interviewees were drawn from 50 different companies and comprised of main contractors, construction companies, architects, engineering companies and clients. Only 5 percent of the interviewees had used i-Build technology on construction management. The data obtained from the authors’ survey were analysed according to the type of profession, which was distinguished by five categories as indicated in Table 2.

<table>
<thead>
<tr>
<th>Categories</th>
<th>No. interviewed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Main Contractor</td>
<td>28</td>
</tr>
<tr>
<td>Construction Company</td>
<td>10</td>
</tr>
<tr>
<td>Architect</td>
<td>1</td>
</tr>
<tr>
<td>Engineering Company</td>
<td>8</td>
</tr>
<tr>
<td>Client</td>
<td>3</td>
</tr>
<tr>
<td>SUM</td>
<td>50</td>
</tr>
</tbody>
</table>

VI. DATA ANALYSIS USING SPSS

Statistical Package for the Social Sciences (SPSS) is a very powerful and user friendly program for statistical analysis (Gaur & Gaur, 2006; Green & Salkind, 2008). The data obtained from the authors’ survey was analysed in SPSS.

1) Scale Reliability

Scale reliability is one of the SPSS techniques, has to be tested for validity and reliability. Proper validity and reliability testing can be done using Confirmatory Factor Analysis (CFA). However, researchers commonly use the Cronbach alpha coefficient for establishing scale reliability. The Cronbach alpha coefficient is an indicator of internal consistency of the scale. A value of Cronbach alpha above 0.70 can be used as a reasonable test of scale reliability. (Gaur & Gaur, 2006) The analysed results are shown in Table 3 where the Cronbach alpha value was calculated to be 0.914 (larger than 0.70).

<table>
<thead>
<tr>
<th>Crohbach’s Alpha</th>
<th>N0. of Items</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.914</td>
<td>8</td>
</tr>
</tbody>
</table>
2) **The Two-Way Anova Analysis**

An analysis of variance (ANOVA) exercise was undertaken to test the null hypothesis that there is no significant difference between the mean values of the groups. This enabled the authors to clarify whether or not the opinions of the separate construction professional groups were the same on the various issues dealt with in the survey. A probability value of ‘F significant’ (Sig.) below 0.05 indicates that the null hypothesis can be rejected, suggesting that there is a high degree of difference of opinion between groups in relation to that factor. The ANOVA results are shown in Table 4 where the ‘type of profession’ has a significant effect on the ‘reasonable monthly price’ (Sig.=0.003 <0.05). However, the ‘annual turnover’ does not affect the ‘reasonable monthly price’ (Sig.=0.102 >0.05). Furthermore, the interaction of the type of profession and annual turnover also does not affect the reasonable monthly price significantly (Sig.=0.579>0.05). A further analysis is therefore necessary to localise whatever differences there may be among the individual treatment means. Table 5 shows the differences between means (Mean Difference (I-J)), their standard errors, p-values (Sig.) and 95% Confidence Interval for each pair. Inspection of the p-values shows that the ‘engineering company group’ differs significantly (p<0.05) from the ‘client group’ in relation to the ‘reasonable monthly price’ factor, but the engineering company group does not differ significantly from the architect, the main contractor and the construction company groups (p>0.05).

3) **Chi-Square Test**

The chi-square test of independence is used to test the hypothesis that two categorical variables are independent of each other. A small chi-square statistic indicates that the null hypothesis is correct and that the two variables are independent of each other (Gaur & Gaur, 2006). Table 6 reveals that the Pearson Chi-Square (2-sided significance reported in the last column) is 0.008<0.05, we can therefore

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**Table 4: Tests of between subject effects**

<table>
<thead>
<tr>
<th>Source</th>
<th>Type III sum of squares</th>
<th>df</th>
<th>Mean square</th>
<th>F</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corrected model</td>
<td>19.702(^a)</td>
<td>12</td>
<td>1.642</td>
<td>2.232</td>
<td>0.035</td>
</tr>
<tr>
<td>Intercept</td>
<td>65.226</td>
<td>1</td>
<td>65.226</td>
<td>88.657</td>
<td>0.000</td>
</tr>
<tr>
<td>Type of profession</td>
<td>12.503</td>
<td>3</td>
<td>4.168</td>
<td>5.665</td>
<td>0.003</td>
</tr>
<tr>
<td>Annual turnover</td>
<td>6.228</td>
<td>4</td>
<td>1.557</td>
<td>2.116</td>
<td>0.102</td>
</tr>
<tr>
<td>Type of profession* Annual turnover</td>
<td>2.828</td>
<td>5</td>
<td>0.566</td>
<td>0.769</td>
<td>0.579</td>
</tr>
<tr>
<td>Error</td>
<td>23.543</td>
<td>32</td>
<td>0.736</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>146.000</td>
<td>45</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Corrected total</td>
<td>43.244</td>
<td>44</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

\(^a\) R Squared= 0.456 (Adjusted R Squared=0.251)

**Table 5: Post Hoc Tests – Multiple Comparisons**

<table>
<thead>
<tr>
<th>(I) Group</th>
<th>(J) Group</th>
<th>Mean Difference (I-J)</th>
<th>Std. Error</th>
<th>P-value Sig.</th>
<th>95% Confidence interval</th>
</tr>
</thead>
<tbody>
<tr>
<td>Client</td>
<td>Engineering company</td>
<td>-1.00</td>
<td>0.577</td>
<td>0.023</td>
<td>-3.264 to -0.653</td>
</tr>
</tbody>
</table>


relationship at 5% significance level between the professional group and annual turnover.

Table 6: Chi-Square Tests

<table>
<thead>
<tr>
<th></th>
<th>Value</th>
<th>df</th>
<th>Asymp. Sig. (2-sided)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pearson Chi-Square</td>
<td>32.823a</td>
<td>16</td>
<td>0.008</td>
</tr>
<tr>
<td>Likelihood Ratio</td>
<td>25.372</td>
<td>16</td>
<td>0.064</td>
</tr>
<tr>
<td>Linear by Linear Association</td>
<td>0.049</td>
<td>1</td>
<td>0.825</td>
</tr>
<tr>
<td>N of Valid Cases</td>
<td>50</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

a. 23 cells (92.0%) have expected count less than 5. the minimum expected count is 0.02.

VII. SURVEY RESULTS AND DISCUSSION

The results have been classified under the following headings:

a). i-Build applications
b). The appropriate level of cost and charging structures
c). The noticeable benefits that have been gained from using the i-Build
d). The barriers that discourage the construction industry from utilising the i-Build

1) I-Build Applications

There are many specialised i-Build applications that are designed specifically for use in construction. The respondents were invited to rate the level of usefulness in improving the effectiveness of construction management from the various i-Build applications. Mean ratings on the level of usefulness were calculated, (on a scale of 1-5) which revealed that Project Information Management (3.90), Cost Management (3.84) and Electronic Document Management (3.84) were considered to be the most useful in improving the effectiveness of construction management. The applications of Programme Management (3.82) and Sub-contractor Management (3.70) ranked fourth and fifth respectively (Table 7).

2) Appropriate Level Of Cost And Charging Structures

The i-Build provider charges a flat monthly rate for the users. The price of such applications range is depending upon the level of functionality, the number of users and an estimation of the data storage required. The authors’ survey results revealed that the majority of respondents (70.5%) indicated that a reasonable monthly price for 10 Gb (Giga bites) data storage space and up to 100 system users is between TWD 6,000 and TWD 7,999. A further 15.9% reported that a reasonable level of monthly rate is between TWD 8,000 and TWD 9,999, only a small share of respondents (9.1%) believed that an appropriate level of monthly price is between TWD 10,000 and TWD 13,999. (See Figure 11)

![Figure 11: Reasonable monthly price of i-Build response analysis](image-url)
3) The Noticeable Benefits That Have Been Gained From Using I-Build

i-Build technology is now a state-of-the-art business collaboration tool in the Taiwanese AEC industry with 5% of Taiwanese construction professionals in the authors’ survey indicating that they have experience of using the i-Build technology. Although 5% of responses seems a low figure at present, in reality, some respondents gained noticeable benefits from using i-Build. Some respondents commented that “In fact, with i-Build the return on investment is enormous”, “Simple to implement in stages, meets our needs, we do not have to adapt our business processes to use them.” and “i-Build is providing a platform for improved assessment within the value chain, and simultaneously issues the daily report of ‘cash-in’ and ‘cash-out’ of a project, it is easy for an enterprise to assess the cash flow of the project.” 65% of mistakes in the construction industry are due to a misunderstanding among architects, contractors and subcontractors over information, according to Bjornsson (2001). Oliver (2002) further commented, “The general statistic is that 80% of mistakes stem from not using the most up-to-date information.” The authors’ survey has identified that one of the main advantages of using i-Build is that it ensures that all members of the project team have access to the most up-to-date versions of the various project documents. This means that traditional mistakes generated from someone working from an old document or drawing are in theory removed or at the very least reduced.

4) The Barriers That Discourage The Construction Industry From Utilising I-Build

The barriers discouraging the effective implementation of i-Build in the Taiwanese AEC industry have been identified in the authors’ survey. The results are illustrated in Table 8, and indicate that the three most significant barriers are:
- Data may be altered in transit and delivery
- System reliability concerns
- Appropriate charging structures

The findings in the authors’ survey are similar to those from the research conducted by Ng et al. (2001), White (2001), Goodwin (2001), Alshawi & Ingrirge (2002), Oliver (2002), Sturley (2002) and Barthorpe & Chien (2003) who identified the reasons for the low level of ICT usage by construction professionals as:
- Software problems
- Confidential information getting into the wrong hands
- Legal disputes arising

However the order of importance of the various barriers has slightly changed.

Table 8: Dependence levels of barriers – response analysis

<table>
<thead>
<tr>
<th>Factors</th>
<th>Main contractor</th>
<th>Construction company</th>
<th>Architect</th>
<th>Engineering company</th>
<th>Client</th>
<th>Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>Appropriate charging structures</td>
<td>3.94</td>
<td>4.00</td>
<td>2.00</td>
<td>2.83</td>
<td>3.00</td>
<td>3.61</td>
</tr>
<tr>
<td>Confidential information getting into the wrong hands</td>
<td>3.25</td>
<td>3.50</td>
<td>3.00</td>
<td>4.00</td>
<td>4.00</td>
<td>3.46</td>
</tr>
<tr>
<td>Speed of information transfer and delivery</td>
<td>3.67</td>
<td>3.50</td>
<td>3.00</td>
<td>3.17</td>
<td>3.00</td>
<td>3.48</td>
</tr>
<tr>
<td>System reliability concerns</td>
<td>3.80</td>
<td>4.25</td>
<td>2.00</td>
<td>3.17</td>
<td>3.00</td>
<td>3.63</td>
</tr>
<tr>
<td>Data may be altered in transit and delivery</td>
<td>4.00</td>
<td>3.25</td>
<td>2.00</td>
<td>3.83</td>
<td>4.00</td>
<td>3.78</td>
</tr>
<tr>
<td>Legal disputes arising</td>
<td>3.07</td>
<td>3.50</td>
<td>2.00</td>
<td>3.50</td>
<td>4.00</td>
<td>3.23</td>
</tr>
</tbody>
</table>

Footnote: In a rating of 1 to 5 where 5 is most important, 1 is least important.

VIII. LIMITATION OF THE SURVEY

According to Olle Samuelson (2008) ‘IT – Barometer 2007 survey’ stated that “Three criteria were set up for the survey tool. It should:
1. Be repeatable and comparable over time.
2. Be comparable between countries.
3. Cover all categories in the construction industry.”

Although the purpose of this survey is to examine the current state of i-Build technology usage by Taiwanese AEC companies, there are several limitations and constraints that have influenced the response obtained in this survey:
- Unfamiliarity of i-Build applications: i-Build is a relatively new technology, particularly by Taiwanese AEC companies and therefore some interviewees were unfamiliar with the i-Build applications available or even the esoteric terminology used.
- Constraints of conducting structured interviews: Although a substantial empirical study was conducted using the questionnaire survey, the expense and time-consuming nature of conducting structured interviews limited the number that were able to be carried out. However although 50 structured interviews can in no way be considered to be
representative of the industry as a whole they do provide important indications.

- Analysis constraints: Some difficulty was experienced in analysing some of the survey interviewee’s comments, due to their subjectivity.

IX. CONCLUSIONS

This paper has presented the findings of a questionnaire survey conducted by the authors among a sample of 50 construction organisations based in Taiwan. The survey results demonstrate that only 5% of the survey respondents have experience of using i-Build. The three most significant barriers that discourage the AEC industry from utilising the i-Build have also been identified in this paper as:

- Data may be altered in transit and delivery
- System reliability concerns
- Appropriate charging structures

From the survey, the majority of respondents (70.5%) indicated that a reasonable monthly price for 10 Gb (Giga bites) data storage space and up to 100 system users is between TWD 6,000 and TWD 7,999. Furthermore, the respondents indicated that the three i-Build applications that were the most useful in improving the effectiveness of construction management in the Taiwanese AEC industry are:

- Project Information Management
- Cost Management
- Electronic Document Management

The Taiwanese construction industry output is annually worth around Taiwan Dollar (TWD) 469 billions, roughly equivalent to 5-6% of the Gross Domestic Product (MOI, 2004). According to the MOI report there were 12,012 construction companies in 2008. Only 5% of these organisations have so far implemented i-Build system, therefore a 95% potential construction market for i-Build organisations have so far implemented i-Build system, exists in this sector alone.

The ICT technology infrastructure is now available for construction in enhancing business performance and future growth. i-Build applications are just one of several possible solutions that can be used to streamline construction processes, form closer client/subcontractor/supplier relationships and operate more effectively in the global market place.

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XI. REFERENCES


