

ENCI 495 Project Report

**A Survey of Information Technology in
the New Zealand Construction Industry**

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ABSTRACT

This report presents findings of a research project that explored the current state-of-the-art of information technology (IT) applications in the New Zealand construction industry. These findings are based on a questionnaire survey conducted between August and September 2000 among 200 New Zealand contractors. A total of 76 valid responses were received, representing a response rate of 39.0% of those delivered. The survey focused on how contractors use information technology in their daily operations, including information flows among business partners, the use of computer hardware and software, IT expenditure and training, management supports, benefits of IT applications, and problems encountered. This report gives a general view of the current state of information technology applications among contractors in New Zealand, and provides first-hand information on how well contractors are aware of and have equipped themselves with this new technology. It also reveals that although information technology applications constitute what are probably the most visible technological changes in recent years, the local construction industry is quite conservative in their adoption and use.

INTRODUCTION

Information technology (I.T.), by definition, is a collective reference to the integration of computing technology and information processing (Long and Long, 1997). Applications of information technology in the construction industry have attracted increasing attention worldwide. A number of surveys have been conducted in the construction industry in recent years to investigate the status of information technology applications in the industry. For example, the Construction Industry Computing Association (1990) carried out a survey of the information technology trends and needs in the construction industry in the UK.

Although there has been some research into information technology applications generally in New Zealand, no work has been done on a significant scale to investigate IT applications in the construction industry. Some fundamental issues relating to the full extent of IT applications in this industry have yet to be fully addressed, such as the types and sizes of business that use IT, the types of information technology used and their functions, and the future prospects for information technology in the New Zealand construction industry.

Information technology has already had some impact on organisations in New Zealand and much more dramatic effects are anticipated for the years to come. Greater attention needs to be paid to the interaction of information technology with business methods, work patterns, employees and organisational culture.

The purpose of this report is to present research findings of a questionnaire survey conducted between August and September 2000. The survey focused on IT applications among New Zealand contractors.

RESEARCH OBJECTIVES

This report focuses on contractors' use of information technology in New Zealand. The project aims to investigate the current state-of-the-art of IT in the construction industry, to obtain an up-to-date and general view of the state of IT applications, and to assist organisations in the industry to understand, design and manage their IT operations. The specific objectives of this research in logical sequence are : (1) to identify the awareness of IT in the construction industry, (2) to explore the opportunities offered by IT, (3) to provide solutions to New Zealand construction firms for positioning themselves in the IT era, (4) to discover the extent of their current IT use, (5) to determine the level of their strategic approach to information technology and (6) to estimate the potential future IT among those surveyed and the total construction sector in general. Although the construction industry consists of three primary sub-sectors, including owners, designers, and contractors, this particular report is confined to information technology applications among contractors only.

This project provides first-hand information on how well the construction industry in New Zealand is equipped with information technology. It is useful in the following four areas : (1) it will be essential for relevant government departments to prepare strategies for information technology in the construction industry; (2) it will

promote the awareness of commercial benefits of IT among managers in construction companies in New Zealand and encourage them to seriously consider information technology in their business; (3) it will increase the competence and confidence in applying IT by local companies by providing management guidance on the selection and development of information technology applications; and (4) it will be beneficial to teaching and further research of construction information technology in educational institutions in New Zealand.

LITERATURE REVIEW

With many surveys being carried out on the use of information technology, it is important to ensure that their results can be compared and that they can be repeated to gain a picture of the growth of IT use and of particular successes. Howard, Kiviniemi and Samuelson (1998) investigated surveys of IT in the construction industry and experience of the information technology barometer in Scandinavia. The IT barometer survey was developed at KTH, Stockholm in 1997 and targeted a representative sample of companies in the Swedish construction industry, spread throughout the country. Both personal interviews by students and a mailed survey form were used. The questionnaire used for the survey that is the subject of this report was based in part on work by Howard.

Doherty (1997) investigated computer use in the New Zealand building and construction industry. One of the conclusions reached is that a large minority of businesses either does not use computers or uses them only casually. A similarly large minority needs to upgrade their computers. Growth is expected in electronic information services, especially on the Internet.

Rivard (2000) conducted a survey on the impact of information technology on the Canadian architecture, engineering and construction industry. It was found that many business processes are now almost completely computerised and the tendency is toward a greater computerisation of the remaining processes. Although the Internet has been adopted by most firms surveyed, design information is still exchanged in its traditional form.

Thomas (1999) studied the use of information technology in the Republic of Ireland construction sector. It was found that IT was increasingly used in the Irish construction sector by the leading organisations. The survey revealed that although there are some similarities in the extent to which each of the sub-sectors are currently using IT and their intended use of IT in the future, there are also some significant differences.

Hugues (2000) and Shen and Wong (1997) report on similar surveys in the Canadian and Hong Kong construction industries, respectively.

In general, research related to understanding the impact of information technology in the New Zealand construction industry appears to be limited. Case studies were primarily identified through articles in industry magazines as well as articles from the Internet.

RESEARCH METHODOLOGY

The mailing list to which the questionnaire survey was distributed was obtained from the *New Zealand Contractors Federation* database at their web site (www.nzcontractors.org.nz). There were approximately 600 organisation addresses in the mailing list representing all regions of New Zealand. Every third organisation address was selected from the mailing list and recorded in a spreadsheet. A total of 200 organisation addresses were thus identified, a mailing list was compiled, and the questionnaire survey form for this research (describe later), plus a stamped return envelope, was sent to each contractor on the list. Among the questionnaire survey forms mailed, five were returned undeliverable. Out of the 200 questionnaire survey forms sent, 76 organisations (38 % of total ; 39 % of delivered) responded to this questionnaire survey form.

The questionnaire responses were entered into a spreadsheet for collation and analysis. The details of the response analysis are shown on the *Response Analysis* section.

QUESTIONNAIRE DESIGN

The questionnaire was designed to achieve the stated objectives and to encourage a high response rate. Ideas on the type of questions to be asked and the associated methods were generated and developed over a two-month period, based on the questionnaires presented in the international journals found on the Internet web site (www.Itcon.org). A draft version of the survey questionnaire was generated purposely for contracting organisations in New Zealand. After comments and amendments, a final version of the questionnaire was produced.

The first five questions sought to identify the organisation's size and character in terms of number of projects the organisation completed in the past year, annual turnover, types of construction in which they specialise, number of personnel, and the number of computers used. The questionnaire then asked for the types and product names of software in use in the organisation and the most significant factors in selecting computer software. The next questions related to the use of company and project web sites and e-mail and their primary purposes. The next two questions sought to identify the use of hardware and the influence on information technology implementation in the organisation. The last two questions sought to ascertain connections between information technology and business strategy and to predict trends in IT applications in construction in the next five years.

Prior to posting the questionnaire, a cover letter was attached to the front page of the survey questionnaire for each contracting organisation in order to identify the most senior person in the organisation with responsibility for information technology. In some organisations, this person was known as the Information Technology Manager but in the majority of cases this person had other responsibilities apart from information technology.

RESPONSE TO QUESTIONNAIRES

The response rate for the contractors in New Zealand is shown in Table 1 as follows :

Number of Replies	76
Returned Undeliverable	5
<i>Total forms sent</i>	200
Response rate (%)	39.0 % (delivered) 38.0 % (total)

Table 1: Response rate

The overall response rate of 39.0 % (of the 195 delivered) and 38.0 % (of the 200 total) was regarded as satisfactory and well above rates often achieved in similar surveys.

SURVEY RESPONSE ANALYSIS

Characteristics of the Responding Organisations :

With the exception of the two project management firms, all the respondents were prime and sub-contractors. The profiles of the organisations that participated in the survey are summarised in the Tables 2 to 4 as follows :

Number Of employees	1 – 10	11 – 25	26 - 50	51 - 75	≥ 76	No Response	Total
Number of firms	27	16	12	6	12	3	76

Table 2: Company size (Number of employees)

The mean, range and the median of the number of employees in the organisations that responded to the survey questionnaire are shown as follows :

Mean = 70

Range = 1 → 2200

Median = 17

Number Of projects	1 – 10	11 - 25	26 - 50	51 - 75	≥ 76	No Response	Total
Number of firms	17	7	11	1	18	22	76

Table 3: Number of projects completed in the past year

The mean, range and the median of the number of projects completed in the past year by the organisations that responded to the survey questionnaire are shown as follows :

Mean = 139

Range = 2 → 1000

Median = 30

Annual turnover	<\$500,000	\$500,000 - \$1,000,000	\$1,000,000 - \$5,000,000	\$5,000,000 - \$10,000,000	\$10,000,000 - \$50,000,000	>\$50,000,000	No Response	Total
Number of firms	6	9	28	13	13	3	4	76
Percentage (%)	7.9	11.8	36.8	17.1	17.1	3.9	5.3	100

Table 4: Organisation annual turnover

The majority of the organisations had an annual turnover of between \$1,000,000 and \$10,000,000. Only three organisations had an annual turnover of more than \$50,000,000. Only 7.9 % of the organisations had an annual turnover of less than \$500,000. Thus, based on this sample, most contracting firms in New Zealand have an annual turnover of at least \$500,000. The percentages shown above follow a roughly normal distribution, with a peak in the \$1,000,000 - \$5,000,000 range.

The types of construction in which the organisations specialise are shown in Table 5 as follows :

	Number of responses	% of 72 that answered this question
Roading	50	70.4
Water and waste management	26	36.6
Bridges	17	23.9
Buildings	12	16.9
Drainage	7	9.9
Excavation and quarrying	4	5.6
Project management	2	1.4
Landscape	2	2.8
Pipe laying	1	1.4
Mining	1	1.4
Marine	1	1.4
Industrial Infrastructure	1	1.4
Asphalt maintenance assets	1	1.4

Table 5: Types of construction specialties

In the results shown above, more than half of the organisations tend to specialise in roading, which is an indication of the importance of this construction in the New Zealand economy. Apart from roading, water and waste management was another type of construction that is of great interest to many contractors. This emphasis reflects the New Zealand government's recent focus on environmental problems, sewage treatment plants and water pollution. The results shown in Table 5 also reflect the types of contractors that are members of the New Zealand Contractors Federation. This sampling may not reflect accurately all of New Zealand's contractors.

Contractors for buildings and bridges also contribute to the development of the construction industry. More new buildings have been built in recent years, such as shopping malls and multi-level car parks in order to attract more tourists and local residents. Only a small proportion of contractors in this sample focuses on drainage, excavation and quarrying.

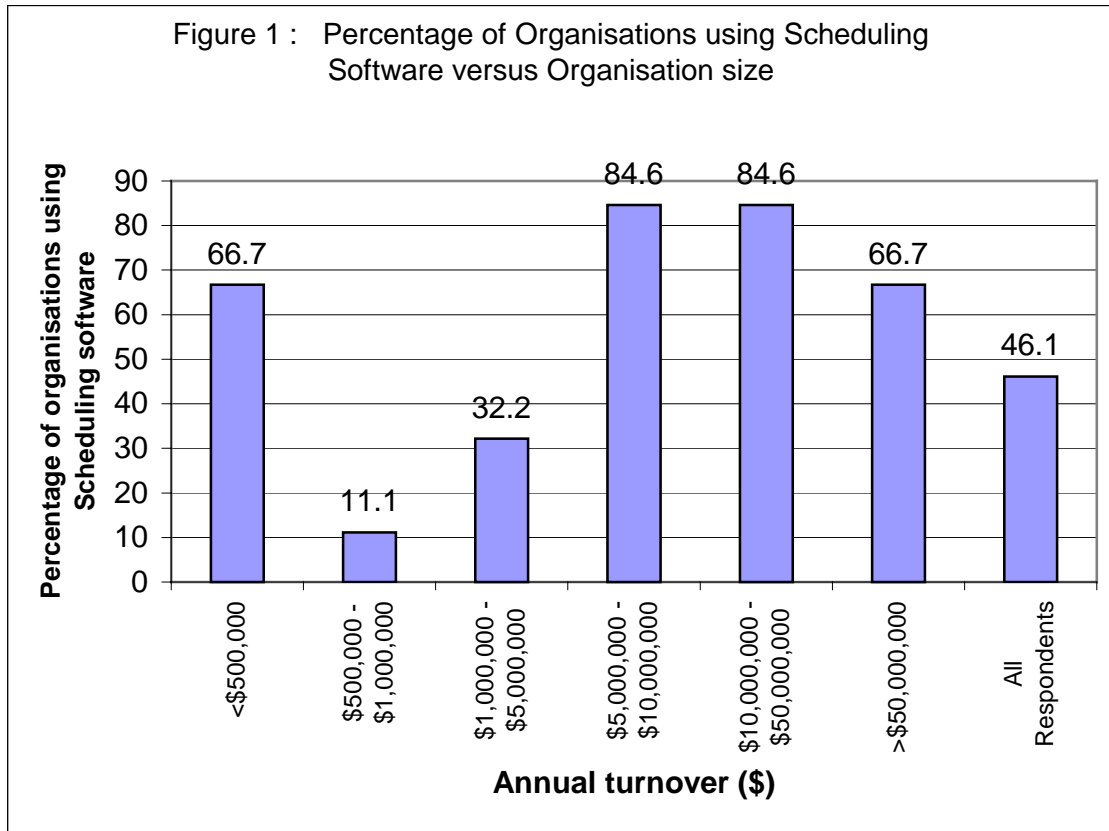
Software Selection and Use :

1. Project planning, estimating and finance software currently in used in the organisation:

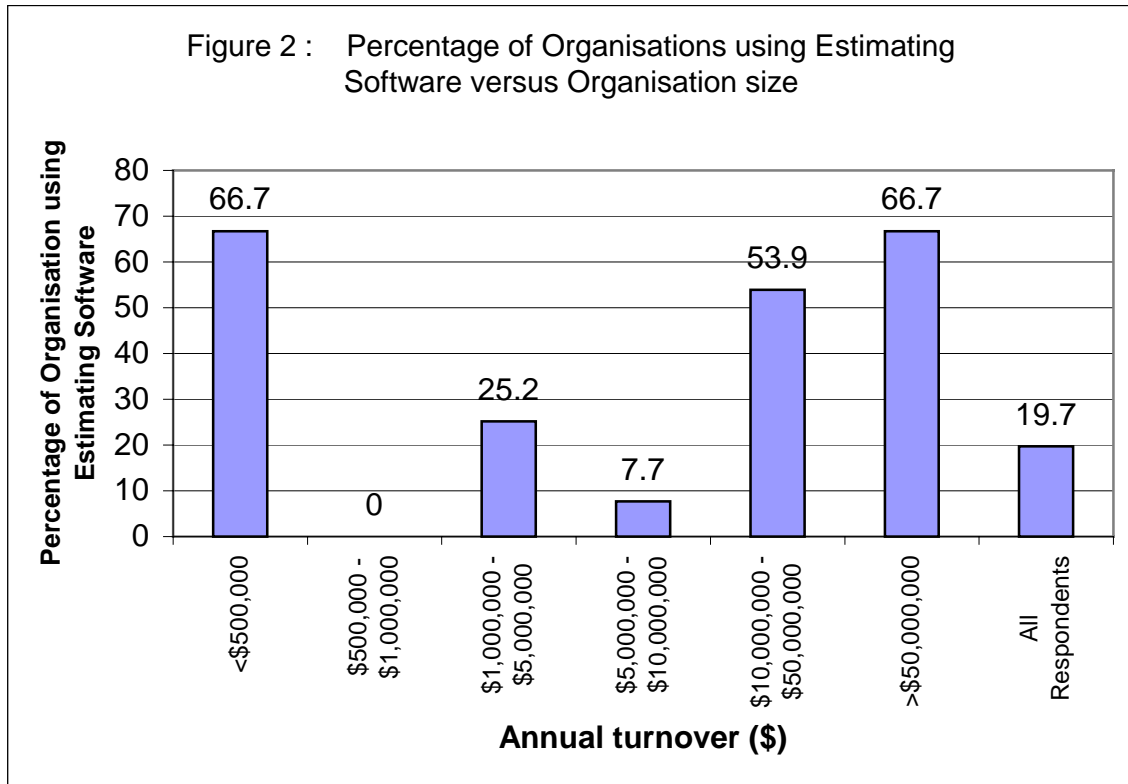
Software	Number of responses	% of 76 respondents
MS Project	30	39.5
Microsoft Excel	5	6.6
Probid	4	5.3
Mapas	4	5.3
Prophet	3	3.9
Primavera	3	3.9
Acumen	3	3.9
Power project	2	2.6
MYOB	2	2.6
Job Costing	2	2.6
Intech	2	2.6
Workbench	1	1.3
Sage Accounting	1	1.3
Reese Easy	1	1.3
Quick Books	1	1.3
Omnis	1	1.3
Jobcard	1	1.3
Intersoft	1	1.3
Instant Accounting 98	1	1.3
CBA	1	1.3
Cashlink	1	1.3
Cash Manager	1	1.3
Cash Concepts	1	1.3
Buildsoft	1	1.3

Table 6: Project planning, estimating and finance software currently in use

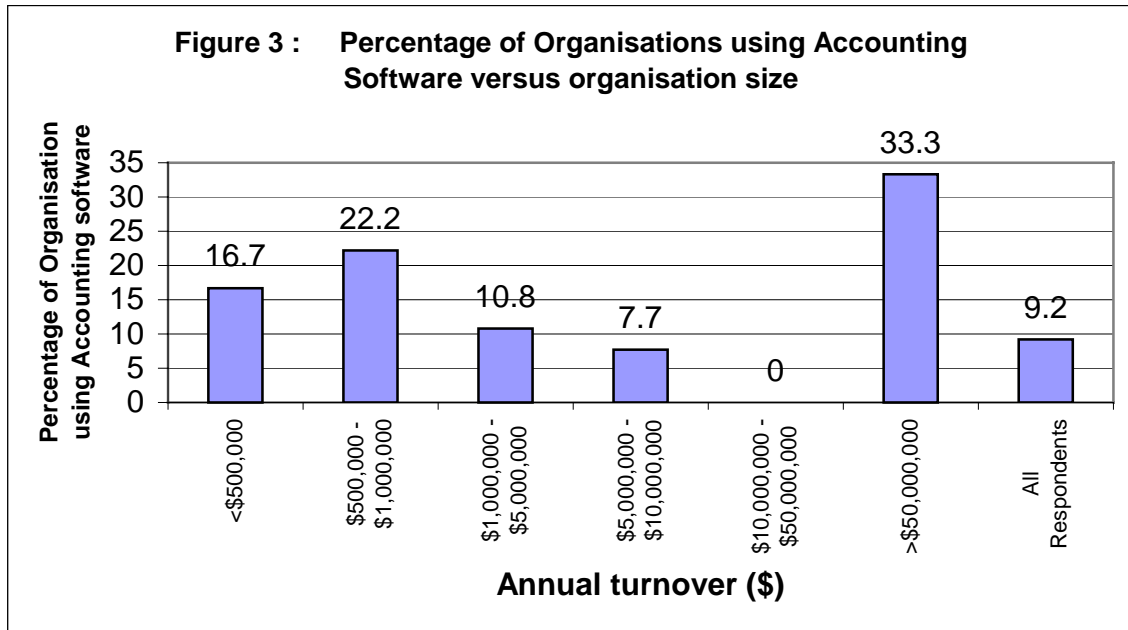
From the survey results above, almost forty percent of the organisations use Microsoft Project for project planning and scheduling. Some of the organisations use Microsoft Excel, Mapas and Probid software for estimating purposes. Apart from Microsoft Project, all of the other softwares have percentages not exceeding 10 %. Overall, the percentage of the use of computer software for planning, estimating and finance in New Zealand construction industry is quite satisfactory.



The percentage of organisations using scheduling software versus organisation size was plotted as shown in Figure 1 above. The organisations with annual turnover \$5,000,000 - \$10,000,000 and \$10,000,000 - \$50,000,000 had the same percentage of using scheduling software (84.6 %). The lowest percentage of organisations using scheduling software was 11.1 % and it fell in the \$500,000 - \$1,000,000 category. In general, the percentage of organisations using scheduling software increases with organisation size, with 46.1% of all organisations using some form of scheduling software.



The percentage of organisations using estimating software versus organisation size was plotted as shown in Figure 2 above. The organisations with annual turnover less than \$5,000,000 and greater than \$50,000,000 had the same percentage of using scheduling software (66.7 %). Regarding to the annual turnover of \$500,000 - \$1,000,000 categories, there was no organisation using estimating software. Figure 2 indicates that, with some exceptions, the larger the company size, the greater the percentage of organisations using estimating software. Overall, the percentage of organisations using estimating software (19.7%) seems low.



The percentage of organisations using accounting software versus organisation size was plotted as shown in Figure 3 above. The organisation with annual turnover of more than \$50,000,000 had the highest percentage of using accounting software (33.3 %), whereas not even one organisation within the \$10,000,000 - \$50,000,000 categories use accounting software. The second highest percentage of organisation using accounting software was 22.2 %. Overall, not many organisations use accounting software since the highest percentage (33.3 %) of organisations using accounting software did not exceed 50 %.

2. General administration/ business software currently in used in the organisations :

Software	Number of responses	% of 76 respondents
MS-office	54	71.1
NZA Gold Accounts	6	7.9
Quickbooks	3	3.9
IMS	3	3.9
Reese Easy	2	2.6
Prophet	2	2.6
MYOB	2	2.6
Lotus	2	2.6
CBA	2	2.6
Acumen	2	2.6
SUN	1	1.3
Quickpay	1	1.3
Intech	1	1.3
Charter Series	1	1.3
Cash Manager	1	1.3

Table 7: General administration/ business software currently in use

From the survey data above, Microsoft Office is the most popular business software with a percentage of 71.1 %. The NZA Gold Accounts software, at 7.9 % is the second most popular software used for general administration and business purposes. All the other softwares except Microsoft Office had a percentage of less than 10 %. Overall I conclude that the use of computer software in the New Zealand construction industry has been well implemented. The use of computer software in administration will enhance the efficiency of the organisations in construction projects.

A review of Tables 6 and 7 indicates that some of the respondents identified certain software as “planning, estimating and finance”, while others classified the same software as “administration or business”.

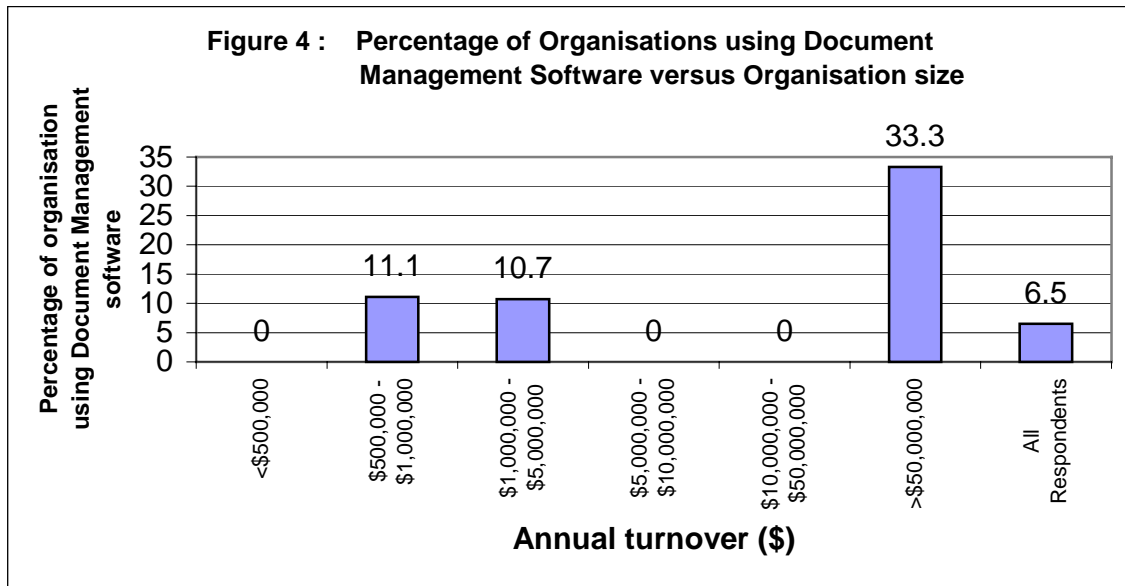
3. Document management software currently in used in the organisation :

	Number of responses	% of 76 respondents
Microsoft Works	3	3.9
Paragon	1	1.3
Module of Project Assistant	1	1.3

Table 8: Document management software currently in use

From Table 8 above, a very small proportion of organisations uses document management software for their construction purposes. This may be due to the organisation's size and therefore the lack of need for this software for their business management.

Only 3.9 % of the organisations that responded to the questionnaire use Microsoft Works, and 1.3 % each use Module of Project Assistant and Paragon software. Overall, we may conclude that the use of document management software in the construction industry has not been implemented in New Zealand.



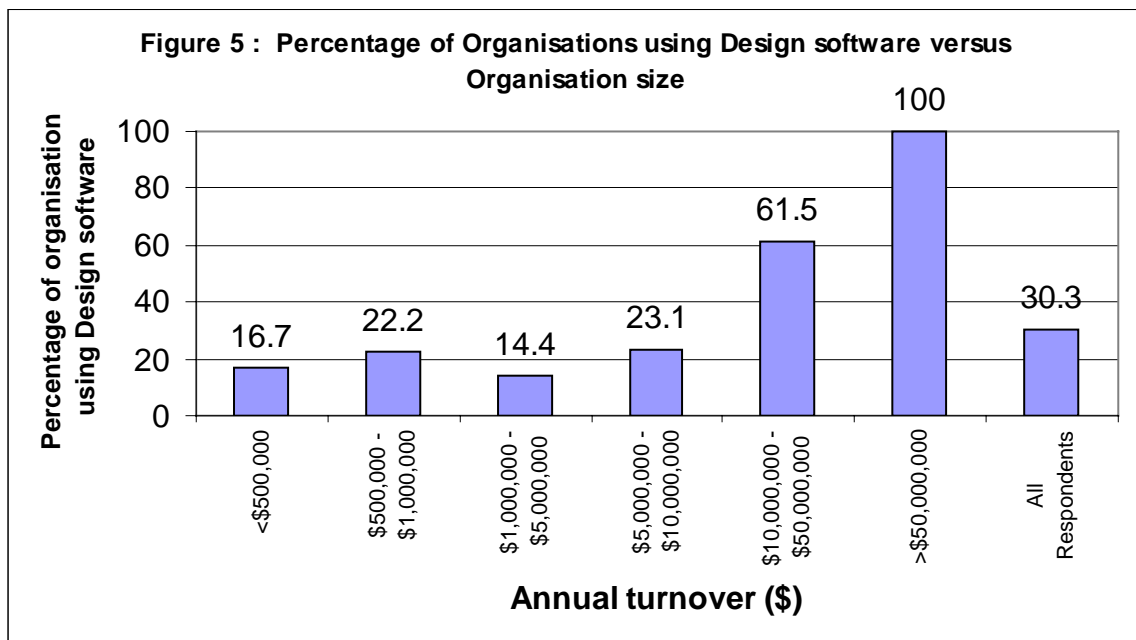
The percentage of organisations using document management software versus organisation size was plotted as shown in Figure 4 above. Organisations with annual turnover of more than \$50,000,000 had the highest percentage of using document management software (33.3%), whereas it was obvious that not even one organisation within the three categories shown in Figure 4 use document management software. The second highest percentage of organisation using accounting software was 11.1 %, which is considered as a low percentage. Overall, not many organisations use document management software since the percentage of using document management software as a whole is very low, at 6.5%.

4. Design software currently in used in the organisation :

	Number of responses	% of 76 respondents
AutoCAD	10	13.2
Adobe Photoshop	9	11.8
Visio Technical	1	1.3
TurboCad	1	1.3
Photo Impact	1	1.3
Microstation	1	1.3

Table 9: Design software currently in use

From Table 9 above, the AutoCAD software shows the highest percentage of 13.2 % among the design software currently used in construction industry within New Zealand. Apart from that, Adobe Photoshop is another popular software that is currently in use for design purposes.



The percentage of organisations using design software versus organisation size was plotted as shown in Figure 5 above. All organisations with annual turnover of

more than \$50,000,000 use design software, whereas the percentage of organisations using design software decreases with the decreasing organisation size. The second highest percentage of organisations using design software was 61.5 %. Overall, 30.3% of the respondents are utilising design software.

5. Operating systems currently in used in the organisations :

	Number of responses	% of 76 respondents
MS-Windows 98	41	55.3
MS-Windows 95	37	48.7
MS-Windows NT	11	14.5
UNIX	2	2.6
MS-Windows 97	1	1.3
MS-Windows 93	1	1.3
MS-Windows 2000	1	1.3

Table 10: Operating systems currently in use

From the survey data above, more than half of the organisations (55.3 %) use Microsoft Windows 98 as their current operating systems, with 48.7 % using Microsoft Windows 95. Construction is not alone in its preference for these two popular operating systems.

Third in popularity, at 14.5 %, is Microsoft Windows NT. Microsoft Windows 2000 is a very new operating system and is likely to increase in use in the future for operating processes in the organisations. The overwhelming preference for Microsoft operating systems overshadows the 2.6% that use the UNIX operating system.

6. The most significant factors considered in selecting computer software :

Factors	Number of responses	% of respondents
User friendliness	51	68.4
Cost	48	64.5
Consultant's advice	20	26.3
Compatibility	20	26.3
Past experience of the software	19	26.3
software integration	12	15.8
Flexibility of report format	7	10.5
Salesperson's advice	5	6.6
Industry standard	1	1.3
Fitness for application	1	1.3

Table 11 : Factors considered in selecting computer software

From Table 11 above, many factors are considered in selecting computer software. The most significant factor is *user friendliness*, which was identified by 68.4 % of all respondents. The second most significant factor is *cost*, which is 64.5 % out of the total percentage.

Equally important factors in this sample, at 26.3 % each, were *compatibility*, *consultant's advice* and *past experience with the software*. Thus, most of the organisations consider the factors of *user friendliness* and *cost* as most important when selecting software.

Communication Technology :

1. Do you have a company web site on the Internet ?

Responses	Number of responses	% of 71 responding to this question
Yes	17	23.9
No	54	76.1

Table 12 : Number of companies with web sites on the Internet

From the survey results above, a small, though significant, proportion (23.9 %) has a presence on the Internet via a company web site. A large proportion of organisations do not have a web site on the Internet, probably because their organisations are small and do not have a staff who are knowledgeable about web site operation. From the responses, it was found that 100 % of the organisations with an annual turnover of more than \$50,000,000, have a web site on the Internet, whereas no one organisation in the \$500,000 to \$1,000,000 category has a web site on the Internet.

2. Primary purposes of having a company web site :

Primary purposes	Number of responses	% of 17 respondents with company web sites
General company information	17	100.0
Project information	3	17.6
Shareholder information	2	11.8
Personnel recruitment	2	11.8
Public feedback	2	11.8

Table 13 : Primary purposes of having a company web site

From Table 13 above, the most significant primary purpose of having a company web site on the Internet is to show general company information. Apart from that, 17.6 % of the organisations use their company web sites for project information. The other primary purposes are for shareholder information (11.8 %), personnel recruitment (11.8 %), and public feedback (11.8 %).

3. Do you use web sites for individual projects ?

Response	Number of responses	% of 71 responding to this question
Yes	5	7.0
No	66	93.0
SUM	71	

Table 14: Number of companies use that web sites for individual projects

From Table 14 above, only 7.0 % of the organisations use web sites for individual projects and most of the organisations (93.0 %) do not use web sites for individual projects. From the responses, three organisations with annual turnover of \$500,000 - \$1,000,000 use web sites for individual projects, while only one organisation each in the \$5,000,000 to \$10,000,000 and greater than \$50,000,000 categories utilise project web sites. I conclude that the increasing popularity of web sites for project communication has obviously not yet reached New Zealand.

4. Primary purposes of using company web sites for individual projects:

Primary purposes	Number of responses	% of 6 respondents with project web sites
Public information about project	5	83.3
Public feedback	1	16.7
Internal communication among team members.	2	33.3
Document depository	1	16.7

Table 15: Primary purposes of using company web sites for individual projects

From Table 15 above, the most significant primary purpose of using web sites for individual projects is for public information about projects (83.3 %), whereas 33.3 % of the companies utilise project web sites for internal communication among team members. Also, there is a small percentage of 16.7 % for public feedback and document depository.

5. Does your organisation use e-mail ?

Response	Number of responses	% of 71 responding to this question
Yes	58	81.7
No	13	18.3

Table 16: Number of organisations using e-mail

Not surprisingly, a large proportion of respondents (81.7 %) use electronic mail. For the \$10,000,000 - \$50,000,000 and >\$50,000,000 categories, they have 100 % of organisations use electronic mail. Most all the organisations of any size have a considerably high percentage of electronic mail use.

6. E-mail system used by the organisations :

Type of e-mail systems	Number of responses	% of 58 respondents with e-mail
Microsoft Outlook express	16	27.6
Microsoft outlook	14	24.1
Xtra	9	15.5
Microsoft Exchange	3	5.2
Lotus notes	2	3.4
Groupwise	2	3.4
Clearnet	2	3.4
Telecom	1	1.7
Iprolink	1	1.7
IHUG	1	1.7

Table 17: Type of e-mail system used by the organisations

From Table 17 above, over half of the organisations use *Microsoft Outlook express* or *Microsoft outlook* as their e-mail system, with 27.6 % and 24.1 % respectively. Apart from that, *Xtra* is another popular system, with 15.5 % out of the total percentage.

7. Purpose of using e-mail by the organisations:

Purpose of e-mail	Number of responses	% of 58 respondents with e-mail
Sending simple / informal message	56	96.6
Distribution of documentation to other organisation.	45	77.6
Sending formal messages	44	75.9
Distribution of documentation within the organisation.	23	39.7
Purchasing	7	12.1
Distributing software	3	5.2

Table 18: Purposes of using e-mail by the organisations

From Table 18 above, the most significant purpose of using e-mail is to send simple or informal messages, which is 96.6 % of those with e-mail claim that as a purpose. Two other important purposes are to distribute documents to other organisations and to send formal messages (77.6 % and 75.9 % respectively). 39.7 % of the organisations use e-mail to distribute documentation within the organisation.

8. Factors restricting the use of e-mails :

Factors restricting use of e-mails	Number of responses	% of 71 responding to this question
Afraid of losing sensitive information	19	26.8
No user training	16	22.5
Lack of management awareness and support.	15	21.1
Insufficient management control over out-going information.	9	12.7
No e-mail system implemented	7	9.9
E-mail does not have legal standing in legal proceedings.	7	9.9

Table 19: Factors restricting the use of e-mail by the organisations

From Table 19, the most significant factor restricting the use of e-mail by the organisations is fear of losing sensitive information, identified by 26.8 % of those responding. Furthermore, 22.5 % of the organisations believe e-mail use is restricted because of a lack of user training and 21.1 % identify a lack of management awareness and support. Small percentages indicate that no e-mail system has been implemented and e-mail does not have standing in legal proceedings.

Hardware :

Information technology (I.T.) hardware currently in use :

IT hardware	Number of responses	% of 71 responding to this question
Cellular phones	69	97.2
Scanners	32	45.1
PDA's / PALMS	5	7.0
CD writer	1	1.41

Table 20: Information technology (I.T.) hardware currently in use

As expected, on overwhelming proportion, 97.2 % of the contractors have cellular phones. Table 20 also shows that 45.1 % of the organisations have scanners. These two information technology devices are very important in order to communicate and enhance the progress of the business and construction process. Only 7.0 % of organisations use PDA's or PALMS hardware, while only one of the 71 (1.41 %) uses a CD writer. The two organisations not using cellular phones both have annual turnover of less than \$500,000.

Influences on Information technology Implementation :

The survey asked contractors to identify reasons for resistance to the implementation of information technology. The questions were divided into four categories, which are technological, human, financial and environmental.

What reasons are hindering the use of information technology (I.T.) in the organisation ?

Technological reasons	Number of responses	% of 76 respondents
Rapid changes in technology	20	26.3
Integration / compatibility problems	20	26.3
Security not guaranteed	16	21.1
Software problems	10	13.2
Reliability / breakdown problems	8	10.5
Hardware problems	2	2.6

Table 21 : Technological reasons hindering the use of IT

From Table 21 above, the primary technological reasons hindering the use of information technology are the rapid changes in technology (26.3 %) and integration or compatibility problems (26.3 %). In addition, 21.1 % of the organisations identified a lack of security guarantee, while 13.2 % of the organisations note software problems and 10.5 % suggest reliability or breakdown problems.

Human reasons	Number of responses	% of 76 respondents
Lack of knowledge / awareness of available IT	40	52.6
Inadequate training	35	46.1
Fear / mistrust of technology	13	17.1
Poor management	4	5.3
Poor leadership	3	3.9
Poor teamwork	1	1.3

Table 22 : Human reasons hindering the use of IT

From Table 22 above, the main human reasons hindering the use of information technology are lack of knowledge or awareness of availability of IT (52.6 %) and inadequate training (46.1 %). Furthermore, 17.1 % of the organisations think that fear or mistrust of technology is a limiting factor, while 5.3 % identify poor management and 3.9 % think that poor leadership hinders IT use.

Financial reasons	Number of responses	% of 76 respondents
Difficulty in proving that the benefits of IT are greater than the associated costs.	26	34.2
Lack of available funding	11	14.5

Table 23: Financial reasons hindering the use of IT

Table 23 indicates that the main financial reason hindering the use of information technology is the difficulty in proving that the benefits of IT are greater than the associated cost (34.2 %). The second main reason is the lack of available funding, which is 14.5 %. Without knowledge about how IT can assist in managing their work for better profits, contractors do not want to risk their financial positions to invest in information technology.

Environmental reasons	Number of responses	% of 76 respondents
Conservative industry that is slow to change	13	17.1
Project driven industry with short term outlook	10	13.2
Susceptibility of industry to economic climate	8	10.5
Complex / fragmented industry	7	9.2

Table 24: Environmental reasons hindering the use of IT

The final question in this series of four sought to identify industry-wide or contextual factors that impede the adoption of information technology in construction. From Table 24 above, the most significant environmental reason hindering the use of information technology is the industry's conservative nature, identified by 17.1 % out of the total respondents. The other significant reasons are the short term outlook characteristic of project-driven work (13.2 %) and susceptibility to the economic climate (10.5 %). These reasons are not major factors compared to the previous three categories. We may conclude that internal rather than external factors are the primary determinants of the willingness, or lack therefore, to adopt information technology in New Zealand's construction organisations.

Information Technology and Business Strategy :

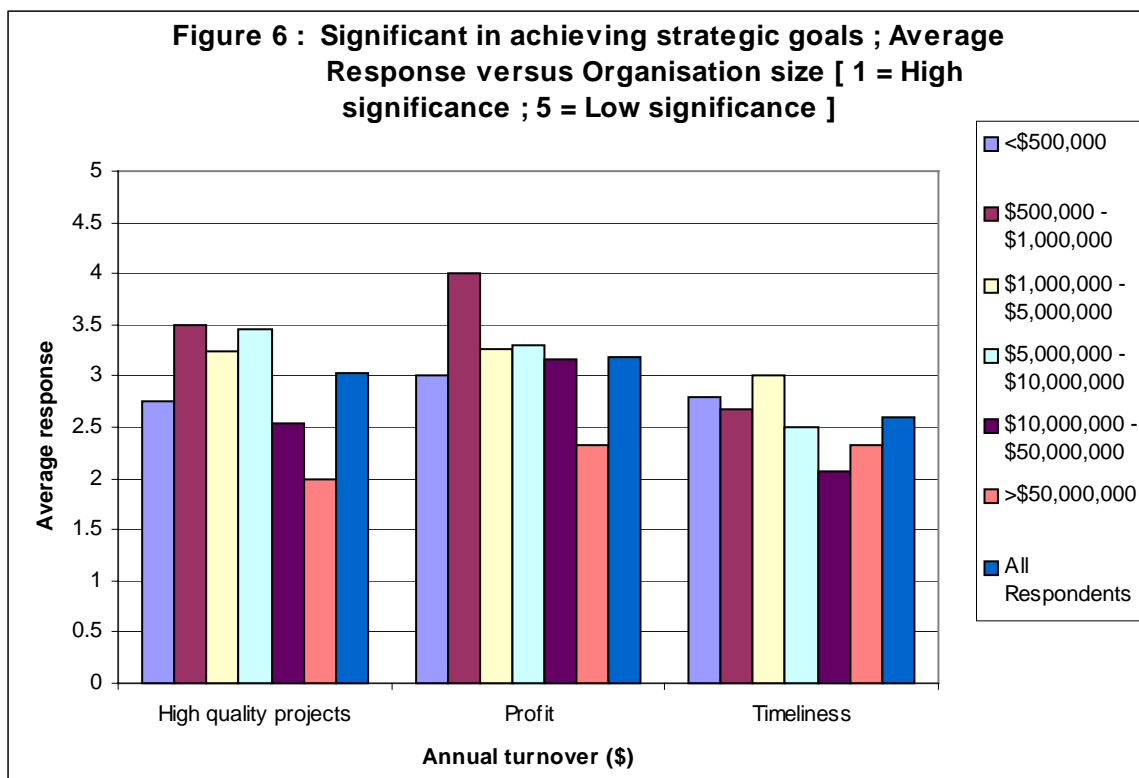
To what extent has IT enabled your organisation to accomplish its strategic goals in the following areas ? (1 - *most significantly enabled*, 2 - *considerably enabled*, 3 - *moderately enabled*, 4 - *slightly enabled*, 5 - *not enabled*)

Areas	Number and percentage of responses, by significance number												Weighted average
	1	%	2	%	3	%	4	%	5	%	No Response	%	
Communication	17	22.4	20	20	16	21.1	2	2.6	2	2.6	19	25.0	2.16
Timeliness	10	13.2	20	20	10	13.2	5	6.6	7	9.2	24	31.6	2.60
Business development	3	3.9	13	13	21	27.6	10	13.2	5	6.6	24	31.6	3.02
High quality projects	6	7.9	15	15	14	18.4	11	14.5	9	11.8	21	27.6	3.04
Profit	3	3.9	10	10	22	28.9	14	18.4	6	7.9	21	27.6	3.18
Safety	0	0.0	2	2	19	25.0	16	21.1	17	22.4	22	28.9	3.89
Environmental concerns	0	0.0	1	1	11	14.5	14	18.4	26	34.2	24	31.6	4.25

Table 25: Extent to which IT enabled the organisation to accomplish its strategic goals

In Table 25 above, *Communication* had the lowest weighted average value of 2.16, meaning that it was seen as the most significant reason. The area of *Environmental concerns* had the highest weighted average value of 4.25.

From the data above, it is clear that communication can be substantially enhanced through the use of information technology. Business communication includes many aspects, such as customer contact, intra-project interaction, contact with the public, and new business development.



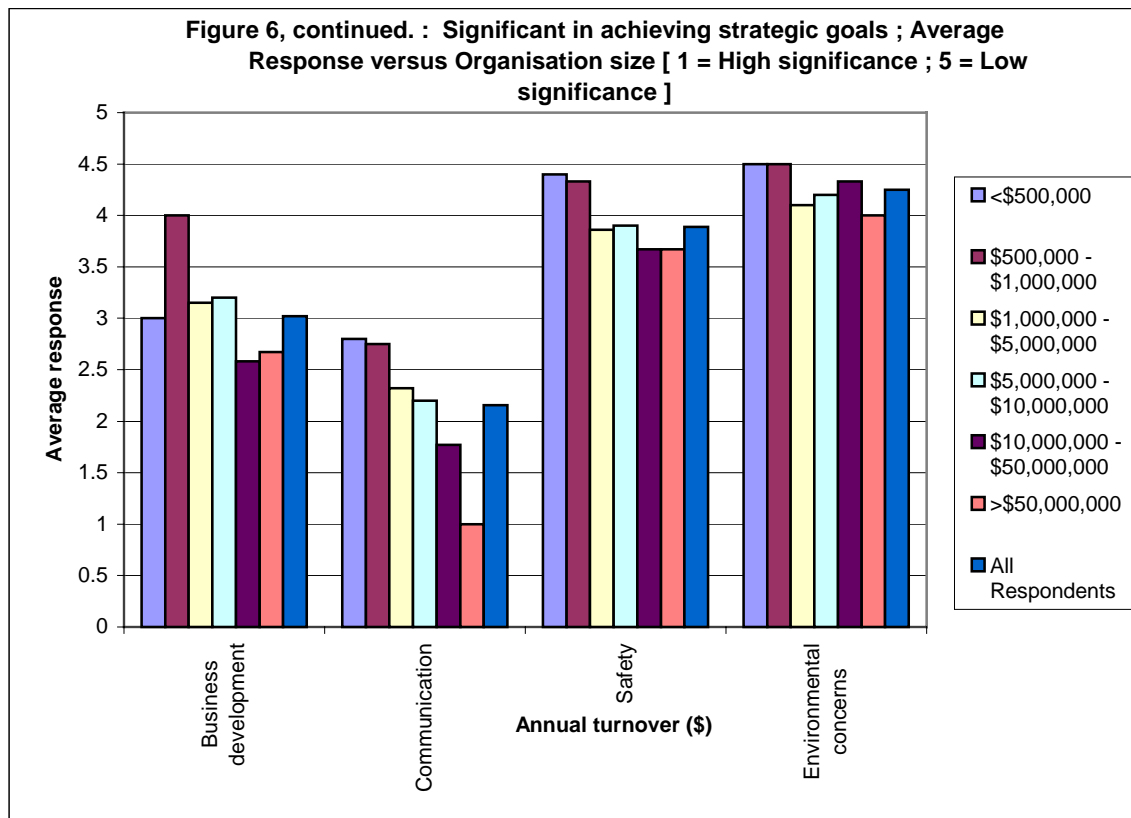


Figure 6 shows the significance in achieving strategic goals for different organisation sizes. Note that low values represent high significance. The highest significance relates to enhanced communication for all sizes of business. For any specific strategic goal, Figure 6 indicates a generally increasing recognition of the importance of IT in meeting the goal as organisation size increases. Not surprisingly, contractors do not view information as helpful in achieving safety or environmental goals.

The Future of Information Technology :

To what extent do you agree with the following predictions about information technology applications in construction in the next five years ?

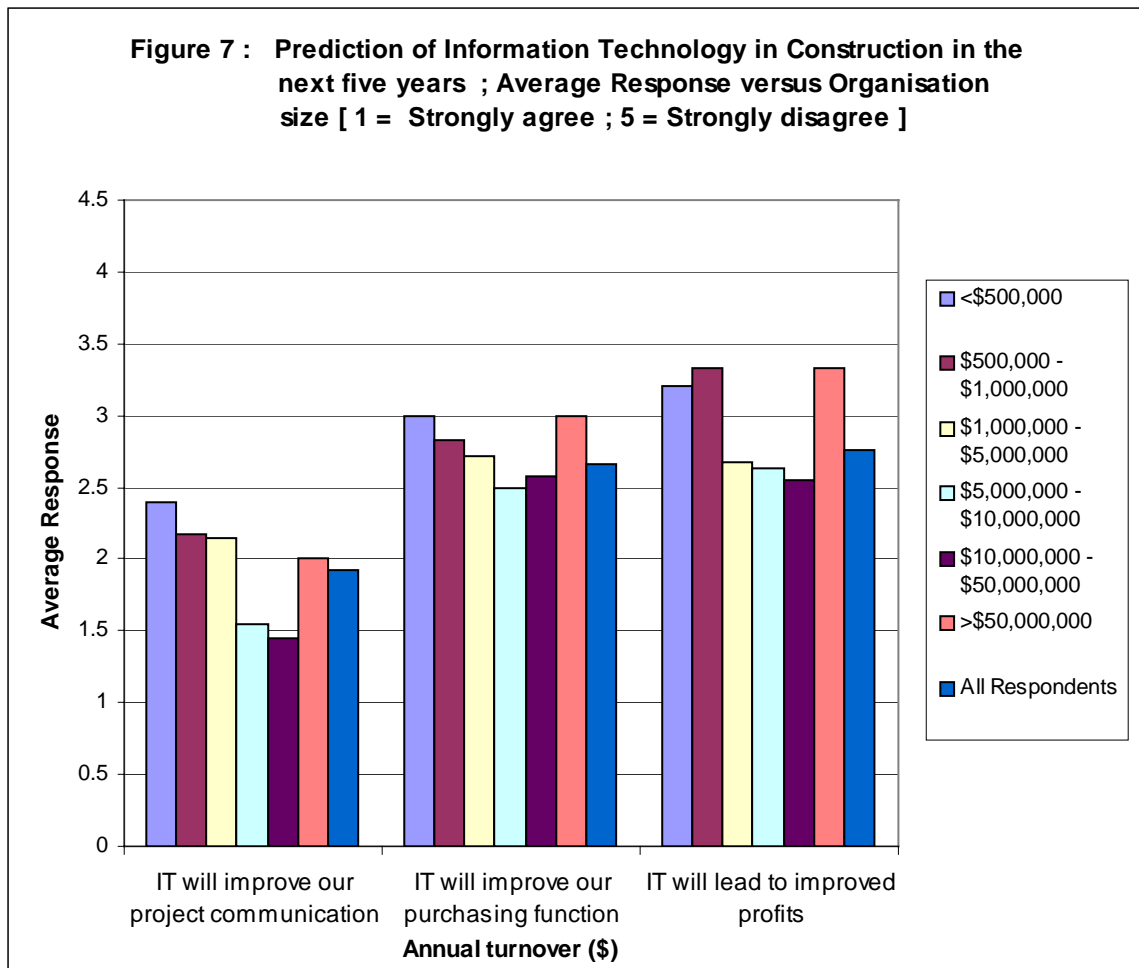
(1 - strongly agree, 2 - agree, 3 - neutral, 4 - disagree and 5 - strongly disagree)

Prediction of IT applications	Number and percentages of responses, by agree/disagree number												Weighted average
	1	%	2	%	3	%	4	%	5	%	No Response	%	
IT will improve our project communication	25	32.9	24	31.6	6	7.9	4	5.3	2	2.6	15	19.7	1.92
IT will result in improved project control	11	14.5	33	43.4	12	15.8	2	2.6	5	6.6	13	17.1	2.32
IT will benefit construction research	9	11.8	22	28.9	23	30.3	5	6.6	1	1.3	16	21.1	2.45
IT will improve our purchasing function	5	6.6	27	35.5	20	26.3	9	11.8	3	3.9	12	15.8	2.66
IT will require excessive training	8	10.5	22	28.9	12	15.8	18	23.7	1	1.3	15	19.7	2.70
IT will lead to improved profits	4	5.3	17	22.4	33	43.4	6	7.9	2	2.6	14	18.4	2.76
IT will become prohibitively expensive	2	2.6	12	15.8	15	19.7	23	30.3	9	11.8	15	19.7	3.41

Table 26: Extent of predictions about information technology applications in construction in the next five years

Table 26 above reports a higher response rate compared to the response rate in Table 25. More so than any other prediction, respondents tend to agree that information technology will improve project communication in the next five years; 64.5 % either agree or strongly agree with this prediction. The second most positive prediction relates to project control, wherein 57.9 % either agree or strongly agree that IT will enhance project control.

On the negative side, 39.4 % agree or strongly agree that IT will require excessive training, whereas only 18.4 % predicted that IT would become excessively expensive. The largest neutral response related to future profits, with 43.4 % neither agreeing nor disagreeing that profits will improve due to information technology.



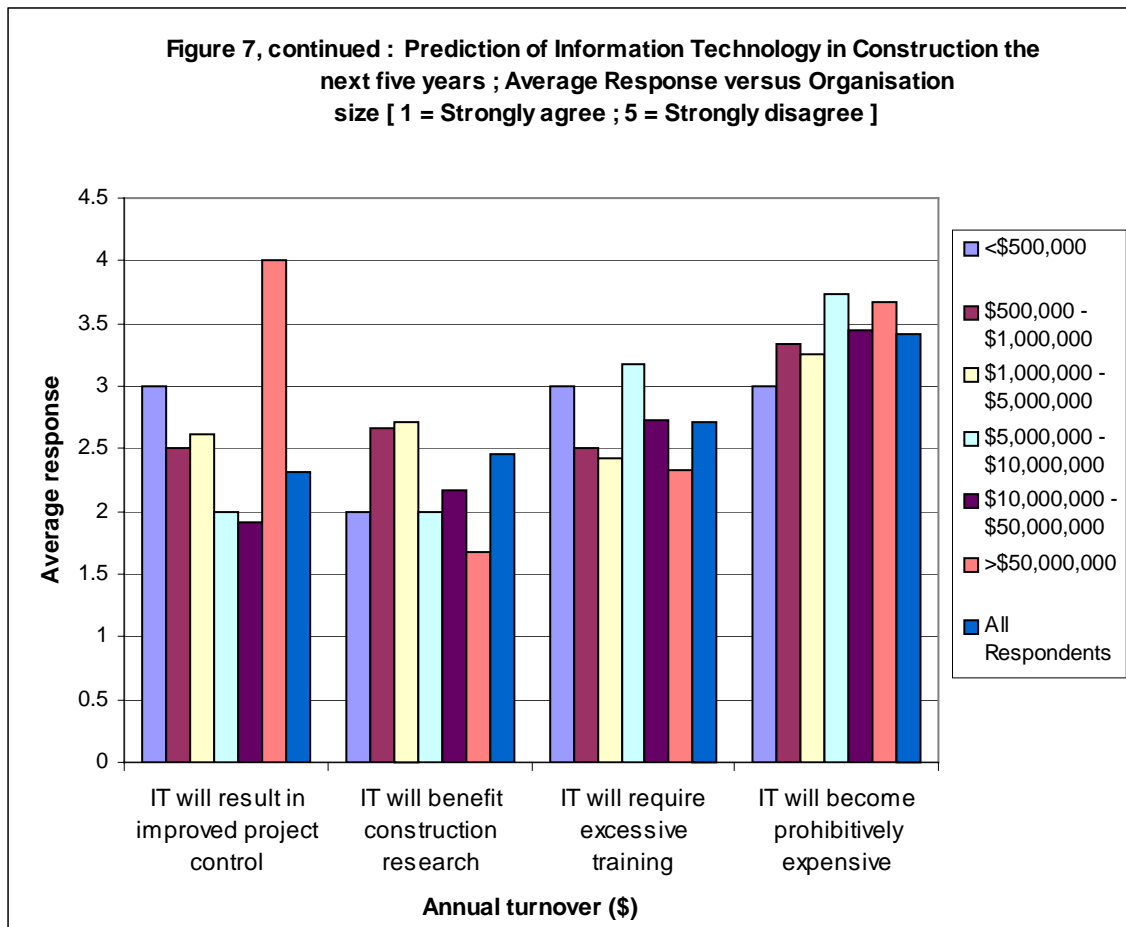


Figure 7 shows the prediction of information technology in construction in the next five years as a function of organisation size. Most of the organisations agree that IT will improve project communication and will benefit construction research. Most of the organisations are more neutral in predicting IT's influence on improved profits and the purchasing function. Most of the organisations disagree that IT will become prohibitively expensive. In assessing the response trend with organisation size for any specific factor, such as improved project communication, larger organisations tend to be more favourable in predicting future impacts. However, an interesting anomaly occurs for the largest organisations, for which there are more negative predictions than for some of the smaller organisation sizes.

INTERNATIONAL COMPARISON

Other similar surveys that have been carried out in the past about information technology in the construction industry include the following :

- A study of the use of Information Technology in the Republic of Ireland construction sector (*Thomas 1999*).
- A study of Information Technology (I.T.) applications among contractors in Hong Kong (*Shen and Wong 1997*).

There is a limit to the extent of comparison that can be made between these different surveys, as there is a variation in both the questions asked and the classification of individuals and firms that supplied answers. Although a direct and exact comparison is not possible, the following general comments can be made in relation to the current and future use of information technology by the contracting firms in New Zealand and that of similar contractors in the Republic of Ireland and Hong Kong.

- The ratio of numbers of computers to numbers of staff by the contracting firms in New Zealand is less than that for the equivalent sub-sector in the Republic of Ireland and Hong Kong. (New Zealand – 21.4 % , Republic of Ireland – 35.8 % and Hong Kong – 65.2 %)
- AutoCAD software use by the leading contracting firms in New Zealand is at approximately the same high levels in the equivalent sub-sector in Hong Kong and greater than that in the Republic of Ireland. (New Zealand – 13.2 % , Republic of Ireland – 14.1 % and Hong Kong – 17.1 %).
- The dominance of *Microsoft Office* as the chosen office administration software by the contracting firms in New Zealand (71.1 %) is less than that in the Republic of Ireland construction sector (88 %) but higher than that in Hong Kong construction sector (65 %).

- The availability of company web sites on the Internet by the contracting firms in New Zealand (23.9 %) is less than that in Hong Kong (68 %) and in the Republic of Ireland (52 %).
- Access to e-mail facilities in the contracting firms in New Zealand (81.7 %) is greater than that in the Republic of Ireland (66 %) and about similar to the one in Hong Kong (82.7 %).

These comments indicate that the contracting firms in New Zealand are about the same as the equivalent sub-sector in the Republic of Ireland but are slightly behind the equivalent sub-sector in Hong Kong. In general, they are all roughly equal in information technology applications based on the indicators cited.

DISCUSSIONS ON THE VALIDITY OF THE FINDINGS

No efforts were spared to boost the response rate of the survey. Methods adapted included an easy-to-complete questionnaire, a personalised cover letter to each contractor, and self-addressed stamped envelopes for convenient replies. With these efforts, the response rate in this questionnaire survey was 39.1%, somewhat higher than expected for similar surveys. A higher response would have been desirable, but there are many reasons for not returning such requests, as follows :

- In New Zealand, people, especially top management, are always fully occupied by their work; they can seldom spare any time to fill in questionnaires or to be interviewed.
- Some New Zealand contractors tend to ignore all sorts of questionnaire surveys. They may assume their contributions will not make any difference to the results.

- Some people try to avoid exposing themselves to outsiders regarding what they are doing or not doing : One example is that some contractors do not want to be identified as not using information technology. They feel less vulnerable to their competitors by not filling in the questionnaire.
- The questionnaire may be too long for busy top management people to complete.

LIMITATIONS OF THE SURVEY

The survey was confined to only one sub-sector (contractors) of the New Zealand construction sector. Other sub-sectors such as architecture, quantity surveying, suppliers and clients were not included in this survey. A sampling of 200 leading organisations in the contracting sub-sector were targeted, based on selecting every third entry from the contracting organisation addresses listed in the *New Zealand Contractors Federation* database from their web sites. It should be emphasised that the *New Zealand Contractors Federation* may not completely representative of all the entire New Zealand construction contracting community.

It is possible that there are New Zealand Contracting organisations that were not included in the survey who are exploiting information technology to a greater extent than some of those that were included. The results therefore do not necessarily reflect the general use of IT in the contracting sub-sector studied or of the construction sector as a whole. They do however show how many of the current leaders in the contracting sub-sector are using and are likely to use information technology.

It was acknowledged that this sampling technique would be likely to produce a biased result. Despite the inclusion of a stamped envelope and the use of an easy-to-complete form, those who actually used computers were probably more likely to fill in the questionnaire survey form. The primary purpose of the survey was to identify non-users, casual users, and regular users, but it is still unknown how representative these respondents are of the general population in New Zealand's building and construction industry. This survey is limited to the contracting sector as the sampled population, and leaves out such sectors as designers and project principals. Although the intent was to obtain an indication of the use of information technology throughout the entire construction industry, the results are based on a sampling of contractors only.

The fact that there may be a number of contracting organisations who are involved in contracting activities but are not registered with any of the recognised representative bodies is also acknowledged. Also, none of the public sector bodies involved in the management, design and construction of public projects (e.g. The City Councils, Corporations) were included in this survey.

IMPLICATIONS AND RECOMMENDATIONS

Information technology - based communication methods are considered by the contractors as a better way to improve the quality, accuracy, timeliness and useability of information. This suggests a serious mismatch between beliefs and behaviours of the contractors in the use of information technology in their daily operations, which can only be solved by changing the attitudes of these organisations towards IT applications.

It is suggested that contractors should have a more positive attitude toward using information technology and move away from the traditional *wait and see* conservatism. Information technology professionals must address the existing problems of information technology - based communication methods such as quality of the scanned documents and their illegibility. The industry as a whole should also take the initiative to promote IT - based communications among all professions within the industry.

Furthermore, the New Zealand Government should take the initiative in promoting information technology applications in the local construction industry. The survey revealed that the current use of information technology among many contractors is still at a low level, despite the fact that almost all of them have considerable experience in using computers. Information technology expenditure and training are also inadequate. This problem is probably associated with the lack of management support for IT applications which puts a serious threat to the appropriate use of information technology in the construction industry. Top management of construction organisations must face these problems and change their attitude to maintain their competitive edge in today's

highly competitive environment. The recent economic slowdown in New Zealand puts a serious challenge to all contractors. They must do whatever they can do to enhance their competitiveness.

As far as the research is concerned, it is envisaged that follow-up interviews should be carried out to further investigate particular interesting cases and to explore people's views and experiences in greater depth. It is planned to undertake a comparative study to identify how well the local construction industry stands among other developed countries in the information technology era, and to reveal differences between these countries and what the local industry can learn from its counterparts in other countries. In the future, studies similar to that reported herein should be conducted; they will provide conclusions about the extent of IT use and the rate with which contractors are adopting the new technology.

CONCLUSIONS

This project illustrated the current state of information technology applications among New Zealand contractors by way of a questionnaire survey. Unlike many other industries, information technology has not received adequate attention from top management in the construction industry. The survey revealed that the level of IT applications among contractors in the industry is relatively low in comparison with other developed countries. A possible reason is that many organisations rely on their staff to do repetitive works, and are not willing to invest in information technology - related technologies.

While the theme of much of today's information technology research is convergence; there has been a steady divergence in development and practice in the construction industry. It is envisaged that this research this would contribute in bridging the gap between researchers and information technology engineers on the one hand, and building industry professionals and practitioners on the other.

The success of IT applications to a large extent relies on the industry's attitude towards information technology. The rapid growth of personal computing may soon bring about a significant change in the industry's attitude towards information technology. Given the competitive nature of the construction industry in New Zealand, contractors must do whatever they can to make the most out of information technology and to make IT a strategic contributor to the success of their business.

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