A survey on application of information technologies

in Chinese construction industry

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Summary

The construction industry is a supportive industry in China. IT (information technolgy), including computer technology and communication technology, as a whole is regarded as the most important means to upgrade the construction industry so that research projects were organized by Chinese government to further the application of IT in the construction industry. This study originated from one of the projects and is aimed at grasping the general situation on the application of IT in the construction industry. A questionnaire was designed for the survey, which used stratified proportional sampling method, and was carried out under the help of a government agency. This study can not only provide sound foundation for the government to make relative policies, but also reveal references for the firms in construction industry to apply IT in their business. This paper presents the preliminary result of the survey.

1   Introduction

The construction industry is a supportive industry in China. Its contributes to about seven percent of the GDP in China and hires about 36 millions employees. The number of comstruction firms is about 70,000 and that of the design firms is about 12,000. Besides, there are about 8000 supervisory firms and consultant firms. Computers have been used in the construction industry in China since 60's in the last century when they were firstly used for structural analysis. With the rapid development of computer technology, they began to find wide use in more and more aspects. A remarkable symbol of the movement is that the drawing table for designers were thrown away in almost all design firms in China in 2000 and computers were used instead. During recent years, information technolgy (IT), including computer technology and communication technology, as a whole is regarded as the most important means to upgrade the construction industry so that research projects were organized by Chinese government to further the application of IT in the construction industry.

This study originated from one of the projects and is aimed at grasping the general situation on the application of information technology in the construction industry. Field investigation was carried out on about 30 firms including construction firms, design firms, supervisory firms and consultant firms. Then a questionnaire was designed and finalized after it was used for trial surveys in three domestic conferneces. Finally, the formal survey was planned by using

stratified proportional sampling method and was implemented under the help of a relative goverment agency. This study can not only provide sound foundation for the government to make relative policies, but also reveal references for the firms in the construction industry to apply IT in their business. In addition, it can guide the software developers and researchers to carry out their work in the right directions.

This paper shows the preliminery results of the survey because more answers on the questionnaire are expected to rerurn in a couple of weeks. The total result will be presented on the conference. The questionnaire and the implementation method are described at first and then the profile of the respondent firms is summarized. Next, analyses on the answers are carried out on two aspects, i.e. the current status of application of IT and the requirements on application of IT, which are based upon the survey.

2 Survey method and response

2.1 Questionnaire design

The questionnaire design is a key to the survey and the first step of the study. Firstly, about 30 firms in construction industry of different kinds were selected for interviews about their organizations, management patterns, workflows, computer applications, information management systems, IT talents and other factors concerning IT application. On the basis of these surveys and by referring to the relative literatures in New Zealand (Doherty 1997); Sweden, Denmark and Finland (Howard and Samuelsson 1998); Hong Kong (Futcher and Rowlinson 1998, Futcher and Rowlinson 1999); and Saudi Arabia (O'Brien and Al-Biqami 1999); Canada(Rivard 2000) came out the first version of the questionnaire. Then it was used to survey at three domestic conferences to gain feedbacks for improvement of the contents. The formal version was accomplished after several revisions according to the feedbacks of the interviews and the trial surveys.

The main contents of the questionnaire can be divided into six parts: the basic conditions of IT application, the quantities of investment, the necessity of IT application, the general effects obtained from IT and the major influential factors, the key points and areas of development. (See Appendix 1 for details)

2.2 Sampling method

Stratified proportional sampling is used in the survey because it is required to make out the IT application requirements of all kinds of firms and this method can guarantee that the samples come from all kinds of firms in the construction industry. The number of samples n for each kind of firm is calculated according to the following equation (1) from statistics.

$$n = \frac{z^2 p(1-p)N}{e^2(N-1)+z^2 p(1-p)} * deff \qquad (1)$$

Where N is the number of population, p represents the proportion of the elements with certain characteristics ($p(1-p)$ was set 0.25 to obtain a conservative value of n) to N, e is the biggest

sampling errors permitted (it was set to 5% here), z is the quantile in normal distribution with a confidence level of 95%, and *deff* represents the design effect (it was set to 2.0 to be in the conservative side).

2.3 Sampling population and respondent profiles

The firms in the construction industry are administrated by the Ministry of Construction and they are classified according to some criteria for admission into the market. There are several levels for construction firms, design firms, supervisory firms and consultant firms, respectively. Among them, the level 1 to level 4 of the construction firms, the level 1 and level 2 of the design firms, the supervisory firms and consultant firms are considered the firms that have the capability to carry out major construction projects and have a large or middle size in capital and employees. The number for the above mentioned firms is 9365, constituting about one seventh of the total construction firms. These firms are regarded as the population of the survey.

There are 838 firms selected arbitrarily as samples by the above-mentioned method. Among them, 405 were selected among 4282 construction firms; 320 among 3840 design firms; 75 among 793 supervisory firms, and 38 among 450 consultant firms.

Mails containing the questionnaires were sent out at the beginning of March 2004 and the return rate till April 5 is 10.5% (88 was returned among 838), which is similar to 7% in the general survey in New Zealand (Doherty 1997); 10% in Denmark and 16% in Sweden (Howard et al. 1998); 9% in Saudi Arabia (O'Brien and Al-Biqami 1999). In general, a mail survey cannot be considered statistically significant under a 50% return rate. Even though a low response was obtained, the findings of the survey still present useful information about the respondents and show tendencies within the industry. Further more, the response is expected to increase in a couple of weeks and the further results will be reported on the conference.

2.4 Analysis method

The statistic analysis tool SPSS is used to analyze the reponses in the collected questionnaire. The analysis methods include: descriptive statistic; correlating analysis; classification; general linear model.

3   Current status of application of IT

3.1 Organizations in charge of IT application

Having or not organizations in charge of IT application in firms indicates if the firm pay close attention to the application of IT. The survey reveals that 12% firms have a steering committee in charge of IT application; 10% firms have an information center; 47% firms have the technology department to take care of the issue; and the left 31% have no such organizations.

As far as the attitudes of the top managers of the firms towards IT application is concerned, about 85% top managers take positive attitude to it and 49% firms have IT application development plan. It shows that more and more attention are payed to IT application.

3.2 Conditions of information infrastructures and application systems

3.2.1 Computers

The design firms equip almost one computer per person upon the request of no-paper design and construction firms equip their white collar employees almost to the same extent. Averagely, two or three staffs of other kinds of firms share a computer. It shows that computers have been widely used in Chinese construction industry.

3.2.2 Network equipments

It is revealed that 84% firms of construction industry have some kinds of network; 80% have local area network; 47% have access to the Internet; 12% have wide area network and 6% have extranet, while 16% have no any kind of network. It shows that network has become an important means for most firms.

3.2.3 Software systems

It is indicated that 94% firms have specialty application software; 67% firms have office automation (OA) system; 33% firms have project management systems. 22% firms have management information systems (MIS); while few firms possess other information systems, such as decision-making support systems (DSS), enterprise resource planning (ERP) systems, knowledge management systems, and large database management systems (DBMS). specialty application software and OA system are the two most popular kinds of application systems. The types of software used by the enterprises are shown in Figure 1.
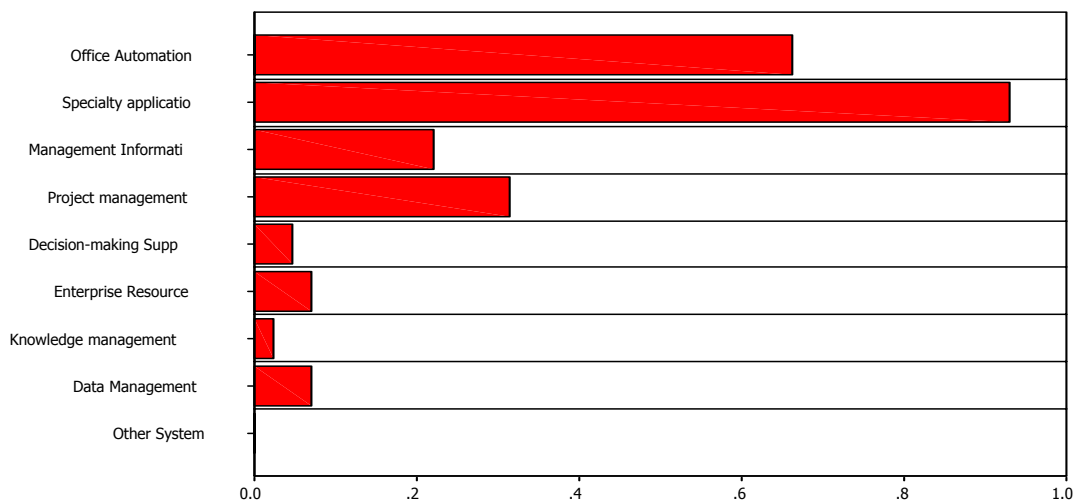

Figure 1: Types of software used

3.3 Investment conditions and ranking of its drivers

The quantity of investment in IT application per person is about 1000 RMB (about 120USD) in the last 3 years.

Concerning the drivers of investment in IT application, 81% respondents consider that improving management is an important driver; about 77% respondents say that the need to

remain competitive is an important driver; 69% respondents say that they want to increase market opportunities through investing on IT application; 53% respondents say that presenting a better image to clients is an important driver; 26% respondents indicate that they only mean to adapt themselves to the tide of IT application; 6% respondents say that they only respond to the calling from the government. So the first three most important IT investment drivers are improving management, remaining competitive and increasing market opportunities.

3.4 Talent and technical ability concerning IT application

The respondents were asked if the employees engaging in Construction IT and technical ability in their firms are enough to satisfy the needs that arise from the business. About 4% respondents rank the talent and technical ability of their firm as "Far from enough", and 47% ascribe theirs to "Not enough", while 37% say that theirs belong to the rank of "More or less enough". Only 12% firms allege that the talent and technical ability of their firms attain to the rank of "Enough", and no firm consider that theirs belong to the rank of "More than enough". The survey indicates that the IT application talent and technical abilities in the firms can hardly meet the demands.

3.5 Levels of IT application

Only less than 2% respondents state that their IT application levels have reached advanced level, i.e. the core business of the firm is managed through information systems. About 45% respondents say that they have reached middle level, i.e. their information systems have been planned in proper form and have covered the major workflows of the core business, but the management information can only be shared partly. More than 53% respondents think that the IT application in their core business is very weak and can only be ranked as preliminary level, i.e. their information systems cover only few of their core business workflows, and most of their management information can not be shared although they have started taking advantage of some software products. No respondents consider the IT application level of their firms belongs to the rank of "At the beginning". The survey reveals that the level of IT application in Chinese construction industry needs to be boosted since the level of IT applicaiton of more than half of the construction firms is still in the prelimiary level.

3.6 Ranking of the major benefits from IT application

About 85% respondents indicate that the increased working efficiency is the major advantage obtained from IT application; 65% respondents say that management has been improved by IT application; 65% respondents say presenting a better image to clients is the result from IT application; 41% respondents say that IT application has increased market opportunities; 28% respondents state that the company's core competence has been improved because of IT application; 22% respondents say that IT application has brought about better quality of products & services; 20% respondents say the main benefits resulted from IT application are economic benefits. Summarily, the three most important benefits resulted from IT are the increase of working efficiency, the improvement of management and the upgraded image to clients.The effects of IT application are shown in Figure 2.
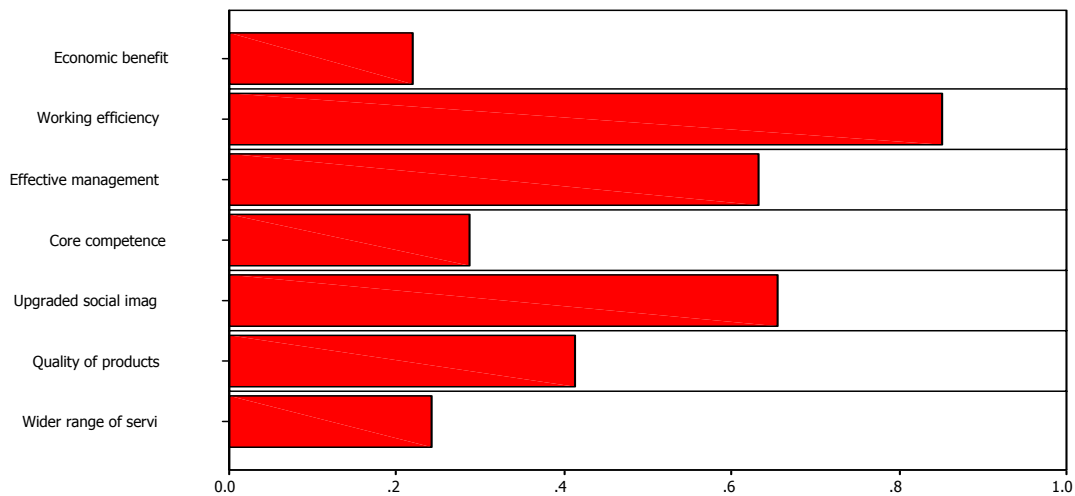
Figure 2: The effects of IT application

4 The demands of application of IT

4.1 Demand for talents in IT application

With citing rate of 80%, the most urgently needed talents of IT application are those who have hybrid knowledge on both IT and management. The second kind of urgently needed talents are engineers for system operation and maintenance with the citing rate of 51%. Planner on Construction IT is the third kind of talents needed by IT application and its citing rate is 31%. System analysts and designers get the citing rate of 26% according to the need of IT application. So, the two kinds of most urgently needed talents in IT application are the persons with hybrid knowledge on both IT and management, and the engineers for system operation and maintenance.

4.2 Demand for proper roles of the government in advocating construction IT

About 65% respondents consider that the government should be the maker and issuer of relative standards on IT application. 53% respondents think that making policies concerning IT application should be the proper role of the government. While 32% respondents consider that the government should be coordinator for implementing construction IT. Only 9% respondents consider that the government should be major investor in construction IT. From the above expectations of the respondents, it can be concluded that the main roles of the government in advocating construction IT are to be the maker and issuer of relative construction IT application standards, and relative policy maker.

4.3 Demand for business process re-engineering (BPR)

About 14.3% respondents cited that it is very necessary and 46.8% respondents said it is necessary to carry out BPR for the effective implementation of IT application, and 30.6% considered it is relatively necessary to do so. Only 8.3% respondents cited that it is not

necessary to carry out BPR. The results of the survey revealed that it is necessary to carry out BPR for major firms in construction industry.

4.4 Demand for the prerequisites for the success of IT application

It is shown that the most important prerequisite for the success of IT application is that the strong support from the top managers of the firm is available, with the citing rate of 71%. Additionally, that the firm can obtain the necessary hardware and software is the second important prerequisite for the success of IT application, winning the citing rate of 63%. It is indicated that the system meets the pressing needs of the firm's business is the next important prerequisite with the citing of 52% respondents. That the systems are available for both the operation of business and the management consists the next one with the citing rate of 48%. As the fifth prerequisite, that continuous and effective support can be obtained from outside parties such as software vendors get the citing rate of 37%, while the support from most of the employees can be obtained get 34%. That the work is supported by the relative standardization and government policies is affirmed by 25% respondents, and that the level of the application of construction IT is high in the whole industry is only supported by 15% respondents. It can be seen that the first four prerequisites are important for the success of IT application.

4.5 Urgently needed software

The most urgently needed software by the firms is project management systems according to the survey, with the citing rate of 61%. Specialty application softwares rank the second and its citing rate is 49%. With the citing rate of 31% and 26% respectively, MIS and OA system consist the next two kinds of major software needed by them. The more advanced systems, such as DSS, ERP system and large DBMS are needed by some enterprises, with the citing rate of 22%, 18% and 17% respectively. The most urgently needed kinds of software are project management systems and specialty application software. The types of software urgently needed are shown in Figure 3.

5 Conclusion

This paper shows the preliminery results of a survey on the application of IT in construction industry. The following summarizes the findings.

The level of IT application in Chinese construction industry is only preliminary, as is illustrated by the low level of investment, the absence of planning, the limited coverage of workflows, and the poor exploitation of information resources. But the majorities of top managers of firms have realized the importance of IT application and have determined to use it as a strategic means to improve the core competence of their firms.

The shortage of investment and the inadaptability of management system constitute the two largest obstacles for IT application. It is necessary for most firms to gain financial support from outside themselves.

IT application talents, proper roles of the government in advocating construction IT, BPR,internal and external conditions, together with some kinds of softwares are also in urgent
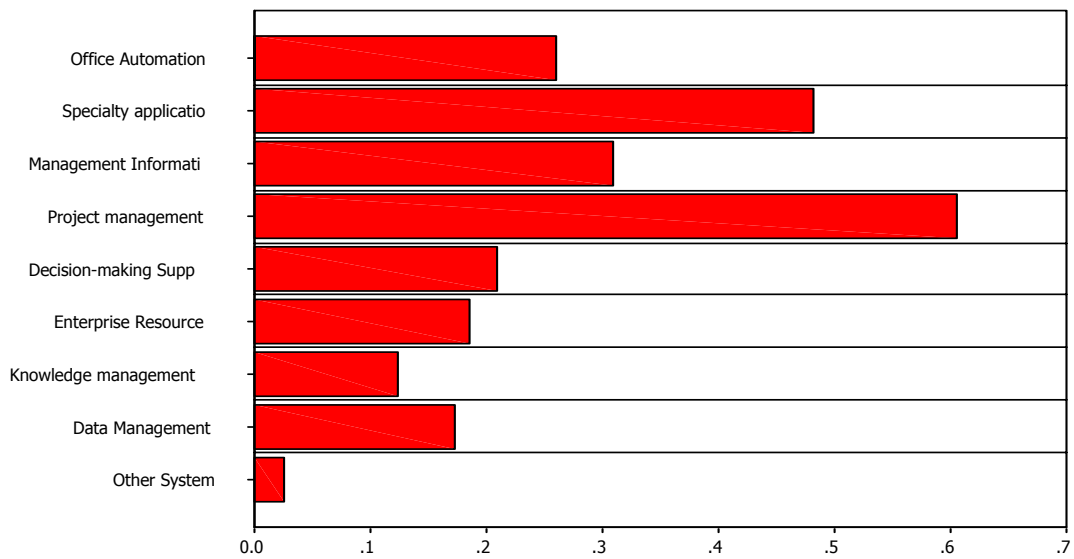
Figure 3: Types of software urgently needed

demand in Chinese construction industry.

The most urgently needed kinds of softwares are project management systems and specialty application softwares.

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Acknowledgment

Appendix 1:Questionnaire for survey on application of IT in Chinese construction firms

1. **Name of your company:** _____
    Number of employees: _____ **Percentage of white collar employees:** _____ **%**
    Number of employees engaging in Construction IT: _____

2. **Net Sales in 2003 (RMB):** _____
    Composition: Construction: _____ **% Real estate:** _____ **% Other:** _____ **%**

3. **Investment in Construction IT in the past three years:** _____ **(RMB)**
    Average ratio of the investment to the net sales in the same period: _____ **%**

4. **Is there a CIO in your company?** □ Yes □ No

5. **The organization in charge of Construction IT in your company is:**
    □ Steering committee on Construction IT   □ Center for information management
    □ Technology department   □ Other: _____

6. **Is there any documented strategy for Construction IT in your company?** □ Yes □ No
    If there is, the time frame of the strategy is _____ years; the budget is kUSD.

7. **The current situation of computer accommodation for white collar staffs in your company is:**
    □ One PC (Personal Computer) per staff   □ Averagely one PC for two staffs
    □ Averagely one PC for three staffs   □ Other: _____

8. **The current ways to access the Internet in your company are: (multiple-tick allowed)**
    □ Telephone dial-up   □ ADSL   □ DDN   □ ISDN   □ Other: _____

9. **Is there any network-based Management information systems (MIS) in your company?**
    □ Yes   □ No

10. **What level is the Construction IT of your company at?**
    □ At the beginning: not used except for word processing
    □ Preliminary: used mainly for data processing
    □ Middle: partial data shared, major business processes supported and a strategic plan documented
    □ Advanced: most data shared and the system for major business processes integrated

11. **What types of software are used in your company now? (Multiple-tick allowed)**
    □ Office Automation (OA) system   □ Specialty application software

□ Management information systems (MIS)   □ Project management systems
□ Decision-making support systems (DSS)   □ Enterprise Resource Planning (ERP) system
□ Knowledge management systems   □ Other: _____

12. **Is the number of employees engaging in Construction IT and technical ability in your company enough to cope with the needs that arise from the business?**
    □ Far from enough   □Not enough   □ More or less Enough   □ Enough   □ More than enough

13. **What kinds of employees engaging in Construction IT does your company desire in three years?**
    □ Planner on Construction IT   □ System analyst and designer
    □ Engineer for system operation and maintenance   □ Those with hybrid knowledge on both IT and management   □ Other: _____

14. **What kinds of roles should the government play in advocating Construction IT? (Multiple-tick allowed)**
    □ Making and issuing the relative standards   □ Making the relative policies
    □ Major investor on Construction IT   □ Coordinator for implementing Construction IT
    □ Other: _____

15. **Where is the capital for implementing Construction IT in your company from? (Multiple-tick allowed)**
    □ Outside investment   □ Government subsidy   □ Loan   □ Company's own capital
    □ Other: _____

16. **Do you think that the work of your company on Construction IT has been returned as what was expected?**
    □ No   □ More or less yes   □ Yes   □ Quite sure   □ More than expected

17. **What effects has your company obtained from the implementation of Construction IT?**
    □ Economic benefit   □ Working efficiency   □ Effectiveness of management
    □ Core competence   □ Upgraded social image   □ Quality of products and services
    □ Wider range of service   □ Other: _____

18. **What should be the purpose for your company to implement Construction IT?**
    □ Improve the core competence   □ Boost image of the company
    □ Increase the opportunities in the market   □ Improve management
    □ Conform to social development   □ Response to the national requirements
    □ Other:

19. **How about the return on investment on Construction IT in your company?**
    □ Almost nothing   □ Little   □ Reasonable   □ Remarkable   □ More than remarkable

20. **How do you think of the impendence of implementing Construction IT in you company?**
    □ No need   □ Little   □ Large   □ Fairly large   □ Very large

21. **What do you think to be the major factors that influence the core competence of your company? (Multiple-tick allowed)**
    □ Tangible assets such as cash   □ Reputation   □ Technological capability
    □ Capability to initiate markets   □ Efficiency of the internal management system

□ Decision-making capability of the top managers   □ Quality of products and services

□ Other: _____

Is the Construction IT critical to enhance these major factors?

□ Yes   □ No

22. **What do you think to be the prerequisites for the success in Construction IT in your company? (Multiple-tick allowed)**

□ The system meets the pressing needs of the company's business

□ The company can obtain the necessary hardware and software

□ The systems are available for both the operation of business and the management

□ Strong support from the top managers of the company is available

□ Support from most of the employees can be obtained

□ Continuous and effective support can be obtained from outside parties such as software vendors

□ The work is supported by the relative standardization and government policies

□ The level of the application of Construction IT is high in the whole industry

□ Other _____

23. **Do you think it necessary to carry out Business Process Re-engineering （BPR）before implementing Construction IT?**

□ No need   □ Less necessary   □ Necessary   □ Fairly necessary   □ Very necessary

24. **When your company invest in Construction IT, do you think that the short term return is important?**

□ No at all   □ Less important   □ Important   □ Fairly important   □ Very important

25. **How do you think of the following risks on developing a Management Information Systems (MIS) successfully and operating it smoothly? Fill in the blank before each item with the following codes.**

1: Very small   2: Small   3: Normal   4: Large   5: Very large

_____Requirements: Caused by deviation from the true requirements or the change in requirements

_____Development: Caused by the developer of the software

_____Technology: Technological risk encountered in the implementation of the system

_____Capital: Caused by the shortage of capital in the implementation of the system

_____Standard: Caused due to the unavailability of the necessary standards

_____Regulation: Caused by the mismatch between the system and the regulations

_____Management: Caused by the mismatch between the system and the management habits

_____Talent: Caused by the unavailability or leaving of the necessary talent

_____Function: Caused by the mismatch between the system functions and the actual requirements

_____Safety: Caused by safety reason

26. **What is the strategy of implementing Construction IT in your company?**

□ Pay close attention to project management while satisfying the requirements of the lifecycle

□ Pay close attention to enterprise management while satisfying the requirements of each

functional department in the enterprise

☐ Pay close attention to what the government requires while satisfying the requirements for the industry

☐ Do according to the current requirements of the enterprise

☐ Other _____

27. What are the most important works in your company concerning Construction IT in next three years? (Multiple-tick allowed)

☐ Establish a plan for implementing Construction IT

☐ Improve the management regulations   ☐ Optimize the major business workflow

☐ Purchase the necessary hardware and establish enterprise network

☐ Develop Management Information Systems (MIS)   ☐ Operate on the existing systems

☐ Recruit employees engaging in Construction IT and carry out training of existing employees

28. What types of systems does your company urgently need at present? (Multiple-tick allowed)

☐ Office Automation (OA) system   ☐ Specialty application software

☐ Management information systems (MIS)   ☐ Project management systems

☐ Decision-making support systems (DSS)   ☐ Enterprise Resource Planning (ERP) system

☐ Knowledge management systems   ☐ Large database management system

29. **Address for correspondence:**

 Address: _____

 E-mail: _____

 Tel: _____