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INTEGRATION OF SSM AND IDEF TECHNIQUES FOR ANALYZING DOCUMENT MANAGEMENT PROCESSES

Vachara Peansupap[1] and Udtaporn Theingkuen[2]

[1]Assistant Professor, Department of Civil Engineering, Chulalongkorn University, Bangkok, Thailand, 10330, email: pvachara@chula.ac.th
[2]Research Student, Department of Civil Engineering, Chulalongkorn University, Bangkok, Thailand, 10330, email: pickolokung@yahoo.com

ABSTRACT: Construction documents are recognized as an essential component for making a decision and supporting on construction processes. In construction, the management of project document is a complex process due to different factors such as document types, stakeholder involvement, document flow, and document flow processes. Therefore, inappropriate management of project documents can cause several impacts on construction work processes such as delay or poor quality of work. Several information and communication technologies (ICT) were proposed to overcome problems concerning document management practice in construction projects. However, the adoption of ICT may have some limitation on the compatibility of specific document workflow. Lack of understanding on designing document system may cause many problems during the use and implementation phase. Thus, this paper proposes the framework that integrates Soft System Methodology (SSM) concept and Integrated Definition Modeling Technique (IDEF) for analyzing document management system in construction project. Research methodology is classified as the case study. Five main construction building projects are selected as case studies. The qualitative data related to problems and processes are collected by interviewing construction project participants such as main contractors, owners, consultants, and designers. The findings from case study show the benefits of using SSM and IDEF. The use of SSM can help identify the problems in managing construction document in rich picture view whereas IDEF can illustrate the document flow in construction project in details. In addition, the idea of integrating these two concepts can be used to identify the root causes of process problems at the information level. As the results, this idea can be applied to analyze and design web-based document management system in the future.

Keywords: Document management system, Soft system methodology, Integrated definition modeling technique

1. INTRODUCTION

Construction documents are recognized as an essential component for making a decision and supporting on construction processes such as bidding, estimating, communication, project planning and control, quality inspection, and also hand-over processes [2,9]. In each construction process, several documents are created, revised and used. The examples of these documents are construction drawing, specification, material order, construction approval, change orders, quality control document, payment etc. These documents are not only related to many processes but they are also used to communicate with many project participants. Due to their complex nature, documents are required to manage in order to obtain benefits.

Document management is an essential process in a construction project, especially the complex project which consists of several processes and documents [11]. In the past, traditional management of document was found to be the difficult tasks and tedious works. Many problems related to the traditional document processes are unknown the status of document, difficulty to modify document errors, lost of document, slow delivery of documents, and waste time to search document [5]. These problems are occurred due to several causes such as lots of documents, many people involvement in approval and sending documents, incomplete documents during inspection etc. To minimize these problems, many research studies are proposed the use of information and communication technology such as electronic database and Internet software [10,11]. This approach can be classified as the decentralization concept because users may have different applications to communicate and exchange documents. Nevertheless, the adoption of these technologies in sending and storing documents are not fully changed the traditional practice [6]. For example, some staff send document via email instead of fax, which is required to call for confirmation of document again.

The next idea for solving document problems in a construction project is the use of Electronic document management system (EDMS) [1,12]. This approach can be classified as the integration concept, in which users use the central document system to exchange their document. EDMS is an electronic document system, which is developed to overcome the problems of conventional document management system. This system uses the web-based technology to centralize the document in a construction project. All project participants involving in a construction project can coordinate and

communicate all documents within the system [12]. This system can help reduce several problems such as delay in sending document, document missing, slow in searching document, and large space in storing document. Thus, the implementation of EDMS can facilitate the management of construction documents in effective manners [1,12].

2. BARRIERS OF EDMS IMPLEMENTATION

The implementation of EDMS in construction projects is still limited due to several aspects such as management factor, technical factor, individual factor, and environment factor. First, the management aspect involves the training and resource support. The lack of training can hinder the use of EDMS in construction project [1]. In addition, management support also includes the investment on computer technology and Internet connection. Both training and computer technology can be classified as the fundamental factors that support the implementation.

The second barrier of implementing EDMS is related to individual aspect. Many users may have a limited background on computer skill. This can influence on the beginning of EDMS use. Similarly, the past experience on using computer applications can impact on the learning of EDMS. It can be argued that users who have previous experience of using it, they are more likely to learn faster. Moreover, the perceived benefits of system can impact on continuous use. Some may reluctance to use the system due to unclear benefits of the system.

The third barrier of EDMS is related to technical issue. It can impact on the implementation of EDMS. They are related to the compatibility between work flow and the system. Each construction project has the difference and complexity of document flow and people involvement. Comparing to other industries, construction industry is quite difficult to implement because of number of documents, people involvement, and document flow. This creates the barriers of applying off-the-shelf EDMS software in a construction project environment. Therefore, it is necessary to analyze and develop the EDMS for a construction project.

Lastly, environment aspect may impact on the use of EDMS because the system may require all project participants to use system. Without users' commitment on using the EDMS, the system may not provide the full benefits. As the result, these barriers should be focused and managed the system during implementation phase.

Prior studies are mostly focused on the development of information and communication technology that supports document management in construction processes. However, these studies are lack of analysis on problems and improvement on document operating processes. Lack of understanding on designing document system may cause many problems during the use and implementation phase. Therefore, this research paper aims to improve the design of document management processes by using the integration of two concepts, which are soft system methodology (SSM) and IDEF. The integration of these two concepts can identify the problems of document flow in construction project. The understanding of problems in document workflow helps design the electronic document management system that suit for construction practice.

3. LITERATURE REVIEW

The literature review consists of three main parts that are types of construction document, Soft System Methodology (SSM) and IDEF techniques.

2.1 Construction Documents

Construction documents used in construction project can be classified into four main groups [5] , which are

Project document such as meetings, progress report, budget control, material order, change order, site inspection, payment, drawing and specification, etc.

Communication document such as memos, letters, request for information (RFI), work request, etc.

Office management documents such as company profile, absent forms, curriculum vitae, announcement, news etc.

Reference document such as material testing standard, design code, local standards, etc.

These documents in construction projects have different types and numbers due to the complexity of construction projects. This research is focused on the processes of work request, construction drawing and change order.

2.2 Soft System Methodology (SSM)

SSM is a method to improve the system by identifying the root cause of problems and attempts to propose the new idea on how to solve problems [4]. This method can be adopted to explore the causes of managing construction problems. The SSM analysis involves the process of interviewing project participants on current practice, control operation process, their responsibility and process problems. The outcome can help managers understand and identify current problems of the system.

Moreover, SSM can analyze social aspects that cause the problems on current system. The improvement of social aspects can be developed by bring people who involve with the system to share and discuss about problems. Those people can learn the situation through conceptual models and suggest on how to improve the system. This process can be defined as the iterative process of learning [4]. During this process, project participants can share and debate about their perception of real situation, their action on current situation, and their reflection on the situation using conceptual models. The reflection and debate is conducted by a number of conceptual models. These models help them perceive the situation, problems and suggest at a certain aspect. The usual general description of SSM is presented as a seven-stage process [4] follow this:

1) Problem situation unstructured.
2) Problem situation expressed.
3) Root definition of relevant systems.

Taking the problem themes identified in steps 1 and 2 the next stage of the analysis involves the analyst moving from the "real world" and applying systems thinking to

the problem situation. Relevant systems are identified and named. Root definitions are developed by means of a "CATWOE analysis" to identify the system components that should be present in the root definition. CATWOE is a mnemonic for the following systems elements -

C The Customer – people who either benefit from the transformation process carried out by the system, or who are affected by it some way, possibly adversely.

A The Actors who would carry out the activities in the system

T The transformation process which transforms the system inputs data into outputs.

W The Weltanschauung (world-view or viewpoint) – how the system is perceived or define from a particular viewpoint.

O The Owner of the system – the decision-maker who has responsibility for the performance of the system. (There may be a hierarchy of system owner, where one is responsible to a higher owner.)

E The constraints on the system from its Environment; features of the real world which the system interacts with but which are outside its control.

4) Conceptual models of the systems named in the root definitions

5) Comparison of models and real world

6) Decide on desirable/feasible changes.

7) Make changes to improve the situation.

From the above SSM steps, the outcome of analysis can help explore root causes of problems and recommend the new approach to improve the current system. However, this outcome can not help identify the relationships between problems and the details workflow processes. Therefore, this research attempts to propose the new idea of integrating SSM and IDEF techniques. The following section will discuss on the detail of IDEF.

2.3 Integrated Definition (IDEF)

IDEF is a process mapping technique combining graphics and text that are then presented in an organized and systematic graphic presentation to gain understanding, support analysis, provide logic for potential changes, specify requirements, or support systems-level design and integration activities. An IDEF process map is composed of a hierarchical series of diagrams that gradually display increasing levels of detail describing functions and their interfaces in the context of your process [7].

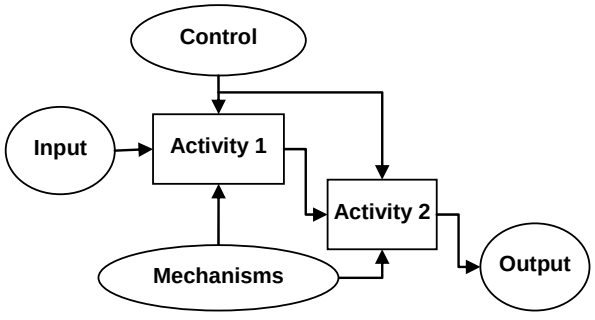

Figure 1 Concept of IDEF

- Input: an object at the point of entry to a process, the input refers to prerequisite resources or data that are used to perform the activity.
- Control: a data or conditions for activating and controlling the activity.
- Mechanisms: The mechanisms are called resource flows because their purpose is to bring resources to perform activity.
- Output: an object at the end point from a process.

The examples of IDEF application in construction are conducted. For example, a view-based approach for construction process modeling is proposed [8]. It is found that IDEF technique helps for definitely showing process of construction about activity and timing. Another research shows the integration of product and process information in the construction sector [3]. IDEF technique can illustrate relationships between product and data for connecting in construction site, in which it contributes suitable management to the constructions.

Reviewing about SSM and IDEF techniques was found the limitation of each technique. SSM technique can explore the problems of system at conceptual level whereas IDEF technique can show required data for processing activity at information level. Therefore, this research argues that these two techniques can complement with each other. Therefore, this research attempts to integrate two techniques for analyzing problems that can present the relationships between problems and required information.

4. RESEARCH METHODS

This research is classified as case study that highlights the experiment of integrating SSM and IDEF concepts. The research attempts to express the different outcome of traditional analysis by

Collecting data and interviewing the engineer and other responsible personnel;

Defining types of document in this trial;

Collecting data about problems and system as well as personnel and limitation;

Developing model SSM in identifying problems;

Developing model IDEF for show data in each process of document work;

Integrating results from both SSM and IDEF and shows the relationships between problems and required information in document processes.

Five main construction building projects are selected as case studies. The case study includes different types of construction document such as request of work, construction drawing, and variation change document. The qualitative data related to problems and processes are collected by interviewing construction project participants such as main contractors, owners, consultants, and designers. The interview data are used to explore the problems and data flow by SSM and IDEF consequently. The outcome of these two techniques is discussed. Then

the integration of both SSM and IDEF is proposed and illustrated its benefits. The benefits of integrating SSM and IDEF are highlights by illustrating the details of problems regarding to construction document processes.

5. ANALYSIS OF DOCUMENT PROCESSES USING SSM AND IDEF

This section illustrates the result of analyzing document processes from two techniques. The objective of this section is to show the original outcome of those two techniques. Case study of documents from building construction projects is used as data to analyze the outcome. Due to the limitation of space, the paper shows one case study of document in a construction project. Work request form is one of documents that are used in construction site. This research has analyzed document related to work request in construction site. The detail analysis of each technique can be described as follows:

5.1 Analysis of Document Processes using SSM

The analysis of document processes using SSM begins with the development of rich picture. The rich picture is developed from interview all project participants. The rich picture consist aims to draw picture of the system. The content consists of people, process and boundary of system. In addition, the problems of document processes are collected from interview. The rich picture is drawn and illustrated in Figure 2.

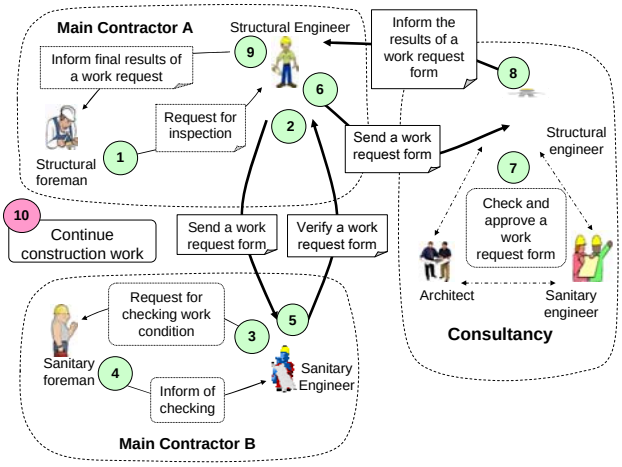

Figure 2 Rich picture of work request submission

Rich picture illustrates the document processes and project participants who involve in work request document. Then researcher uses the rich picture to identify the problems related to the document from all project participants' experience. The results from the interview highlights the problems related to work request. These problems can be occurred from three project participants, which are a structural engineer of main contractor and an engineer of sub-contractor, an engineer of consultant firm, and project manager from main contractor. These problems are analyzed by using "CATWOE" to identify root cause of problems.

C (Customer) is an engineer from main contractors who create and submit the work request form

A (Actor) is an engineer from consultant who reviews the work request form

T (Transformation) is the review process of work request form by using operational information from all participants.

W (World-View) is new approach to delivery of document review information to all participants

O (Ownership) is project manager from main contractor

E (Environment) Project duration, cost, equipment, and tool that influence on approving document request

Table 1 Analysis of Problems from SSM technique

CATWOE	Experienced problems related to work request document
Customer (C) Opinions from main contractor	- Consultants take time to approve the work request - Other works related to the work process did not inform to main contractor in advance - Loss of work request form during document processes
Customer (C) Opinions from M & E contractor	- Main contractor submits work request document late - Consultants take time to approve the work request - Main contractor did not inform prerequisite works to M&E contractors in advance
Actor (A) Opinions from consultant firms	- Both main contractor and M&E contractors lack of coordination in work operation - Contractors did not submit document or delayed on document submission - Contractors did not check site conditions before submitting work request form - Unclear details of construction work before sending work request form
Transformation (T) Approve process of work request	- Incapability data between site conditions and work request form - Lack of information related to approval of work request form
World-view (W)	- The new system that provides information related to the work operation to all project participants. The information is work plan, the successor activity, activity duration, materials and equipment.
Owner (O) Project manager of main contractor	- Project manager perceives problems due to the work request delay - Delay of construction project due to the time of document approval
Environment (E) Other issues related to problems on work request document	- Separated contracts between main contractor and M&E contractors cause the problems on work request document

The CATWOE analysis under SSM technique shows the problems related to document processes (see Table 1). The analysis of SSM explains the problems related to work request process. These problems are:

- Lack of coordination between a main contractor and M&E contractors
- Incapability data between site conditions and work request form
- Withhold information about site-conditions from other project participants
- Delay in work request submission
- Loss of work request forms during document processes
- Long-time to consider document approval

Next step is to develop conceptual model in solving problems by comparing between real processes (Figure 2) and improved process (Figure 3).

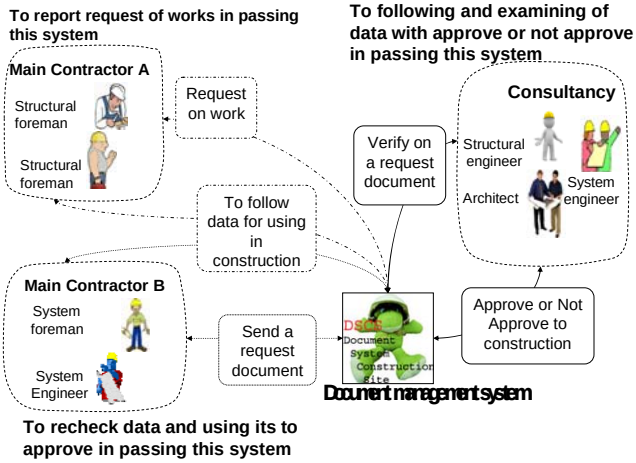

Figure 3 An improved process of work request processes by using electronic document management system

The analysis of SSM helps identify the problems related to work request document. These problems can lead to suggest the improvement of current processes. It should be noted that some problems of document flow are occurred from social barriers which are hardly solved by technological approaches. Some problems can be solved by using information technology. These problems are loss of documents, withhold information related to work request processes and unknown the status of document flow. However, the problems from SSM analysis are difficulty to design an appropriate information technology because these problems do not shows details of problems at information level. The development of information technology should define the links between problems with detail information such as the prerequisite data,

constraints and resources. Thus, it is required to identify the additional technique to overcome this limitation.

5.2 Analysis of Document Processes using IDEF

The diagram of IDEF illustrates information flow of the work request document processes. The diagram presents activities of process. It also includes prerequisite data, control data and required resources for operating each activity. The diagram of IDEF is developed from the in-interview of project participants and reviewed from them. To display the original outcome from IDEF, this section only focuses on a case study of work request document. The scheme by IDEF technique is shown in Figure 4.

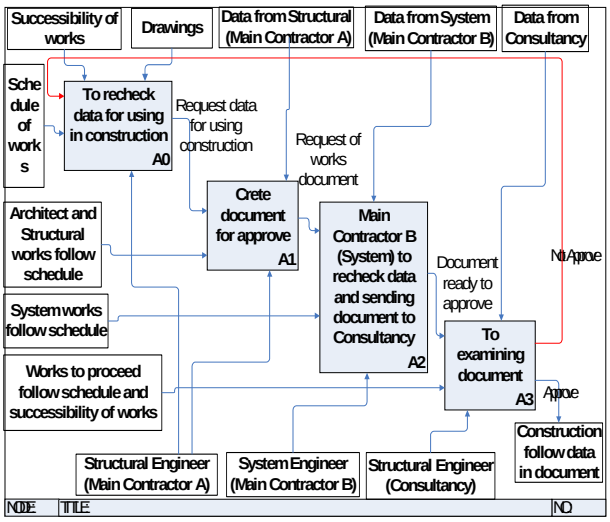

Figure 4 Model of work request document using IDEF

Table 2 Data related to work request document

Work request processes	Data related to work request document		
	Prerequisite data	Control data	Mechanism
A0. Identify and check structural work operation	- Work plan - Drawing & specification - Current work operation - Inspection form	- Prerequisite activity - Milestone - Site condition - Work quality standard	- Foreman and site engineer from main contractor
A1. Create work request form	- Title of work operation - Operation date - Position of work operation - Quantity of work - Checking from site engineer or foreman - Output from A0	- Current work progress - Prerequisite activity - Work plan - Drawing & specification - Complexity of work - Equipment information - Labor availability - Work quality standard - Site condition - Weather	- Structural site engineer from main contractor
A2. Check M&E works corresponding to structural work	- Work request form - Signature from main contractor - Output from A1	- Conflict with structural work - Prerequisite activity - Work plan - Drawing & specification - Site condition - Work quality standard	- Site engineer from M&E contractors
A3. Check and approve work request form	- Work request form - Signature from main contractor - Signature from	- Conflict between structural work with M&E work - Prerequisite	- Site engineer from consultant firm

	M&E contractor - Actual work operation & quality - Output from A2	activity - Work plan - Drawing & specification - Site condition - Work quality standard	

Table 2 describes the data related to each activity in work request document processes. The IDEF analysis can identify the data that are required to perform each activity. These data can be used to design the system of document. However, the analysis of IDEF can not identify the current problems related to each activity and those problems. Therefore, it is required to explore the links between problems and required data for work operation.

It should be noted that analyzed data about the problems by SSM technique can only express all occurring problems. But the results of SSM analysis can not identify problems that cover data related to all activities in document processes. Thus, the results from SSM should be combined with additional technique. This research proposed the idea of integrating problems from SSM with IDEF technique. The results of integration can be defined what the point of problems, who controls, and what the controlling equipment, which are available into the preventing system.

6. INTEGRATION OF SSM AND IDEF TECHNIQUES FOR ANALYZING PROBLEMS IN DOCUMENT PROCESSES

The integration of SSM and IDEF techniques aims to identify the relationships between problems and data related to work activity in processes. In case study of work request document, it was found the problems in two activities, which are *"A0. Identify and check structural work operation"* and *"A1. Create work request form"* as shown in Figure 5. The relationships between data and problems can be shown in Table 3

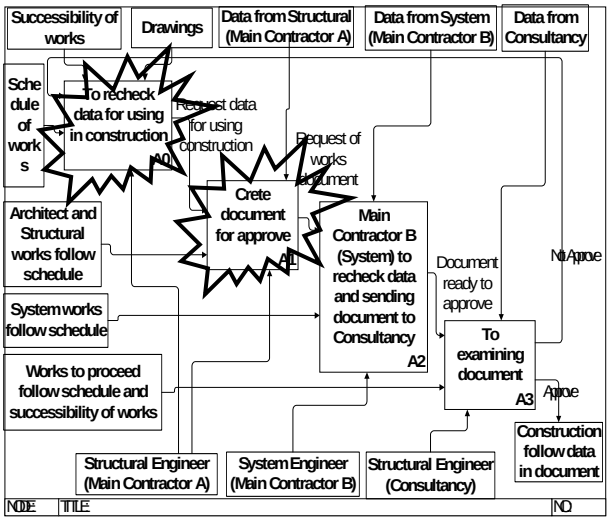

Figure 5 Integration of problems from SSM with IDEF diagram

Table 3 shows required data related processes of work request document. There are three types of required data in processes, which are prerequisite data, control data, and mechanism. The data related problems are highlighted in bold see in Table 3. These data are claimed as the root cause of data related problems in work request processes.

Table 3 Data related to work request processes and highlight the problems of some data

Work request processes	Data related to processes of work request document		
	Prerequisite data	Control data	Mechanism
A0. Identify and check structural work operation	**- Work plan** **- Drawing & specification** **- Current work operation** - Inspection form	**- Prerequisite activity** - Milestone **- Site condition** - Work quality standard	**- Foreman and site engineer from main contractor**
A1. Create work request form	- Title of work operation - Operation date - Position of work operation - Quantity of work **- Checking from site engineer or foreman** - Output from A0	**- Current work progress** **- Prerequisite activity** - Work plan - Drawing & specification - Complexity of work - Equipment information - Labor availability - Work quality standard **- Site condition** - Weather	**- Structural site engineer from main contractor**

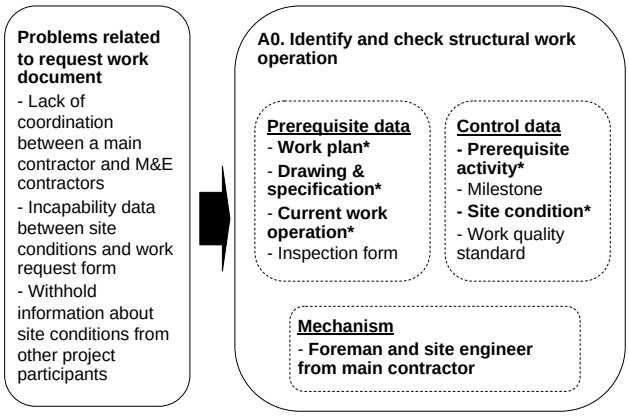

Figure 6 Relationships between problems from SSM and data related to operation of each activity

Figure 6 shows the relationships between problems and data related to operation of each activity. The left box of diagram shows the problems analyzed from SSM. These problems have some links to the data related problems. For example, case study found the lack of coordination between a main contractor and M&E contractors. This problem can link to data related problems about prerequisite activity. Case studies report an unknown data of prerequisite activity that affects on checking structural work operation (A0). The next problem is a problem

related to incompatibility data between site conditions and work request form. The problem occurred due to unclear data about site condition, current work operation, and drawing and specification. Last problem is about unclear data about site conditions among project participants. Based on the IDEF diagram, it found that foreman and site engineer from main contractor did not send work request form or informal communicate to engineers at M&E contractors in advance. As the result, there are some missing items that M&E should be put together with structural work tasks. These examples illustrated that the root cause of problems sometimes occur due to the unclear data at information level. Therefore, the integration between SSM and IDEF can help us understand the relationships between problems and data that may be required in order to perform the activity.

7. CONCLUSIONS

This paper research aims to propose the concept of integrating SSM and IDEF technquies. The concept helps identify the relationships between problems and data related to operate activity. The research uses a case study of document management system to highlight the benefits and limitations of applying SSM and IDEF techniques. The case study presents the different benefits of using SSM and IDEF techniques. The output of SSM helps analyze the problems of the system in both technical and social aspects while the analysis of IDEF can identify the required data for operating the activities in processes.

The analyzed data about the problems by using SSM technique can show all occurring problems but the results of SSM analysis can not identify data related problems to all activities in document flow processes. Meanwhile, IDEF technique can present required data for processing activity at information level.

Thus, the results from SSM should be combined with additional technique. This research proposed the idea of integrating problems of SSM with IDEF technique. The results of integration can be defined prerequisite data, control data and mechanism that are required to operate each activity in document processes.

The result of this research found the benefits of integrating of SSM and IDEF techniques. First, the integration helps to identify the detail data, which lead to the problems of document processes. Second, required data are sometimes causes the problems of document processes. Lastly the integration of SSM and IDEF helps improve the design of electronic document management system. It can help protect technical problems from current construction document process. Therefore, this concept can applied to analysis and develop data management process in construction organization which can define problems and improvement of the process.

REFERENCES

[1] B.C. Björk, Electronic Document Management in Construction. Research Issues, ITcon 8 (2003) 105-117.

[2] B.C. Björk, P. Huovila, S. Hult, Integrated Construction Project Document Management (ICPDM), in: M. Behesti, K. Zreik (Eds.), Advanced Technologies - architecture - planning - civil engineering, Proceedings of the EuropIA'93 conference, Elsevier, Amsterdam, Delft, 1993, pp. 135-146.

[3] D. Bouchlaghem, A. Kimmance, C. Anumba, Integrating product and process information in the construction sector, Industrial Management & Data Systems 104 (3) (2004) 218-233.

[4] P. Checkland, J. Scholes, Soft systems methodology in action, Wiley, Chichester, West Sussex, England ; New York, 1990.

[5] B. Duyshart, The digital document: a reference for architects, engineers, and design professionals, Butterworth-Heinemann, Oxford, 1997.

[6] M. Hjelt, B.-C. Bjork, End-User Attitudes toward EDM Use in Construction Project Work: Case Study, Journal of Computing in Civil Engineering 21 (4) (2007) 289-300.

[7] V.D. Hunt, Process mapping : how to reengineer your business process, John Wiley, New York, 1996.

[8] V. Karhu, A view-based approach for construction process modeling, Computer-Aided Civil and Infrastructure Engineering 18 (2003) 275-285.

[9] G.D. Oberlender, Project management for engineering and construction, 2nd ed., McGraw-Hill, Boston, 2000.

[10] C.M. Tam, Use of the Internet to enhance construction communication: total information transfer system, International Journal of Project Management 17 (2) (1999) 107-111.

[11] M. Zhiliang, K.D. Wong, L. Heng, Y. Jun, Utilizing exchanged documents in construction projects for decision support based on data warehousing technique, Automation in Construction 14 (3) (2005) 405-412.

[12] Y. Zhu, R.R.A. Issa, R.F. Cox, Web-Based Construction Document Processing via Malleable Frame, Journal of Computing in Civil Engineering 15 (3) (2001) 157-169.