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Information System Strategy for Promoting Demolition Project Management

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Abstract

Building demolition has been undergoing evolutionary development in its technologies for several decades. In order to achieve a high level of demolition material reuse and recycling, new management approaches are also necessitated, in particular in conjunction with the applications of information technologies. The development of an information system for demolition project management is an impactful strategy to support various demolition activities including waste exchange, demolition visualization, and demolition method selection and evaluation. This paper aims to develop a framework of an integrated information system for building demolition project demolition decision-making and waste minimization. The components of this information system and their interactions are demonstrated through a specific demolition project.

Keywords: Building Demolition, Information System, Information Technology, Innovative Management, Project Management

1. Introduction

Building demolition is regarded as the last stage of building lifecycle following planning, design, construction and maintenance. After solely concerning building construction, the industry has been paying intensive attention on building planning and design stages. Since the 1980s, maintenance has been taken into more consideration following some infrastructure crisis due to poor maintenance (Itoh and Liu 2000). Until recently, the industry turned its considerable focus on building demolition. The increased emphasis on building demolition is predominantly due to the increasing environmental pressures, in particular the issue of waste disposal. Reducing wastes before they are generated is apparently important in waste minimization for a demolition project. Although demolition can be seen as a reverse process of building construction, it is inappropriate to copy management strategy in construction into demolition project management. Building demolition has some distinct characters from construction, such as issue of waste disposal, reuse and recycling.

In order to effectively and efficiently manage a building demolition project, some new innovative management approaches and strategies have been brought forward (Liu et al. 2004, Liu and Pun 2004). These approaches involve heavily in information processing and exchange, visualization, intelligence and other late information technology in addition to innovative management strategies. The major objectives of these management approaches are to support the demolition project team in conducting complex tasks such as decision-making, simulation, information retrieval and design optimization. There is a research need to develop an information system to integrate those management approaches so that the demolition project manager can systematically plan and control the building demolition project in practice. This paper aims to discuss various issues in the development of such an information system for building demolition project management. Firstly, the paper introduces the

situations in the demolition industry and basic demolition technologies. Then, it presents a series of new management approaches in building demolition. Finally, a framework of implementing an integrated information system for building demolition project management is demonstrated.

2. Demolition Project Management in Practice

2.1 Demolition industry and companies

It is apparent that the construction and demolition are two independent processes. They however are associated. The construction of a new building requests the demolition of an old one on the site. The demolition industry is just a decentralised and diverse segment of the large and fragmented construction industry (Centre for Studies in Construction 1994). Only in large cities are there a few companies dedicated solely to building demolition projects or other civil infrastructure projects. One possible reason is that there are only a small number of independent demolition projects. In most cases, building demolition is immediately followed by a new construction project, and it must be kept as brief and uncomplicated as possible. The importance of demolition is completely underestimated because of the domination of building construction for huge amount of materials and energy it consumes. In fact, manufactures and supplies of building materials are only the intermediate sources for construction, as the original source is nature, despite being largely invisible in the modern construction industry (Birkeland 2002).

2.2 Demolition project techniques and approaches

Demolition techniques have constantly been developing. Generally, demolition techniques are becoming more time-efficient and environmental friendly, cheaper and safer. Generally speaking, demolition techniques include demolition by machine, demolition by hand, and demolition using explosives (Liu et al. 2003). Demolition by machine is very currently popular due to the simple approach and well developed equipments, such as wrecking ball, crane, hydraulic excavator with attachments and so on (Abdullah and Anumba 2002). The process of demolition by machine brings out mixed and contaminated building materials, which are extremely difficult to be reused or recycled. They are most likely disposed to landfills, which make up large portion of total solid waste stream. Demolition by hand, known as deconstruction, is the most ancient demolition technique. It dismantles building structures so that the materials can be easily processed. Deconstruction can be seen as a reverse process of construction. Materials from the deconstruction process are more likely to be reused. On the other hand, deconstruction requires relatively higher intensive human labor, and more demand on safety considerations.

2.3 Waste handling in demolition projects

The aspect of demolition contractors to salvaged building materials are generally monetary motivated (Liu et al. 2003). In other words, contractors are willing to participate in material reuse and recycling while they are profitable. Waste recycling can be achieved by business transactions with recycler. As a result, some recent demolition projects have achieved a very high level of material recycling. Waste reuse, which seems to be more beneficial to the environment than recycling, is mainly accomplished using a waste exchange system. In other words, waste building components or materials producers and demanders trade the wastes through such an exchange platform. For the time being, the essential strategy to increase the exchange amount of demolition components or material is to improve the service of their producers to meet the requirements of their demanders.

3. Innovative Management Strategies in Building Demolition

Due to the increasing environmental concerns, the concepts and approaches of building demolition are being developed remarkably. For example, the building deconstruction approach promotes building components and materials reuse and recycling and thus benefits the environment. At present, there are many technical developments in engineering and architectural aspects to support new concepts of building demolition, such as deconstruction and design for deconstruction. On the other hand, the building industry also started to concern other issues like safety, legal, environmental issues. There are needs to develop systematic managing approaches to cover new areas in order to support the management of a building demolition project. The remaining of this section will introduce some of these innovative strategies.

3.1 Innovative waste exchange

Waste reduction has been put on agenda for construction and demolition industry. In particular, construction and demolition wastes are contributing a large portion of wastes stream to landfill. Apart from the control of generating wastes during construction and demolition project, wastes reuse and recycling is the major mechanism to decrease the amount of wastes that are sent to landfill. The waste material recycling may not be the best practical choice for waste reduction in building demolition. The building components produced from building demolition can be directly reused in other construction projects if the quality is assured.

Waste exchange enables wastes to be exchanged among wastes producers and demanders, and therefore to achieve a high level of building component and material reuse. The principle of waste exchange is to release information on availability or demand of secondary building components and materials on a media to reach a broad range of users. Under the approach of conventional demolition, the waste exchange only happens after the demolition project is physically completed. As a consequence, the waste exchange might fail to achieve its original goal due to several reasons. Firstly, there are extra resources required to deal with the waste exchange including time and storage space. There is a limited period between the demolition and the cleaning up of the site. The demolition site is very likely to be used to start another construction project. Secondly, it is impossible for the demolition project team to obtain exact requirements of the product before the demolition process, and thus hardly takes into account any specific consideration from the demanding side. Wasted materials from the demolition project might not meet the secondary material demanders' requirements. They therefore need to be reworked, returned or disposed of. Thirdly, it is hard to adequately describe the wasted materials if the material owner does not have relative engineering background. Finally, people in the industry have not been getting used to the reused and recycled materials and products. Due to these obstacles, many demolition project teams did not take waste exchange into serious consideration.

3.2 Demolition visualization and simulation

The visualization and simulation technology has been applied into construction projects for a relatively long period. The graphical presentation of a building structure has experienced different stages, including 2D, 3D, 4D model and even multiple-dimensional model (nD). The development of visualization in the construction industry strongly depends on the development of computer hardware and software, in particular their capacity and functionality of graphical manipulation. The building model for demolition refers to the computer-based visual model for the building that is to be demolished. Due to the nature of demolition and limited human resource, the level of detail required in demolition might be

lower than it in construction. It is nature to have a building visual model for newly erected building in recent years and in the future, however, it is less likely that the buildings that are built decades ago had visual models. To enable a 4D visualization model for a demolition project, both demolition project schedule and building model for demolished building are needed. Demolition process scheduling is to determine the sequence of various demolition activities in which each demolition product is allocated with one or more time intervals. In addition to 4D building demolition visualization that visually simulate the whole demolition process against time, information such as waste production can also be integrated into the visualization (Pun and Liu 2004). As the requirements of final waste products are acquired from demanders through waste exchange system, the waste products can be located from building components that are from particular parts of the demolished building. The waste products can then be positioned and displayed in a building model. The final building demolition visualisation model therefore reflects not only the general schedule of the building demolition project, but also the schedule for waste components and materials production.

3.3 Just-in-time demolition processes

Just-in-time (JIT) philosophy is a matured management approach used in the manufacture industry. The main concepts of JIT include reducing the inventory of raw materials and products, and speeding up the manufacture process by decreasing the manufacture batch size. Recently, JIT has been applied to construction projects to reduce the waste from building material management (McGeoge and Palmer 2002). In the case of building demolition project, waste components and materials can be regarded as products manufactured from the demolition process by the project team, and consumed in a new construction project or recycling program. The principle is exactly same as the situation in the ordinary manufacture industry (Pun and Liu 2003). Under the conventional demolition scenario, wastes are generated and then sold through waste exchange to demanders that utilize secondary materials in construction projects or directly to recycling company. The information of wastes is not available before the actual demolition project implementation. Conventionally, the inventory of waste components and materials from demolition project need to be held and then go through waste exchange program. The situation causes the discontinuous demolition project process and delayed production, which further cause less efficiency in waste exchange. A solution applying JIT is to perform wastes production after they are actually wanted. Waste components and materials should not be produced until the requirements are given. In order to achieve wastes information exchange ahead of actual waste exchange, information must be generated and released on a waste exchange system as virtual waste. The forward waste information exchange can be seen as an ordering process in the manufactured product market.

4. Information System Development for Managing a Demolition Project

In previous sections, several innovative management strategies are brought forward. These strategies along with general knowledge of project management provide an integrated and unique management model for a building demolition project. Most current software packages concerning one or more aspects in construction management are featured with general approaches that do not specifically fulfill the requirement of demolition project management. Therefore it is necessary to develop an information system that is capable to address various management issues in demolition project, such as waste exchange and demolition simulation. The newly invented management strategies for building demolition project management are built based on waste handling. This also provides opportunity to the system integration since all system components share identical information, namely waste database. The following

section identifies major components of the proposed information system by analyzing their requirements, functionality, restrictions and possible logical design.

4.1 Waste exchange system

The first step of a demolition project, as designated above, is to perform waste exchange. In particular, waste exchange helps to reduce the amount of wastes that are sent to landfills by enabling reusing and recycling waste materials exchanged through the system. The information exchange, or information collection and retrieval, is the essential step to achieve waste exchange transactions. The waste exchange system is ideal to function over the Internet to reach more construction contractors and other building material demanders. Under aforementioned planning management strategy in building demolition project, demands and requirements of wanted waste building components and materials are expressed from users to demolition project team through an information exchange platform. It is natural for demolished components and materials demanders' involvement as they are key stakeholders for the demolition project itself. Their opinions should be collected prior to the project commences.

There are several servers involved in the proposed waste exchange system, including Web server, application server and database server. The data collected from building components and materials demanders is stored on database server for further usages, such as visualization and environmental impact evaluation. A demolition project executor publishes the information of potential wastes on the Web-based system. The material demanders find the supply that satisfies the need of quantity, quality, location, time and cost through search function. Once the supply and demand is matched, a transaction can be made and the further actions such as payment and transportation can be arranged. To fully achieve the proposed waste exchange system that handles the information exchange prior to actual physical building demolition, some technical issues must be addressed. The amount of waste building components and materials generated from the demolition project has to be accurately estimated to enable the information exchange. This ability of the system relies on the knowledge collected from the industry, especially from the demolition section. The knowledge can be acquired from previous demolition project or experienced demolition project contractors (Liu and Pun 2003). It can take the form of an expert system, taking some major engineering and structural characters of the demolished building as criteria and parameters, such as the dimension, material, age and function of the building. Each of the factors will affect the quantity and the quality of final waste product differently. After considering various factors and calculation, the knowledge-based system can perform the estimation and generate the information for waste exchange.

4.2 Demolition visualisation development

Comparing with construction, demolition planning is more demanding in time, space, safety and environmental regulations. Unfortunately, due to a lack of engineering experiences and theoretical knowledge, rational demolition planning is difficult to suit practical project. 4D visualisation of a demolition project is critical in improving the feasibility study and demolition design. To further exploit the advantages of 4D visualisation, a waste production schedule can also be integrated into 4D visualisation. To create building demolition project visualization, several information system elements need to be developed, which include the 3D building model, the demolition processes schedule and the demolition product requirements. The demolition products, which are building components and materials, are visualized and integrated into the whole visual model. As a result, the waste production is visualized against both building model and time. Several knowledge bases need to be

constructed to enable the integration for the demolition project visualization. The first is to illustrate the positional and dimensional information of a specific building component or certain materials on a demolished building. For example, the content of the knowledge base might describe the position and amount of reusable windows and doors of a building. The query result, which could be the position and dimension of wanted material or building component, should then be shown on 3D building model. This requires building model to be constructed by aggregation of individual objects. In a result 3D building model, customer wanted materials or components can be shown in different colour and special annotation for describing further requirement. Another knowledge base, commonly used in construction visualisation, stores spatial relations imbedded in the 3D model and computer scheduling information. The information is usually captured from the experience and knowledge of construction planner (Alyazjee 2002). To produce the demolition visualisation, software package should be developed and used to process the knowledge bases, integrate information and generate animation.

4.3 Selection and evaluation of demolition technique and method

There are currently different building demolition approaches available in practice, such as demolition by machine, demolition by hand and demolition by explosion. Meantime, new demolition technologies are emerging through research and trail. The selection of building demolition method always involves in numerous factors including safety, environment, financial benefits or constraint, time constraint, transportation consideration and so on. Among these factors, safety seems to be the most important one that strongly dominates the selection of demolition method (Abdullah et al 2003). There should be a knowledge-based system to deal with the multiple criteria selection scenario in a building demolition project. As a result, demolition engineers can make the selection of demolition plan with the consideration of various aspects. Environmental consideration, as the increasing concern, is more and more important shown in a construction project, in particular the demolition project that generates massive waste to the landfill. The calculation and analysis of embodied energy of waste materials from the demolition project can be used in evaluation of building demolition plan or method on performance of environmental protection.

4.4 System integration

The above innovative waste exchange, demolition visualisation and selection and evaluation of demolition plan and method are the essential components of the proposed information system that is to promote the innovative management approach in building demolition project. Therefore, different new aspects of a building demolition project including waste, visualisation, time, cost, human resource, site management, safety and so on need to be considered and processed roundly as well as conventional construction project management principles. It is possible and certainly beneficial for a demolition project team to have an integrated information system covering various aspect of demolition project management with the application of latest information technologies. In the proposed management approach to a demolition project, waste handling is the key issue. In other words, building demolition can be seen as firstly waste exchange, then waste production, and finally wastes delivery. The waste centric feature is therefore shown in the information systems for the demolition project management. It is suggested that the information about building waste components and materials are organised as a database. This database is shared among various components or modules of the demolition project management system. It enables the consistency through out the planning, design, implementation and closing phases of a building demolition project.

5. Conclusions

In this research, several new management approaches have been proposed for building demolition projects in order to minimize their environmental impacts. It is demonstrated that the information system strategy is crucial for employing new management approaches into the demolition project practice. In particular, a waste exchange system promotes building components and materials reuse and recycling, as well as user requirement collection. Building demolition visualization shows the animated project schedule over a 3D building model, and is also used to indicate the production schedule for waste components and materials. The demolition method selection and evaluation system is used to analysis various building demolition techniques against multiple criteria including environment, waste, safety, cost, time and others. An integrated building demolition project management information system can carry out the proposed new management approaches in addition to the conventional project management elements.

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