This is the published version:


Available from Deakin Research Online:

http://hdl.handle.net/10536/DRO/DU:30005381

Every reasonable effort has been made to ensure that permission has been obtained for items included in Deakin Research Online. If you believe that your rights have been infringed by this repository, please contact drosupport@deakin.edu.au

Copyright : 2004, Construction Industry Development Board Malaysia
INFORMATION TECHNOLOGY APPLICATIONS FOR PLANNING IN DECONSTRUCTION

CHUNLU LIU AND SUNG KIN PUN
Deakin University, Waterfront, Geelong 3217, Australia

AND

YOSHITO ITOH
Nagoya University, Chikusu-ku, Nagoya 464-8603, Japan

Abstract. In recent years, there has been obvious emphasis on the shift from design and construction of new facilities to maintenance, refurbishment, and demolition management of existing facilities. Demolition technology has gradually changed from conventional destruction to the recently developed deconstruction. Demolition management, particularly deconstruction management, is becoming a novel, but a fertile teaching and research discipline. This paper focuses on an important issue of deconstruction management, how to work out a deconstruction plan using information technologies.

1. Introduction

In recent years, with urbanization and industrialization worldwide, the emphasis in both academic research and engineering practice began to shift from the planning, design and construction of new facilities to the maintenance, refurbishment, and demolition management of existing facilities with their deteriorations. In some cities (particularly in old industry regions) in order to improve the living quality or to meet other objectives, there are apparent increasing examples of demolishing buildings to a green land area, in which demolition is independent of construction. With the increasing demands of demolition, the final lifecycle stage of a constructed facility, its technology has gradually been moving from the conventional complete destruction to the recently developed deconstruction, by which a constructed facility is dismantled fully or partially to salvage the demolition materials. Demolition management, particularly deconstruction management, is becoming a novel, but a fertile teaching and research discipline (Liu et al., 2003). As the converse of construction, deconstruction puts forward some new management themes or adds some new contents even though the same issues have been faced in construction management. For example, the demolished materials’ disposal is rarely considered in construction management, and the deconstruction planning has different characters from the construction planning in products, processes and operation spaces. This paper focuses on an important issue in deconstruction management: how to work out a deconstruction plan driven by the latest information technologies. The paper is organised as follows: deconstruction management is first necessitated by indicating its position in the project lifecycle. In section 3, the progress of planning deconstruction is demonstrated in detail. Section 4 describes the approaches of applying the latest information technologies for working out a deconstruction plan. Finally, the fifth section concludes this research.

2. Necessitarianism of Deconstruction Management

2.1. PROJECT LIFECYCLE STAGES

It has been widely recognised that the lifecycle approach can play an important role in project management by considering all lifecycle stages at the same time (Itoh and Liu 2000). However, people initially concentrated on the design and construction stages, and then involved the planning. It might be since 1980s that maintenance has been taken into serious consideration, and maintenance attracted much emphasis from 1990s (Liu and Itoh 1997). Choate and Walter (1981) argued in concise language that there was an infrastructure crisis in USA due to a lack of inadequate maintenance of existing facilities.
However, publishing the book did not draw society's attention immediately to the crisis, and the scope of the problem became clear in the following years while a large number of bridges in USA collapsed partially or completely (Dunker and Rabbat 1993). The lessons learned from the failures and disasters led to better understanding of the importance of the proper maintenance. Therefore, till 1996, it could be concluded that most of the national governments, and local authorities in the developed world had switched their minds from new infrastructure projects requiring large capital investment to the maintenance of the existing stocks (Harding et al., 1996).

The emphasis on the demolition stage was highly due to the increasing environmental pressure, particularly in waste disposal. The demolition of building structures produces enormous amounts of materials that in most regions result in significant waste streams. The Australian construction industry, particularly in the demolition of existing facilities, is responsible for some 30-40% of the country's solid waste streams which total about 14 million tonnes annually according to the Australian Bureau of Statistics (2003). In recent years, there have been various attempts to improve landfill disposal technologies as well as to set up advanced recycling technologies. As further improvements in processing are technically limited, future efforts will have to concentrate on improving the demolition method from destruction to deconstruction.

2.2. DEMOLITION TECHNOLOGY

The conventional demolition technology, destruction, mixes various materials and leads to cross contamination of building components from demolition. For example, a residential house made of timbers, bricks, tiles, glass, and others is normally pulled down with a backhoe, and the demolished materials are a mixture of all these materials. It is very hard to reuse or recycle these mixed materials, and the first option in many cases is to send them to the landfills. In addition, a small fraction of the solid waste generated during the demolition of buildings contains chemicals hazardous to human health and the environment.

Although it is obvious that the deconstruction of a building, dismantling it into various parts during demolition, has many advantages over the conventional demolition by destruction from the viewpoints of local and global environmental protection, few successful approach has been available so far (Kibert and Languell 2000). This is partially because the low or minus economic benefit of deconstruction influences the industry to consider not dismantling a building but destructing it (Lyle 2003). Deconstruction was rarely considered while existing buildings were designed or constructed. In addition, neither the equipment nor the techniques have been specially developed for deconstruction. Another factor is that demolition is usually dependent on construction, and demolition is given much less importance, time, consideration and criteria than construction. In conclusion, to promote deconstruction as the dominant demolition technology, it needs long-term efforts in various aspects including a research approach in deconstruction management.

2.3. DECONSTRUCTION MANAGEMENT

Deconstruction management aims to establish legal regulations on demolition activities, spread environmental awareness in the industry, develop deconstruction techniques, and improve economic implications through management approaches (Liu et al., 2003). So far, most buildings have been designed and constructed with no consideration of what will happen to them after their service lives, and design or construction for demolition has been recognised for a few years by some researchers (Chini 2002). Environmental awareness has not yet been well established in the minds of building owners, designers and contractors. Research and development on deconstruction technology and management has not been widely understood by managers or engineers, and no authoritative governments or associations have published any deconstruction code. Some current legal regulations do not promote deconstruction implementation. For instance, the certification procedure of used components' quality has not been well established or widely understood. The disposal costs for demolition waste are rather low. In the Victorian landfills, the difference of disposal costs per tonne between municipal solid waste, and construction and demolition waste is only one dollar (IRSR 2000).
In order to deconstruct a project, diverse groups of people in various fields come together, divergent materials or components change their shapes, functions and positions, and demolition machines act in three-dimensional space. The deconstruction activities need achieve requirements in time, cost, quality and safety. Deconstruction contains unique management contents due to its strict environmental protection requirements, its newly emergent issues, and the uncertainty during its process. Figure 1 describes a breakdown of demolition related fields. The middle box lists some potential disciplines that may influence the development of demolition, one lifecycle stage. The right box shows some key contents in developing demolition management.

3. Deconstruction Planning Approach

3.1. MODELLING DECONSTRUCTION

Deconstruction planning of a project starts from the location investigation, which aims to survey the site conditions around the building so that the possible space available for deconstruction activities such as the accumulation of the dismantled building components and their transportation can be indicated. The deconstruction components of a building need not be as detailed as the construction components. For instance, the walls are usually classified as external walls and internal walls at least for the purpose of construction, but the walls on a certain floor may be defined as only one deconstruction product. Therefore, instead of the detailed construction code system of a building, the relatively brief architectural code system is preferred to be adopted or referenced to represent the deconstruction components. To fully display the deconstruction procedure of a building, all deconstruction components called deconstruction products are drawn in a three-dimensional model such as CAD.

Similarly, different dismantling activity (operation) called deconstruction process has to be defined according to many variables, including the type of the building under consideration, the dismantling techniques available, and the objective of the final products. Different environmental constraints such as obligatory levels of separation lead to different dismantling activities (Schultmann and Rentz 2002). After the dismantling activities are determined, the resources necessary and the duration of the activities need to be specified in detail. Each dismantling activity can be achieved using different techniques and resources, and will also result in different processing durations. For instance, dismantling an outer wall in a residential house can be performed using pneumatic hammers, by a grabbing bucket, or with a hydraulic excavator.

3.2. DECONSTRUCTION SCHEDULING

A deconstruction schedule is, for each deconstruction process, an allocation of one or more time intervals to one or more deconstruction products. Deconstruction schedules may be deconstruction product oriented or deconstruction process oriented. Deconstruction scheduling is to find a schedule to meet the various challenges in the most efficient way. The planning of dismantling activities is undertaken based on project scheduling principles so that the scarce resources available for the deconstruction can be allocated to these dependent or independent activities over time throughout the site in the most efficient way.
manner possibly. Both the deconstruction product and process planning can be scheduled with a scheduling tool such as MS Project. Various resources can be analysed and reported under such as a tool. The principles of network analysis are used to determine and optimise the whole building deconstruction schedule. The technological and environmental precedence relations of the dismantling process are proposed to be illustrated using a topologically ordered activity-on-node network, in which the nodes represent the dismantling activities and the arcs represent the precedence relations among activities. The optimal deconstruction schedule is then presented in bar charts in order for it to be easily presented and understood.

4. Deconstruction Planning Driven by Information Technologies

4.1. DECONSTRUCTION DATABASE DEVELOPMENT

Before planning deconstruction of a project, the deconstruction data and the general information have to be collected from various sources (Liu and Pun 2003a). The deconstruction of a building contains product data to represent the details of each building component such as an outer wall, and process data related to a dismantling activity. The database may be developed using a database management system such as Microsoft Access or Oracle. The database is used for planning and controlling the deconstruction progress. The national architectural design code system may temporarily be referenced to draft a deconstruction code system to be used in the database development to represent each dismantling activity. The data related to each deconstruction product are input into the database, and these data will contain all the resource requirements for materials, machines, workforce, budget, time, space as well as the geometrical data generated from the drawing model. The precedence relations among the deconstruction products are also recorded in the database. So far, no methodology has been developed to estimate the resources needed for each deconstruction process, and discussion with the practical engineers in demolition companies may turn out to be the main means used to attain such data. The recourse needs and operational duration of each deconstruction product are then calculated based on the data of deconstruction processes.

4.2. ELECTRONIC DECONSTRUCTION SIMULATION

The availability of deconstruction project planning relies heavily on the project participants' ability. Compared to construction, deconstruction planning is more demanding in time, space, safety and environmental regulation. Furthermore, due to a lack of engineering experience and theoretical knowledge, rational deconstruction planning is more difficult to generate for a practical project. Therefore, an electronic deconstruction simulation is particularly necessary for the deconstruction process in practice (Liu and Pun 2003b). The electronic approach of a construction project has been developed in the n-dimensional visualisation (McKinney and Fischer 1998). The development of an electronic technique for deconstruction planning is conducive with the spreading of deconstruction in practice. However, in most cases of existing buildings to be demolished, the digital drawings are not documented. A simple three-dimensional model following the brief architectural code of building components need be prepared for visualising the deconstruction planning over time. The deconstruction process representing the dismantling activities is strongly dependent on the building structure and is also affected by the site environment. Therefore, visualisation needs to be developed for the building components, the dismantling activities, and the site location. By connecting the three dimensional model and the database, the data of each building component recorded in the database can be visualised over time in the drawing environment. Both the project process and the site space availability can also be visually checked.
4.3. DECONSTRUCTION PLANNING SYSTEM

A deconstruction planning system needs to be developed to deal with all possible issues from demolition to reuse. The main target of developing such a system is to maximise the conservation of construction resources through prolonging the cycle from the extraction of raw materials to the final disposal of them to landfill (Liu et al., 2003). An ideal situation for a constructed facility, which cannot be used as it is from the structural or functional requirement, is to renovate or relocate it. In this case the life of the whole building is extended, and the majority of the building retains. In addition to this, buildings that are optimally designed with environmentally sustainable materials and with deconstruction in mind are of extreme value when it comes to reducing waste at the demolition stage. By deconstructing the building, the reuse of materials would provide the next best result following the refurbishment or relocation in terms of waste minimization. Deconstruction makes it possible for a majority of materials to be recycled and reprocessed into a building element. The last option in order of preference is the demolished waste disposal to landfill after all others have been fully explored.

The development of a deconstruction planning system will benefit both suppliers and demanders of recycled materials, and will also promote the implementation of deconstruction as well as reduce the landfill pressure. With the increase of demolition projects, the deconstruction planning system to be developed may provide services to the deconstruction clients, the professional deconstruction firms, the professional recycling firms, the qualification of reused or recycled materials, the reused or recycled material market, and the demanders of reused or recycled materials as well as the landfill.

4.4. DECONSTRUCTION STRATEGY EVALUATIONS

To gain an understanding of where deconstruction management should be focused, a comparison depicting both the typical advantages and disadvantages of destruction and deconstruction need be carried out for a range of selected construction products and materials. The main factors to consider are the current technology available, time, cost, environment, and safety issues (Lyle 2003). Computational results for a typical building are able to show the differences under various deconstruction scenarios from both economic and environmental points of view, particularly the waste disposal. Each deconstruction scenario with different techniques and restrictions will be carefully defined in cooperation with the demolition company. Each deconstruction scenario is then evaluated according to a set of criteria.

5. Conclusions

This paper presents a comprehensive research approach on deconstruction management, in particular deconstruction planning, in order to use information technologies to promote the shift in demolition from destruction to deconstruction. Emphasis on demolition was put forward so that the demolition stage of a constructed facility will be given the same importance and consideration as other lifecycle stages that are planning, design, construction, and maintenance stages. Information technologies were considered to drive the development of new academic disciplines on demolition and a new industrial sector specialising in demolition.

References

Australian Bureau of Statistics: 2003, Year Book Australia, Canberra, Australia.


