THE PROCESS AND FEASIBILITY OF BUILDING DECONSTRUCTION: A CASE STUDY IN ANKARA

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ABSTRACT

THE PROCESS AND FEASIBILITY OF BUILDING DECONSTRUCTION: A CASE STUDY IN ANKARA

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Today because of changes in the zoning plans, structural problems, building obsolescence and owner's wishes, old buildings are being demolished to erect newer, larger and taller ones. The objective of this study was to investigate the process and feasibility of building deconstruction.

A literature survey was conducted on two unpublished theses at Middle East Technical University (METU), and publications available on web sites and international conference proceedings. Case studies were conducted on building deconstruction and demolition processes, and recovery of used building materials (UBMs) in Ankara. Information related to these issues was obtained through informal interviews with demolition contractors, demolition teams, merchants of UBMs and building contractors. Information regarding the official procedure of demolition was gathered from Çankaya and Yenimahalle Municipalities.

This study confirmed that recovery and reuse of UBMs is a continual practice in Ankara. In the light of case studies and interviews, it was possible to determine the problems in building deconstruction, such as building systems, materials, components and connections that give rise to difficulties during the deconstruction of buildings. It was also observed that UBMs are being reused either as it is or after modifications, and waste timber components are sold for fuel, while only metals are recycled to be used in new production. On the other hand, reinforced concrete components such as slabs, columns and beams can neither be reused nor recycled, and thus they are wasted.

The findings of the investigation indicated that building deconstruction practices were found to be feasible and profitable job. The success of building deconstruction is dependent on type of tools used, sufficient time, and worker ability and experience, whereas the feasibility of deconstruction depends on the quality, quantity, type and condition of materials, components and connections used in a building.

Keywords: Building deconstruction; Demolition; Feasibility of deconstruction; Recovery of used building materials; Used building materials.

ÖZ

BINA SÖKÜM METODU VE UYGUNLANABILIRLIGI: ANKARA ÖRNEGINDE DURUM INCELEMESI

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Yüksek Lisans, Yapi Bilimleri Anabilim Dali, Mimarlik Bölümü
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Günümüzde eski binalar imar planlarindaki degisiklikler, strüktürel problemler, binalarin eskimesi ve bina sahiplerinin istekleri gibi sebeplerden dolayi yikilip yerlerine yenileri insa edilmektedir. Bu çalismada bina söküm metodu ve uygulanabilirligi arastirilmistir.

Binalarin sökümü, kullanilmis yapi malzemeleri ve söküm tasarimi konulariyla ilgili literatür taramasi Orta Dogu Teknik Üniversitesi'nde (ODTÜ) yapilan yayinlanmamis iki tez, web siteleri ve uluslararasi konferans raporlarindan yararlanilarak yapilmistir. Ankara'da binalarin sökümü, yikimi ve kullanilmis yapi malzemelerinin geri kazanimi üzerine saha çalismasi yapilmistir. Konuya iliskin bilgi edinmek amaciyla yikimcilar, yikim ekipleri, kullanilmis yapi malzemesi tüccarlari ve müteahhitlerle röportaj yapilmistir. Yikim uygulamalarina iliskin resmi prosedürle ilgili bilgi Çankaya ve Yenimahalle Belediyelerinden elde edilmistir.

Arastirmada Ankara'da geri kazanim ve geri dönüsüm çalismalarinin devam eden bir uygulama oldugu teyit edilmistir. Yerinde incelemeler ve yapilan röportajlar isiginda binalarin sökümünde karsilasilan problemler belirlenmistir. Geri kazanilan yapi malzemelerinin ya oldugu gibi ya da iyilestirilerek yeniden kullanildiginin yanisira atil ahsap malzemelerin yakacak olarak satildigi, sadece metallerin yeni üretimde kullanilmak üzere geri dönüstürüldügü belirlenmistir. Döseme, kolon ve kiris gibi betonarme elemanlardan ortaya çikan molozun ise atildigi tesbit edilmistir.

Arastirmanin bulgulari bina sökümü uygulamalarinin ekonomik açidan uygun ve karli bir is oldugunu göstermistir. Bina sökümünün basarisi kullanilan aletlere, uygun zamana, isçilerin beceri ve tecrübelerine bagli oldugu belirlenmistir. Bina sökümünün uygulanabilirligi ise binada kullanilan yapi malzemelerinin, elemanlarinin ve baglanti elemanlarinin sayisina, kalitesine ve türüne bagli oldugu gözlemlenmistir.

Anahtar Kelimeler: Bina sökümü; Bina sökümünün uygulanabilirligi; Kullanilmis yapi malzemeleri; Kullanilmis yapi malzemelerinin geri kazanimi; Yikim.

To My Family

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LIST OF ABBREVIATIONS

ACM	Asbestos Containing Material
ATO	*Ankara Ticaret Odasi*, Ankara Chamber of Commerce
ANKESOB	*Ankara Esnaflari Odalar Birligi*, Ankara Chamber of Trades
C&D	Construction and Demolition
CDW	Construction and Demolition Waste
CIB	International Council for Research and Innovation in Building Construction
CO	Carbon Monoxide
CO_2	Carbon Dioxide
DfD	Design for Deconstruction
EPA	Environment Protection Authority
FORA	Fort Ord Reuse Authority
ILSR	Institute for Local Self-Reliance
LBP	Lead Based Paint
METU	Middle East Technical University
NAHBRC	The National Association of Home Builders Research Center
SO_2	Sulphur Dioxide
SSK	Sosyal Sigortalar Kurumu, Social Insurance Institute
TG39	Task Group on Deconstruction
TSE	*Türk Standartlari Enstitüsü,* Turkish Standards Institute
TUS	*Teknik Uygulama Sorumluluk* Technical Implementation Responsibility
UBM	Used Building Material
Ykr	New Turkish Kurus
YTL	New Turkish Lira

CHAPTER I

INTRODUCTION

In this introductory chapter are presented argument, objectives, methodology and disposition of the study. These are explained in sections 1.1, 1.2, 1.3 and 1.4, respectively.

1.1 Argument

In Turkey, besides increasing population, migrations from rural to urban areas (especially to big cities like Istanbul, Ankara and Izmir) raise the need for more buildings and hence, more building materials. However, existing buildings are not able to meet this increase in population due to migration. This need for more buildings on limited land is met by demolishing low-rise structures and building high-rise ones instead. Consequently, more accommodation is provided on the same piece of land. Even if the reason for demolishing a building is not the need for such replacement it can also be because of the end of its useful service life as well as building obsolescence, modifications in the zoning plan, owner’s desires, and structural problems.

Building deconstruction conserves energy and raw materials. According to Sherman (1998), more than one-third of the raw materials annually entering the global economy are consumed by the construction industry. Furthermore, this industry is also responsible for consuming 50% of energy generated around the world (Sev and Özgen, 2003). The enormous amount of waste produced during construction, renovation and demolition activities is a serious environmental problem, which is worsening as building activities increase over the years. The activity of building demolition causes increasing waste generation and thus negative environmental impacts. On the other hand, deconstruction is a process of carefully dismantling of a building or a structure, into its components, subcomponents and materials with the aim of maximizing their recovery for reuse, recycling and resale. Deconstruction of buildings has gained more and more importance in recent years in some countries. Deconstruction of buildings helps to increase the amount of components and materials to be reused or recycled while reducing environmental impacts and the need for new materials and resources.

Recovery, reuse and recycling of used building materials (UBMs) offer economic, social, environmental and historic benefits. Reuse and recycling of building materials can significantly reduce the need for new materials and resources and the use of energy and natural resources. This helps save time and money while protecting the environment. From the social point of view, recovery, reuse and recycling activities open up new opportunities for local enterprises and workforce to recover, recycle and sell UBMs locally, nationally or internationally. These activities also help to preserve materials and components with historical value.

The tradition of recovery and reuse of building materials and components from demolished buildings dates back to Ottoman Empire era (Özkan, 2000). Our ancestors recovered especially marble and stone columns and their pedestals from structures that could not be repaired, and then they reused them in new structures. It is possible to see these columns and pedestals in some mosque structures in Turkey. Nevertheless, there is no known written document about these recovery and reuse practices, which are referred to as *'devsirme'* in Turkish.

At present, old buildings are being demolished to erect newer, larger and taller ones. In Ankara, demolition of old structures is being performed in two types of settlements; one in old building settlements, such as Emniyet, Esentepe, Çerçideresi, Gazi, Güzelevler, Isinlar, Sentepe, Tepealti, Varlik, Yeniçag, Yunusemre etc.; the other in squatters' settlements, such as Avcilar, Baristepe, Burç, Çigdemtepe, Çukurca, Ergenekon, Kaletepe, Kayalar, Kubilay, Mehmet Akif, Pamuklar, Yildiz etc. In Ankara, selective dismantling is usually performed and then the building is demolished manually. To pull down a masonry building, it is preferred to use simple tools while more complex tools and equipment are used to demolish a reinforced concrete building.

1.2 Objectives

The aim of this study is not only to examine local deconstruction works, dismantling tools, techniques and methods, but also to investigate the feasibility of building deconstruction. By observing the deconstruction and demolition processes of three residential buildings in Ankara, it was possible to determine the problems in deconstruction of buildings, such as building systems, types of building materials and components, and connections used in installing building components that give rise to difficulties during the deconstruction of buildings. It is hoped that the findings of this study will encourage researchers in Turkey to give special attention to the recovery and reuse of used building materials from economic, environmental and social points of view.

1.3 Methodology

The methodology of this research incorporated a literature review on building deconstruction, used building materials and design for deconstruction. A literature survey was conducted on two unpublished theses at Middle East Technical University (METU), and publications available on web sites of international research groups and organizations working on deconstruction and demolition processes /projects, design for deconstruction, UBMs and guide books; web pages of demolition companies; regarding international reports published by NAHB Research Center; and related to ongoing projects and research around the world as reported by the International Council for Research and Innovation in Building Construction (CIB) Task Group on Deconstruction (TG39) and the 11th Rinker International Conference.

Local deconstruction and demolition works and recovery of used building materials and components in Ankara were investigated. In order to obtain information pertaining to deconstruction techniques and methods, and recovery, repair, storage and marketing of UBMs, informal interviews were conducted with building contractors, demolition contractors, and demolition workers on demolition sites visited during the study. Furthermore, the officials of the Building Authorization Office in Çankaya and Yenimahalle Municipalities in Ankara were interviewed to obtain information regarding official procedure for building demolition.

The survey also covered reasons for demolition, official procedure for demolition practices, worker training, health and safety, and the rules and regulations concerning demolition practices in Turkey. Furthermore, a price investigation was conducted not only to compare the prices of used building materials with new ones, but also to assess the feasibility of the deconstruction work.

1.4 Disposition

Including this introductory chapter the study consists of six chapters. In Chapter II a literature survey is presented consisting of three main sections namely building deconstruction, used building materials and design for deconstruction. In Chapter III, the material and methodology of the study are presented.

Material presented in the preceding chapter is discussed and analyzed in Chapter IV. Starting from the reasons for demolition, official procedure for demolition practices, worker training, health and safety, and the rules and regulations on the subject, this chapter focuses on deconstruction and demolition practices observed and recovery of UBMs in Ankara. Also it summarizes all visual and documented information gathered from informal interviews and from field research.

Chapter V presents results and discussions pertaining to current deconstruction works observed. Data regarding the results of market survey were analyzed and presented in tables.

Finally, Chapter VI concludes the study with a summary of problems faced in deconstruction works, and recommendations for the improvement of building deconstruction practices.

CHAPTER II

LITERATURE SURVEY

This chapter presents a literature survey on three subjects: building deconstruction, reuse of used building materials and design for disassembly. The first part of the chapter includes definitions, aspects, benefits and challenges, and the process of building deconstruction. The second part consists of the reuse of UBMs, salvaged material management, market demand and market perceptions for UBMs. In the last part, the focus is on design for disassembly (DfD), the need for DfD, principles of DfD, and design criteria of building systems, components and materials, connections and connectors.

Published material in Turkey on deconstruction and demolition practices, UBMs and their recycling and reuse in new projects, is limted to two unpublished theses at METU and one article in the Journal of Mimarlik on the subject. Furthermore, international conference proceedings and on-line information related to building removal processes, design for deconstruction, and reuse and recycling of UBMs in other countries of the world was limited to small-scale projects.

2.1 Building Deconstruction

Deconstruction is a process of carefully dismantling of a building or a structure, into its components, subcomponents and materials with the aim of maximizing their recovery for reuse, recycling and resale. According to

Sherman (1998), preservation, rather than deconstruction or demolition, should be the first consideration when deciding what to do with an old building. Buildings with historical relevance or architecturally important features are best left intact. Such buildings can be restored and possibly moved to a new site.

Languell (2001) states that the primary reason for demolishing buildings depends on the needs of society's supply and demand. There is a demand for the building removal. This demand can be a result of a need for the land a building exists on, the building does not meet the occupants' needs, that is, it is outdated, or it has completed its structural life

According to Sherman (1998), the deconstruction process is the exact opposite of constructing a new building. Structures are dismantled backward from the order in which they were built. There are five basic steps of deconstruction: (1) remove the trim work, including door casings and molding; (2) take out kitchen appliances, plumbing, cabinets, windows and doors; (3) remove the wall covering, insulation, wiring and plumbing pipes; (4) disassemble the roof; and (5) dismantle the walls, frame and flooring, one story at a time. At each of step of the deconstruction process, pick up the materials; remove any nails; and sort, clean and stock the recovered materials for future reuse.

Crowther (2002) discusses the practical dimension of the deconstruction process and states that disassembly of a building or a structure may be understood as the reverse order of its assembly, but in practice it seldom occurs in this way. Construction of a building is a slow and careful process and it requires many people, large amounts of material, tools, equipment and long period of time. Deconstruction of a building is a process that requires less people, simpler tools, less time and effort than construction process. In this context, deconstruction process is not the reverse sequence of construction process.

There are a number of distinctions between deconstruction and demolition practices in view of definitions, processes, duration and economy. These are explained as follow:

a) Definition

The first distinction between deconstruction and demolition arises from their definitions. According to Hobbs and Hurley (2001), deconstruction is ‘an activity in which the construction process is reversed; that is, the structure, or parts of the structure, are disassembled and removed’. Disassembly is ‘taking apart building components and materials without damaging, but not necessarily to reuse them’. Demolition is ‘a term for both the name of the industry and a process of intentional deconstruction; that is, demolishing or destroying a building or a structure’. In the literature, the terms of deconstruction and disassembly are usually used synonymously.

According to Abdullah and Anumba (2003), deconstruction technique is the systematical dismantling of structures. The technique is also known as a *top down* technique or the demolition from the roof to the ground.

According to Macozoma (2001a), deconstruction means dismantling of a building with the aim of maximizing the reuse, recycle and resale potential of its materials and components. Demolition means razing of a building in a manner that its materials and components are useless and go landfill.

b) Process

Different processes are followed in deconstruction and demolition of buildings. Macozoma (2001a) states that deconstruction employs labour, simple tools and sometimes mechanical equipment to some extent to disassemble structures and salvage their components firstly for reuse and secondly for recycling. On the other hand, demolition uses machines and mechanical equipment to tear down buildings by diverting potentially resalable materials to mixed debris to be landfilled.

During deconstruction, reuse and recycling of salvaged materials should be considered. The reuse and recycling process can be done during or after the structural demolition process. The technique of deconstruction can be used as part of renovation or modification work and to prepare the way for deliberate collapse. The deconstruction can be done by hand, machines, bursting, or hot cutting. It is possible to separate demolition debris with the current technologies, such as hydraulic excavators attached with pulverizers, concrete crushing, and screening machines. This process can both maximize the use of resalable materials and reduce waste produced, and accordingly waste disposal costs (Abdullah and Anumba, 2003).

Traditional demolition involves mechanical demolition, resulting in a pile of mixed debris to be sent to the landfill area. Seemingly, demolition is a quick and inexpensive activity for the building removal; however, it often disregards the environmental impacts caused by wasteful practices. Demolition practice does not esteem the wasted materials that can be salvaged, only the labor to remove the structure and the cost to landfill the debris (Languell, 2001).

On the other hand, the deconstruction process has many steps and considerations starting from permitting process, building assessment, scheduling, safety to dismantling techniques, processing, sorting, marketing and resale. Therefore, it is understood that while demolition is highly mechanized, capital-intensive, and waste generating process, deconstruction is labor intensive, low-tech, and environmentally sound (Sherman, 1998).

According to Chini and Acquaye (2001) the choice between demolition and deconstruction depends on some factors that are the amount and quality of the materials that can be recovered, the market for the salvaged material, the presence of hazardous materials and their impact on the process and products, and enough time for the efficient building removal.

c) Duration

There are also differences between deconstruction and demolition in the view of duration. Macozoma (2001a) states that demolition takes a few days whereas deconstruction requires a few weeks for the building removal. This is due to the fact that deconstruction is labour intensive and requires more time for the building removal.

d) Economy

The last difference between deconstruction and demolition is costs of the work. According to Guy (2003), the cost of deconstruction varies between slightly higher or lower than that of demolition. However, deconstruction can help save much more money and make more revenue than demolition when all economical factors are considered, i.e. including salvaged material resale value, avoided transport and disposal costs and life cycle costs of landfill. Furthermore, Macozoma (2001a) states that the net income from demolition can be increased by the increase in diversion of construction and demolition (C&D) waste from landfill to recycling. However, the mixed nature of demolition C&D waste would increase the pre-recycling costs of sorting and screening, may be inefficient for the process. On the other hand, the net income from deconstruction can be increased in two ways: training and considering salvage material quality with market resale value to avoid cases where salvage costs is higher than resale value. Increasing landfill-tipping fees will favour of deconstruction while having a negative impact on demolition.

2.1.1 Aspects of Deconstruction

Deconstruction is one solution to reduce the demand on natural resources and the amount of waste resulting from construction and demolition works. Unlike demolition, the concept employs both reuse and recycling approaches, and materials can be diverted from landfills (Chini and Nyugen, 2003). Therefore, the salvaged waste can be converted into useful secondary materials and develop a new resource pool for the construction industry (Macozoma, 2001a).

Key aspects of deconstruction, which have been described by Seldman and Jackson (2004) and Macozoma (2001a), are as follows:

- a low-cost alternative to demolition
- a technique for building removal
- a strategy that can be used to reduce waste generation
- a renewal tool to help dismantle, renew and reuse old and abandoned buildings
- a community economic generation strategy to help create employment, local businesses and use local resources
- stimulates local businesses development
- attracts federal funding for local projects
- diverts materials from landfills and incinerations
- reduces the C&D industry's reliance on virgin materials
- safeguards the environment
- deals with the dismantling of buildings to maximize material salvage for reuse
- helps create the low-end markets with affordable building materials for low-income communities, and the high-end markets for discerning buyers.
- uses labour intensive methods.
- provides job and training opportunity for workers who are willing to do the demolition work.

- turns trainees into business owner
- support a secondary construction materials market and ensure the supply of secondary materials to meet the demand.
- Have environmental, economic, social and historical benefits that can contribute to help improve people's lives.

According to Kibert and Chini (2000), the benefits of deconstruction are significant, and when compared to demolition, are advantageous. The main benefit comes from the fact that materials are being diverted from landfill and that natural resource is preserved. Guy (2001) states that the specific benefits of deconstruction over traditional demolition depend on the project. However, recovery and reuse of building materials has clear environmental, economic and social benefits. Besides these three benefits, Macozoma (2001a) adds the historical benefits of building deconstruction. These benefits are explained in the following sections.

2.1.1.1 Environmental Benefits

Environmental benefits of building deconstruction are perhaps the most important ones, but often stay unnoticed when comparing with the social and economic aspects. Each benefit depends on another one, that is, there is a benefit loop. Macozoma (2001a) states that building deconstruction helps divert large volumes of construction and demolition (C&D) waste away from landfill sites. This helps conserve landfill areas and extend the life of landfills by the reduction of demand for landfill areas helps reduce health hazard risks.

Deconstruction helps reduce waste generation, thus lowers the amount of waste disposed in landfills. This decreases not only climate gas emissions, but also has a direct impact at the local level. It is a known fact that disposal facilities conventionally are located in low-income and minority areas. These landfill areas present potential health hazard. Citizens are subjected to a host of environmental calamities from airborne toxins caused by incineration, and exposed to groundwater pollution resulting from improper disposal of contaminated materials (ILSR, 2004c).

a. Solid Waste

The construction and demolition industry is responsible for the enormous quantities of generated and disposed waste, much of which is reusable or recyclable. Building deconstruction activity can recover millions tons of C&D waste for reuse and recycling. By reducing waste generation, deconstruction also diminishes climate gas emissions, and the need for landfilling and incineration. Most importantly, it helps to direct the C&D industry from traditional consumption and disposal activities towards sustainability and reuse (ILSR, 2004c).

According to Erkelens (2003), the enormous amount of waste generated by construction, renovation and demolition of buildings causes negative environmental impacts. This is worsening the image of construction and demolition industry as the building activities continue.

Referring to Kim and Rigdon, Isik (2003) states that due to the C&D of buildings material flow constitutes a major share (10-15%) of the total municipal solid waste stream. Furthermore, natural disasters such as floods, earthquakes and hurricanes greatly increase these percentages.

b. Resource and Energy Efficiency

Reducing the consumption of virgin materials, the concept of building deconstruction helps preserve natural resources and protect the environment from the air, ground and water pollution associated with the extraction, processing and disposal of raw materials (ILSR, 2004c).

Sherman (1998) points out that building deconstruction conserves energy and raw materials. More than one-third of the raw materials annually entering the global economy are consumed by the construction industry. This industry is also responsible for over 11 percent of the total energy consumed each year in the United States. While only 15 percent of this energy is used directly at the construction site, about 85 percent of the energy is used for the production and transportation of materials used in new construction. These levels of energy consumption can be lowered significantly by deconstructing buildings and reusing the materials locally.

Chini and Nyugen (2001) reported that the construction industry in the United States every year consumes an average of 146 million cubic meters of virgin lumber. When structures have reached the end of their lives, become obsolete or change the use, the lumber in those structures can be salvaged and reused in new structures by using less energy than that required for a new structure.

According to Macozoma (2001a), the salvage of materials for reuse preserves the embodied energy, which is already present in the materials in buildings. Consequently, building deconstruction helps close the loop on material flows by contributing to resource recovery in construction.

c. Natural Environment

Successful strategies for implementing building deconstruction can reduce energy use, land consumption, groundwater degradation and greenhouse gas generation. Lumber is the most common and the most reusable material recovered from buildings. Salvaging lumber for direct reuse has multiple components with environmental damage avoidance. These include the protection of forest resources from floods and soil erosion, maintenance of bio-diversity, and reduced levels of CO_2, energy use and pollution from the harvesting, milling and transportation of new lumber (Guy, 2001).

Chini and Nyugen (2001) state that for many centuries not only has wood been a natural and the principal building material for the construction industry, it is the only renewable structural construction material today. For many centuries, forest areas have been depleted enormously due to harvesting of wood for the construction industry as well as fire.

Chini and Nyugen (2001) further reported that harvesting of wood and production of lumber has been increasing and has many adverse effects on the environment. As long as effective measures are not taken into consideration to ensure sustainable practices, the negative impacts will increase and affect the future generations. Environmental issues of the harvesting of wood include loose of bio-diversity, plant and animal habitat, species extinction, soil erosion, and deforestation, and increase in atmospheric carbon dioxide, which is a consequence of increase in global warming. To harvest wood, trees are cut. This brings about a decrease in atmospheric moisture. Accordingly, conduction of water from the soil to the atmosphere is restricted. In the production of lumber, fuels used in mills pollute the air by releasing toxic gases such as carbon monoxide (CO) and sulphur dioxide (SO_2). Environmental and health hazards related to these toxic gases include global warming, decreased visibility, smog, eye irrigation and lung damage. Implementation of building deconstruction activity and promotion of building materials reuse helps to minimize these negative outcomes.

d. Toxicity and Hazardous Substances

Building deconstruction provides a through inspection of buildings for hazardous substances, which are sometimes disregarded by demolition. This allows for the appropriate and safe disposal of hazardous waste materials. Deconstruction also decreases airborne asbestos, lead particles and dust in the atmosphere that would be created through demolition (Macozoma, 2001a).

Guy (2001) claims that at present some demolition practices, especially at the scale of residential buildings, are not completely responsible for all hazardous materials. Deconstruction requires a strict environmental health and safety protocol to manage any hazardous substances and to protect worker health. This attention to the management of hazardous materials enhances to reduce future impacts such as disposal of asbestos-containing materials (ACM) and of materials with lead-based paint (LBP). Thanks to the environmental friendly version of demolition, the release of hazardous materials from breaking, crushing, abrading and grinding generally associated with mechanical demolition is eliminated. The opportunity of the reuse of UBMs into new construction helps protect human health risks from LBP exposure; extends the life of the valuable reused material and keeps the LBP out of the natural environment as long as possible.

2.1.1.2 Social Benefits

Deconstruction requires disassembling, salvaging or recovering materials and components from the structure manually. This helps create job opportunities while attracting local businesses. According to Macozoma (2001a), deconstruction can create employment opportunities for unskilled and low-skill workers. Deconstruction work provides more labour for building removal, whereas demolition employs a few people to operate mechanical equipment. Deconstruction has two main spin-offs for the construction industry: training of labour in the construction trades and creation of a bigger labour resource pool.

Chini and Bruening (2003) state that deconstruction creates more employment and training occasions for low-skilled labour than does demolition. This provides the community with job and career opportunities, which thereby stimulates the local economy. These skills learned from deconstruction practices are marketable in the construction industry as well. While learning how a building is disassembled, workers also learn how to put the building put together.

Deconstruction is an efficient solution for the regeneration of the community by employing local labour and using local resources to dismantle, collect and distribute salvaged materials. Distribution of recovered material helps develop new businesses such as used building materials for communities (Macozoma, 2001a).

Building deconstruction is more labour intensive than mechanical demolition. It also requires different set of labour skills, which are similar to that required to erect new buildings, such as job safety, tool use, teamwork and basic carpentry. Past researches indicated have that resource recovery and deconstruction for reuse and recycling can require ten times more labour hours than resource collection and disposal. More labour hours means more job created at a lower pay rate compared with that of a heavy machine operator (Guy, 2001).

2.1.1.3 Economic Benefits

Economic benefits of deconstruction are crucial. As infrastructure of cities gets older, and need for housing increase due to the population growth and migration to urban areas, there will be a greater requirement towards renovation and redevelopment for existing buildings in urban areas. There will be a greater need to reuse all kind of building materials because of the combination of increased availability of recoverable materials, increased need for housing, increased cost of disposal and of gasoline for global warming via fossil fuel use, and its impacts on the natural environment. These conditions will stimulate the economic and environmental viability of building deconstruction and reuse as a sustainable business enterprise (Guy, 2001).

According to Macozoma (2001a), building deconstruction and material recovery for reuse and recycling can reduce costs of the building removal activity and generate extra revenue for business. He adds the other economic benefits of building disassembly including:

- cost savings from avoided transportation and disposal costs of C&D waste
- delayed capital expenditure for the development of landfills due to extended lives of existing landfill sites.
- delayed closure costs for existing landfills
- cost savings from avoided procurement costs of virgin materials
- the development of a new economic stream, i.e. the secondary materials industry of retail businesses for salvaged materials, recycling businesses and recycled content product manufacturers
- revenue generation from the resale of salvaged waste materials
- improved financial performance of the construction industry due to reduced energy and pollution costs.

According to Chini and Bruening (2003), besides environmental and social benefits, building deconstruction is a cost-effective alternative to demolition. Many studies have shown that total costs of deconstruction are generally higher; however, the resale of recovered materials makes deconstruction a cheaper solution to building removal than demolition. Deconstruction and building materials reuse stimulate the economy by allowing for the creation of a salvaged materials market. This market arouses local business development and availability of cheap building materials.

2.1.1.4 Historical Benefits

Deconstruction serves to preserve historically significant buildings via selective dismantling, renovation or relocation of these buildings. Moreover, old buildings usually have valuable materials and components, and contain craftsmanship that is no longer available at present time. They may be rare and have an antique value, so very expensive. Since materials are recovered and preserved during building disassembly, deconstruction can salvage these historical materials and/or components, and make them available to the discerning buyers or collectors (Macozoma, 2001a).

In addition, Chini and Bruening (2003) claim that the reuse of old building components helps preserve preceding architecture and craftsmanship through salvage and resale. Items with historical significance often have a high price as they are in high demand by collectors. There is a short supply of many woods and heavy timbers used in the construction of buildings before 1950. Furthermore, many materials used in building construction are no longer available from any resources today. This creates a strong demand for such items on the salvage market. These materials are generally considered to be of higher aesthetic, value and quality than today's lumber manufactured.

2.1.1.5 Challenges Facing Deconstruction

There are a number of challenges faced by deconstruction. Guy (2001) states that since deconstruction takes more time and care than demolition, project labour costs can be higher. This constraint must be overcome by implementing deconstruction on a widespread basis. One way to handle this constraint is to minimize the preparation time and increase information on labour time and scheduling requirements. Other constraints include the uncertainty of resale markets and the ability to pre-sell materials for deconstruction to be economically feasible.

Modern materials such as plywood and composite boards are generally difficult to remove from structures. Furthermore, new building techniques such as gluing floorboards and using high-tech fasteners represent a barrier to deconstruction. Another problem is asbestos-containing materials. Asbestos may be found in pipe, dirt, wall and ceiling insulation, ceiling tiles, roofing, siding, vinyl sheet flooring, wallboard and mud joint compound, plaster, and window caulking. Proper removal of asbestos-containing materials requires special equipment and training (Sherman, 1998).

According to Chini and Bruening (2003), the successful implementation of deconstruction is dependent on successful resale of salvaged building components. Unless materials can be marketed and sold in a short time, it is virtually impossible for deconstruction to be profitable. For this reason, consumer tastes and perceptions about the use of recovered and recycled building materials represent a barrier to deconstruction. Architects and landscape architects have a potential influence for the use of UBMs in new construction. While architects tend to be more open to the use of used and recycled materials, builders and their subcontractors do not seem to easily accept them. The prevailing attitude of consumers/clients remains that reused and recycled building materials are environmentally friendly but substandard. According to many architects and builders, they would use more used and recycled products if their clients requested them to do so.

2.1.2 Feasibility of Building Deconstruction

There are different factors that influence the feasibility of building deconstruction. These factors represent both the opportunities and the barriers to deconstruction. According to Macozoma (2001a), the factors that influence the feasibility of deconstruction include the availability of buildings to be deconstructed, the physical conditions of the buildings, local construction activity and practice, the local economy, secondary markets, prevailing policy, labour issues, environmental concerns, tipping fees, time constrains, government support, prevailing codes and specifications, environmental concern, and public perceptions of secondary materials.

Furthermore, Macozoma (2001a) states that feasibility of deconstruction can be assessed with these aspects:

- Deconstruction can be incorporated into strategies to minimize waste from the construction industry.
- Deconstruction can be used in urban renewal plans to rehabilitate dilapidated.
- Deconstruction can be used as a community economic regeneration tool to create employment and business development opportunities using local resources and circulating the money with in the community.

Guy (2001) states that key factors in the feasibility of deconstruction are allowable time to deconstruct, labor costs, local disposal costs, and salvage valve of the building materials. Other factors include labor scheduling, tipping fees at C&D waste landfills, hazardous characteristics of demolition waste, markets, materials grading systems, time and economic constrains, contractual agreements, and public policies.

According to Chini and Nyugen (2003), factors that affect the deconstruction feasibility include building selection, operation, industry and regulatory agencies. For building selection, important issues are location of the building, site conditions, construction type, building's integrity, components' condition, scale of project, and age of building. For operation, significant factors include invasive inspection for hazardous materials, building inventory assessment, processing and flow of materials, combination of manual and mechanical deconstruction.

The factors that influence the feasibility of deconstruction can be summarized in three subtitles namely physical factors, economical factors and environmental factors. These are explained in the following sections.

2.1.2.1 Physical factors

According to Macozoma (2001a), physical factors that influence the feasibility of deconstruction include available building stock and building condition. These are explained in the following.

a) Building Stock

Building stock depends on the availability of buildings that will constitute the feedstock for the industry. Also, the amount of deconstructable buildings is significant for deconstruction. Practices. Building types can be variable depending on local, regional and national characteristics. Furthermore, buildings can vary according to their function such as residential, commercial or industrial. Buildings can be disassembled using structural and/ or non-structural deconstruction. A decision between the two types of deconstruction is determined by the physical condition of the building and the cost-benefit analysis of each option. (Macozoma, 2001a).

b) Building Condition

The physical conditions of a building that influence its feasibility include building type, building status, building location, neighborhood context, building physical condition, building materials and property access. Table 2.1 shows the issues related to building conditions for residential buildings (Macozoma, 2001a).

Table 2.1 A summary of the issues related to building conditions for residential buildings

Building condition	Description
Building type	High-rise multi-family, low-rise multi-family, attached (row) housing, semi-detached, single dwellings
Building status	Condemned, abandoned, for sale, under renovation
Building location	High density residential area, residential suburb, inner city
Neighborhood context	High or low income area, high or low crime rate, old or new neighborhood, derelict neighborhood
Building physical condition	Structurally unsafe, fire damaged, gutted, overgrown, water damaged, weathered, vandalized
Building materials	Timber, concrete, steel, aluminium, brick, gypsum etc.
Property access	Site access, mobility

Source: Macozoma, 2001a: p.30-31.

Concrete and steel structures are usually not suitable for structural building deconstruction. However, after mechanical demolition, the concrete and scrap steel can be recovered for recycling brick buildings can be structurally deconstructed. Timber structures are by far the most attractive and suitable buildings for structural deconstruction due to the quality and reusability of the salvaged materials (Macozoma, 2001a).

2.1.2.2 Economic Factors

The economic potential of building deconstruction depends mainly on the relationship between the availability of buildings with recoverable materials and the market demand for salvaged materials. Some of the factors that influence this relationship include the local economy and construction activity in the region, the salvaged materials infrastructure, government programmes and incentives (Macozoma, 2001a).

Guy (2001) states that a price competitive with demolition and accounting for revenues from resale of recovered materials. Guy (2001) developed economic equations for demolition and deconstruction to estimate the net income for the work. These economic equations for demolition and deconstruction are given below.

The net income for deconstruction is:
(Price Paid by Owner + Salvage Value) - (Pre-Deconstruction + Deconstruction + Processing + (Transportation + Disposal)) = Net Income

The net income for demolition is:
(Price Paid By Owner) - (Pre-Demolition + Demolition + (Transportation + Disposal)) = Net Income

According to these equations, it can be interpreted that deconstruction is economically feasible if properly managed. The feasibility of deconstruction is dependent heavily on the salvage value and reduced disposal costs. For deconstruction to be economically feasible, salvage value and revenue from resale of recovered materials is very important and comprises large part of the income. Furthermore, a greater opportunity is savings in transportation and disposal costs. The net income from deconstruction can be increased by carefully salvaging more material with the least damage, so amount of waste material is reduced while increasing reuse and recycling potential of salvaged materials.

According to Lassandro (2003), the economic definition of an intervention aimed to recycle and reuse materials and components can be dependent on the following:

- costs of different possible demolitions (such as controlled or selective demolition, deconstruction, cherry-picking of materials)
- costs for transportation of C&D waste

- waste disposal fees and waste treatment centers' fees
- eco-taxes
- costs for treatment of C&D waste in the construction site
- incomes from reuse of recovered materials

All these costs depend on the context characteristics such as the presence of local qualified companies specialized in controlled and selective demolition and appropriately equipped laser systems, special diamond blades, and water-demolition techniques etc. Furthermore, deconstruction is a labour intensive activity, so it requires more working hours, specific skill and safety measures for workers compared to demolition. These aspects mean an increase in costs; however, if properly managed, these are covered with the resale of salvaged materials (Lassandro, 2003).

2.1.2.3 Environmental Factors

In addition to physical and economic issues, some environmental indicators should be taken into consideration. Lassandro (2003) points out environmental considerations that influence deconstruction feasibility include:

- load of the C&D on the environment
- consumption/ safeguard of the natural resources
- availability of raw materials
- availability of secondary raw materials
- impacts connected with the transport of C&D waste materials in terms of consumption and harmful emissions
- acoustic impacts and pollution from dust associated with the different solutions of demolition.

2.1.2.4 Market for Used Building Materials

The success of building deconstruction is dependent on the supply and demand of salvaged materials. For this reason, there is a need for both a supply of secondary materials and end markets to ensure their rapid distribution. According to Macozoma (2001a), if deconstruction is taken place in an area, where a significant amount of building stock should be identified for demolition. In many cases, there are problems with the storage space for salvaged materials, and with the location of end markets to avoid additional costs for transportation. Therefore, there is a need for investment promoting the establishment of secondary material businesses such as used building material stores, recycling companies that divert salvaged waste into secondary materials, and product manufacturers that use secondary feedstock.

2.1.3 Building Deconstruction Process

The demolition contractor has to consider some issues in more detail while using the technique of deconstruction for the building removal, because it is different from the traditional demolition process. Although the specific methodology followed by the deconstruction crew can be variable, this section provides an outline of the deconstruction process. The issues that comprise the elements of building deconstruction can be grouped as: permitting, building material inventory, environmental site assessment, planning for deconstruction, site security, field safety, labour, scheduling, field organization, building disassembly, tools, techniques and methods, processing and materials handling, and site cleaning (Abdullah and Anumba, 2003; Kibert and Languell, 2000; and Macozoma, 2001a).

Abdullah and Anumba (2003) assume demolition is general name of building removal process. Therefore, they state that there is no difference between the processes of deconstruction and demolition except from actual demolition stage. The demolition process can be divided into four main stages: tendering stage, pre-demolition stage, actual demolition stage, and post-demolition stage. These stages are schematized in Figure 2.1.

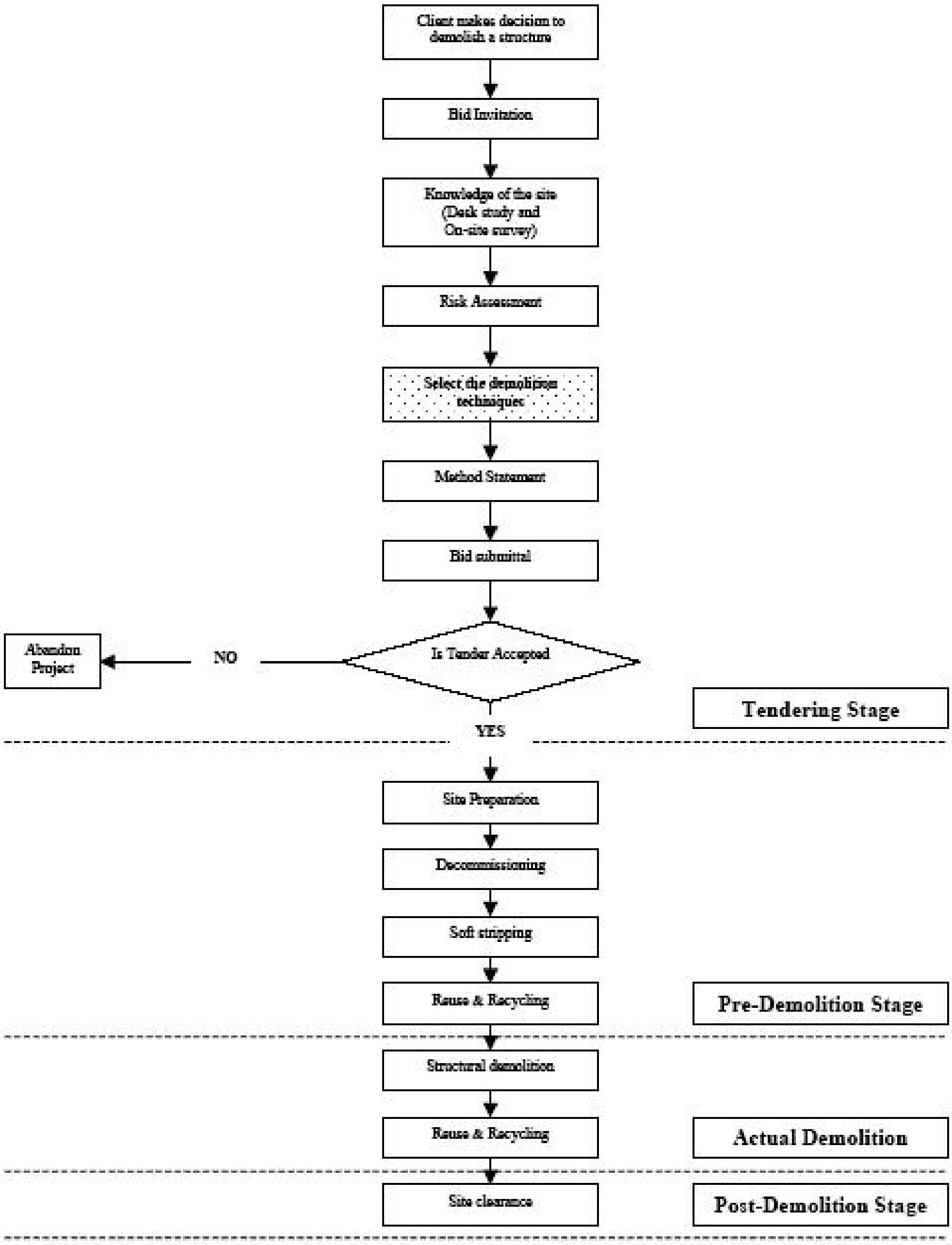

Figure 2.1 Flowchart for the demolition process

(Abdullah and Anumba, 2003: p.57)

2.1.3.1 Permitting

Prior to beginning any processes with the building, it is important to investigate any permitting issues related to the deconstruction process, which are specific to the region. Local building jurisdictions usually require demolition permits or formal notification of intent to remove a building (Kibert and Languell, 2000). Approval of the demolition permit is often followed by the satisfaction of the following requirements (Kibert and Languell, 2000; and Macozoma, 2001a):

- the disconnection of electrical power
- the capping of all gas and sewer lines
- the abatement of asbestos, lead and other hazardous substances
- pre payment for site inspection by building authority.

Permitting is the first step in building deconstruction to obtain a permit for demolition or deconstruction; however, some local jurisdictions necessitate the third requirement about the abatement of hazardous substances. In this case, it can be possible to obtain a permit for the building removal only after building inventory process (Macozoma, 2001a).

Kibert and Languell (2000) also note that in many regions, where deconstruction is not an established or well-known practice, there will be no difference between the procedure required to get a permit for demolition and deconstruction.

2.1.3.2 Building Material Inventory

The building inventory is used to determine the extent to which a building can be deconstructed manually (Macozoma, 2001a). While assessing the feasibility of deconstruction for a building or a structure, the first and most important step is a detailed inventory of how and what the building is made (NAHBRC, 1997).

According to Chini and Bruening (2003), in the deconstruction planning process, the first decision to be made is whether the building is a good candidate for deconstruction, because every building may not be in the right physical condition or has right components to be deconstructed for material salvage. The decision for deconstruction can be made according to a detailed building inventory. The detailed inventory is intended to identify the cost effectiveness of the work. The inventory helps to identify construction methods and fasteners of the components, and hazardous materials.

Macozoma (2001a) states that the site assessment can be performed in two forms. The first is through visual assessment that is known as non-invasive inspection of the building. The other is an invasive inspection to assess the hidden layers of the building. This inspection intended to identify each type of material used in the building, its condition, its assembly to the structure and the way of its easy removal.

Referring to NAHBRC (2000), Chini and Bruening (2003) summarize the favourable characteristics of highly deconstructable buildings:

1. Wood framed buildings using heavy timbers and unique woods such as Dougles fir, American chestnut, and old growth southern yellow pine.
2. Buildings that are constructed using high value specially items such as hardwood, flooring, architectural moldings, and unique doors or electrical fixtures.
3. Buildings constructed with high-quality brick and low-quality mortar. These will be easy to break-up and clean.
4. Buildings that are generally structurally sound and weather tight. These buildings will have less rotted and decayed materials.

In addition, Kibert and Languell (2000) state that there are some indicators that can be used in determining whether a structure is suitable for deconstruction. These are:

- brick buildings built before 1933
- structures with old-growth or rare wood species
- interesting or high-quality architectural features
- hardwood floors
- large timbers
- large quantities of unpainted wood.

Kibert and Languell (2000) also note that some other factors used to assess the extent to which a building can be deconstructed include:

- age of structure
- type and condition of materials in the structure
- methods of construction, which will impact the ease or difficulty to recover materials
- availability of recycling options for materials that cannot be reused.

While conducting the building inventory, the deconstructor not only gets an idea of how to disassemble the structure, but also determines the possibility of making a profit. The more detailed the building inventory is, the more accurate the estimation for building deconstruction can be. Such an assessment should include items such as number of windows and doors, the type and square footage of flooring, and any other distinctive features (Kibert and Languell, 2000). This initial building inventory process is followed by the environmental assessment process.

2.1.3.3 Environmental Site Assessment

Environmental site assessment is intended to determine the amount of hazardous substances. Building and environmental regulations require the identification and abatement of hazardous materials before starting the building removal process. The main hazardous materials that create problems in the building removal process are mainly asbestos and lead (Macozoma, 2001a). Other hazardous wastes include fluorescent tube, mercury-containing waste, and latex paint (Abdullah and Anumba, 2003). There are also other potential problems including underground fuel tanks, electrical transformers and PCB certainty materials. The environmental site assessment must be conducted by individuals with construction experience and basic training on hazardous substance identification (Macozoma, 2001a).

According to Kibert and Languell (2000), proper handling of hazardous materials brings about additional cost in the building removal process. Because of these additional costs, deconstructors usually look for a way proper handling of hazardous substances. Some materials contaminated with lead-based paint (LBP) or chemicals that prevent wood from rotting can be handled by the demolition/deconstruction contractor, while abatement of asbestos-containing materials must be handled by a licensed asbestos abatement contractor. The property contractor is responsible for making a reasonable investigation to identify hazardous substances on the site before demolition or deconstruction. This would include a visual non-invasive inspection of the site and structure by an individual trained in environmental assessment. If any hazard is identified, further investigation is necessary, i.e. collection of sample for asbestos content test. This further inspection is known as invasive inspection.

a) Asbestos-Containing Materials (ACMs)

Asbestos-containing materials is assumed to be used in buildings prior to 1981 (NAHBRC, 2001). In the past, asbestos has been extensively used in buildings. ACMs are more likely to be disturbed by building removal process, and this comprises a health hazard. There are two main types of asbestos: friable and non-friable. Friable asbestos is easily crumbled or crumpled by hand pressure, and if disturbed, it can easily be suspended in air and create a health hazard. Non-friable asbestos is not easily reduced to dust, and so if disturbed, it does not cause a problem. However, over many years previously non-friable asbestos can become friable and present health hazard (Macozoma, 2001a).

Demolition activity tends to disturb buildings leading to high level of dust that contains airborne particles including asbestos. Deconstruction activity has two aspects related to asbestos. Since deconstruction involves a through building inventory, it may uncover previously unnoticed ACM and help diminish the risk of worker exposure. Unless asbestos-containing material is determined in the building inventory process, this can cause workers to be close contact with ACM due to labour intensity deconstruction. In this context, deconstruction requires more attention on environmental and health and safety precautions compared to demolition (Macozoma, 2001a; and NAHBRC, 1997).

According to NAHB Research Center report (1997), there is no definite method to determine the presence or absence of ACM in the field. Experienced abatement contractors can identify which materials are suspect. However, the presence and amount of asbestos content can only be identified by certified laboratories by using polarized light microscopy.

According to Sherman (1998), asbestos may be found in pipe, dirt, wall and ceiling insulation, ceiling tiles, roofing, siding, vinyl sheet flooring, wallboard and mudpoint compound, plaster, window caulking and finishing. Removal of ACM in a proper manner requires special equipment and training. Therefore, before deconstructing any building, it is required to consult a licensed, professional abatement firm to handle asbestos.

b) Lead-Based Paint (LBP)

Lead-based paint can be defined as paint that contains more than 0.06 percent lead. It was often used for exterior applications and commonly found on older windows and doors. The paint was also used for interior applications of buildings constructed prior to 1950 (NAHBRC, 2001).

Toxic effects of elevated levels of lead can affect the human blood system. Nearly one million children were affected in the United States. The reason for lead poisoning is attributed to the deterioration of lead-based paint and lead-contaminated soil. Furthermore, the presence of lead-based paint negatively affects the feasibility of deconstruction. These effects include increased investments in worker safety, extra time for the removal of LBP, a decreased supply of recoverable materials, and increased costs for disposal of materials contaminated with lead-based paint (NAHBRC, 2001).

There are different tests to assess the building to be deconstructed for presence or absence of lead content. LBP and lead content in buildings can be determined by using the following methods (NAHBRC, 1997):

- LBP Test Sticks – the sticks are used in the initial determination of lead content in the field. Affirmative results suggest a need for a more detailed analysis while negative results are not accepted as conclusive evidence of lead absence.
- X-ray Fluorescence and Atomic Absorption Spectroscopy – these tests determine the percentage concentration of lead in paint or other coatings.
- Toxicity Characteristic Leaching Procedure (TCLP) – this determines the lead leaching potential of mixed C&D debris. It helps classify C&D waste as hazardous or non-hazardous.

- Air-Monitoring – this method assesses the concentration of lead in the air to determine worker exposure.

Appendix A provides a detailed description of asbestos and lead abatement, adopted directly from the NAHB Research Center Report (1997) and Kibert and Languell, (2000).

2.1.3.4 Planning for Deconstruction

According to the results of the building inventory and environmental site assessment, the deconstructor can decide on whether deconstruction is a suitable technique for removal of the building. The outcomes of the assessments can give the deconstructor an idea of the amount of recoverable building components and materials depending on their type, condition, assembly technique, and ease of recovery. This information will help in deciding on the type of deconstruction to be conducted. It will also be useful in estimating costs and revenues from the project (Macozoma, 2001a).

According to Abdullah and Anumba (2003), the demolition contractors are invited to bid for the job. The contractor has to find out about the site by doing desk study and an on-site survey. Then a risk assessment plan is prepared, which identifies the risks associated with the work and planning the removal or reduction of the risks. The main part of the deconstruction process is the selection of the most appropriate demolition techniques. Demolition contractors are generally faced with decision problems in the selection of demolition techniques. They make judgments depending on their skills, knowledge on the techniques, and past experience. The next step is to develop a method statement, addressing the site's particular requirements (i.e. site preparation), and detailing the planned sequences and techniques of demolition. After that the demolition contractor prepares the tender document with the method statement and submits to the client. If the client accepts the tender, the contractor will continue with the next step. If the client does not accept the tender, the contractor has to abandon the project.

2.1.3.5 Site Security

Security of a deconstruction site is intended to protect the workers as well as the general public. Furthermore, deconstruction requires the protection of salvaged components and materials on the site during the deconstruction process. Recovered materials are stored and, if possible, processed on the site to ensure good quality for resale purposes. These materials can be realized and become susceptible to theft. For this reason, it is necessary to take simple security measures that include the erection of a perimeter fence with a lockable gate, lockable storage areas, and the monitoring of the staff upon entry and exit of the site to protect the salvaged materials from being smuggled. Other items such as electrical equipments and tools should also be kept in lockable storage areas (Macozoma, 2001a; and Kibert and Languell, 2000).

2.1.3.6 Field Safety

Field safety means the protection of workers from potential operational hazards. Building deconstruction involves the disassembly of both structural and non-structural elements. While stripping structural components, the workers should take attention to critical building supports and ensure to prevent structural collapse at all times (NAHBRC, 1997).

Furthermore, workers usually need protection from falling while working in elevated parts of the structure, protection from falling objects in the building, protection from fire and the collapse of the whole structure (Macozoma, 2001a). Kibert and Languell (2000) claim that partial protection can be provided the workers with work boots, long pants, shirts, safety glasses, hard hats, and gloves. Debris generated on work site should be cleaned up after each phase of deconstruction. Piles of debris should not be kept in work areas where they can cause a hazard or impediment to the workers.

2.1.3.7 Labour

Since building deconstruction is a labour intensive activity, it is necessary to give special attention to labour issues, as well as the aspects of occupational health and safety. The workers should be protected from physical and environmental hazards through the use of protective equipment, provision should be provided for compensation in the case of an accident, and workers should be paid according to current wage rates (Macozoma, 2001a).

a) Insurance

The issue of worker insurance should be given importance in case of a work related accident on the deconstruction site. Kibert and Languell (2000) state that deconstruction firms have to provide general liability insurance for the project. They also need to provide worker compensation insurance due to the level of risk for their workers activities.

b) Training

Since deconstruction is reverse order of construction, deconstruction workers will need basic construction training/ knowledge. All workers have to be familiar with the use of tools, material handling and basic safety requirements. They also need to undergo lead awareness training to be able to remove building components coated with lead-based paint. Finally, they have to be aware of asbestos and asbestos-containing materials, although asbestos is considered a specialized activity and responsibility of professional abatement contractor (Macozoma, 2001a).

c) Wages

The department of labour determines the wage rates for construction activities such as new construction, alteration, repair including painting and decorating, remodeling and demolition. Deconstruction is not counted in this list, because it does not present in the activities of construction industry. For determining wage rates for deconstruction, it can be made use of prevailing wage rates of construction and demolition. Influence factors of deconstruction wages can include the level of worker skill, the type of tasks performed, and the value of recovered materials (Macozoma, 2001a).

2.1.3.8 Scheduling

In almost all cases, deconstruction requires significantly more time than demolition, because it involves carefully dismantling, sorting, processing and storing of building components and materials as well as structural demolition. These tasks usually are done in very limited time upon the desire of the construction contractor/ property owner. Time is very important and it means money for a property owner with redevelopment plans after building removal (Kibert and Languell, 2000; and NAHBRC, 1997).

2.1.3.9 Field Organization

The first process in the pre-demolition stage is site preparation. In this stage, it may be required to erect security fencing, and welfare facilities such as site office, washing facilities and toilet (Abdullah and Anumba, 2003). For a proper deconstruction activity, there is a need for some areas such as parking, de-nailing, processing, loading areas and dumpster locations. It is important to note that every deconstruction site will differ in space allocation. Figure 2.2 is an example of the use of site and shows how a site could be set up for the intended deconstruction work.

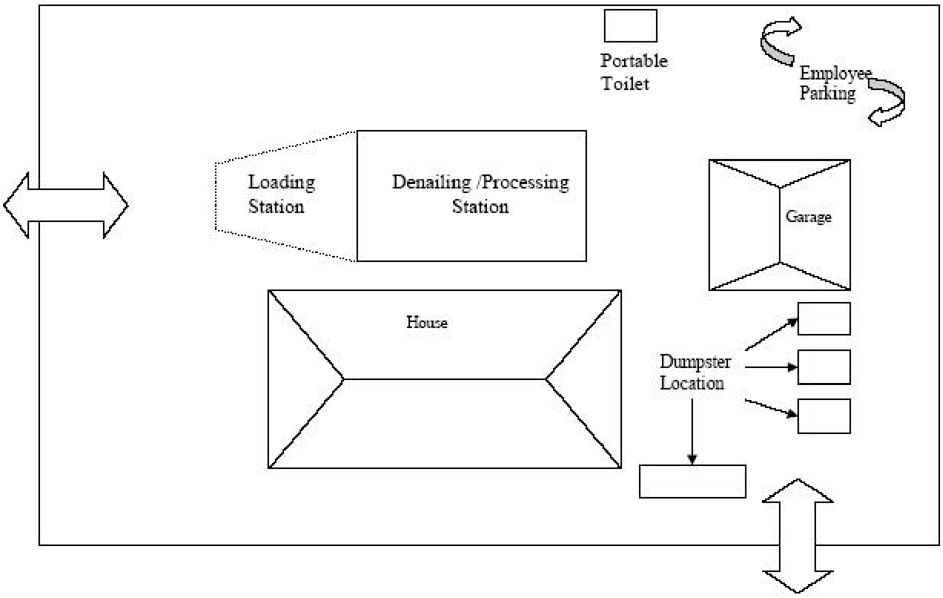

Figure 2.2 An example of deconstruction field organization
(Kibert and Languell, 2000: p. 74)

It should be predetermined what to do with a salvaged material removed from the structure. Most materials fall into three main categories: immediate reuse, process further, and dispose of. For this reason, it is important to have the storage space, processing space, and dumpsters close to the structure. Since recovered materials are taken to the processing space, it should be placed between the storage and dumpster areas. If the material is not cost effective to further salvage, it can be put into the dumpster. If the material has a reusable potential, so it is put into the storage area then to be processed (Kibert Languell, 2000).

2.1.3.10 Building Deconstruction

Demolition contractors use a variety of methods to lower disposal costs and achieve profit with building deconstruction. There two basic types of deconstruction that provide the supply of salvaged materials, structural and non-structural deconstruction. Non-structural deconstruction is also known as 'soft-stripping' or 'high-grading'. It involves few tools, typical job-site safety considerations, and in a time of hours or days. On the other hand, structural deconstruction can be accomplished with a range of tools, mechanization, heightened safety considerations, and in a time of days or weeks (NAHBRC, 2001).

Table 2.2 below, which has been taken from NAHBRC (2001), shows definitions, characteristics and types of materials salvaged through structural and non-structural deconstruction processes. Non-structural deconstruction has both high-end and low-end markets. High-end markets include architectural antiques and salvage, including custom-made cabinetry and rare items. Low-end markets include materials that are commonly used for maintenance and replacement purposes.

Structural deconstruction is more affected by time constraints than non-structural one. Non-structural deconstruction often occurs prior to demolition, and generally prior to the demolition permit. Structural deconstruction is often performed as a supplement to mechanical demolition, so it is heavily dependent on the demolition permit. Structural deconstruction is mainly dependent on demolition activity, while non-structural deconstruction can be performed independently. Structural deconstruction always involves various mechanical demolition activities. Mechanical methods are also used to recover brick materials by pulling the exterior walls away from the structure. Structural deconstruction requires a greater skill level of workers than non-structural deconstruction (NAHBRC, 2001).

Table 2.2 Description of Structural and Non-Structural Deconstruction

Deconstruction Type	**Definition**	**Characteristics**	**Types of Materials Salvaged**
Non-structural	Non-structural deconstruction involves the removal for salvage/reuse of any building components or contents that are not a part of or whose removal is not dependent on the structural integrity of the building.	Usually light, can be salvaged relatively easily and with minimum safety concerns. Material can be viewed without much destructive access. Typically does not require support or bracing to salvage.	Finish flooring Appliances/mechanical Cabinetry Windows/doors Trim Fixtures/hardware Fireplace mantels
Structural	Structural deconstruction involves the removal for salvage/reuse of building components that are an integral part of the building or contribute to the structural integrity of the building.	Dissembling a structure to salvage the structural building components such as beams, joist, and brick. Materials are typically large, rough products that are to be reused as building materials or remanufactured into value added products such as chairs, tables, and surface coverings.	Framing Sheathing Roof systems Brick/Masonry Wood timbers/beams Wood rafters Floor joist system

Source: NAHBRC, 2001: p.6.

The process of deconstruction is simply reverse order of construction, that is, the material that was assembled last to the structure is the first to be dismantled and so on. In building disassembly, the first process is soft stripping. The soft stripping includes the removal of non-structural items such as fixtures and fittings, windows, doors, frames, suspended ceilings and partitions, some of which can be reused and recycled (Abdullah and Anumba, 2003). Throughout the stripping process, it is important to keep structural integrity to prevent the structure from collapsing. During the stripping of the structural components, it will be better to erect scaffolding to ensure stability, worker access, mobility and safety. Some building components may need supporting to maintain rigidity. Furthermore, elevated building components can be brought down to ground level for stripping, if possible, because it is easier, safer and faster to work on the ground (Macozoma, 2001a). Table 2.2 below gives a typical sequence for the disassembly of building components. In the table, the first column shows item numbers. Building components are grouped in five as fixtures, roof, walls, floor and other components and presented in the second column. The last column lists removal sequence, types and tools of the named components.

Table 2.3 A typical sequence for building disassembly

Item	Component	Comments
1	Fixtures	-Typical fixtures that are removed include doors, windows, shelving, cabinets, appliances, HVAC systems, wiring, water heaters, boilers etc. -Stripping typically by hand tools -The materials are stored indoors e.g. warehouse
2	Roof	-Typical roof material includes sheeting, rafters, truss system, chimney top, ceiling joists, gypsum board, gutters etc. -Stripping typically by hand tools -Useful materials go to processing and the rest is stored in dumpsters and recycling containers
3	Walls	-Typical wall components include exterior wall, interior wall, framing material, chimney, tiles etc. -Typical materials include timber, brick, gypsum drywall, steel etc. -Stripping typically by a combination of hand tools and mechanical equipment -Useful materials go to processing and the rest is stored in dumpsters and recycling containers
4	Floor	-Typical components inc1ude floor finishing e.g. tiles and carpeting, and floor layers e.g. floor bed and foundation. Typical materials inc1ude timber, concrete, ceramics etc. -Depending on the floor material, stripping can be done by hand tools or mechanical equipment -Useful materials go to processing and the rest is stored in dumpsters and recyc1ing containers
5	Other	Special features such as stairs, basements, elevated floors, etc. should be given special attention with due consideration of site-specific conditions

Source: Macozoma, 2001a: p.19-20.

Chini and Bruening (2003) suggest a deconstruction sequence for a basic residential structure:

- cabinet removal
- light fixture removal
- window removal
- door removal
- floor coverings
- roof deconstruction
- wall deconstruction
- floor deconstruction

After each step in this process, all nails should be removed and the materials should be sorted, stacked, cleaned and carefully stored on the site.

2.1.3.11 Dismantling Tools, Techniques and Methods

Deconstruction practice can take a variety of forms. A building can be a good candidate for complete structural disassembly when majority of materials has potential for reuse. Not all deconstruction projects involve complete disassembly of the building. Deconstruction of a building can be performed using complete structural disassembly, non-structural disassembly, a small soft stripping, or an individual disassembly (Chini and Bruening, 2003).

Soft stripping involves the removal of specific building components before demolition. For example, a structurally weak building does not have much salvageable material, so only a few items may be desirable to recover. Good candidates for soft stripping include plumbing or electrical fixtures, appliances, HVAC equipment, cabinet, doors, windows, hardwood, and tile flooring (NAHBRC, 2000).

In the case of a building that may not be worth entirely deconstruction, particular deconstruction can be performed to dismantle certain assemblies within the building. For instance, the rafters in an old building are of high quality heavy timbers, so they represent a high salvage value. Other particular building assemblies to be dismantled include floor joists, wall framing members, and sheeting materials (NAHBRC, 2000).

Chini and Bruening (2003) state that an understanding of how materials are installed is of paramount significance to be able to uninstall them without damage. Having the proper tools and equipment helps to reduce material damage and make worker's job much easier.

Deconstruction tools are usually simple construction tools. They are intended to provide easy low-level skill building material disassembly and give minimal damage to salvaged materials. The tools represent the simplest form of deconstruction and enable deconstruction work to be performed at low cost (FORA Report, 1997).

Typical deconstruction tools include individual worker tools such as screw drivers, wire cutting pliers, de-nailers, hard hat; shared tools and equipment such as dumpsters, chutes, pallets and recycling containers. Depending on specific conditions of project, sometimes there may be a need for heavy-duty equipment such as cranes, waste disposal trucks, heavy-duty trucks etc. (FORA Report, 1997).

Appendix B contains further information on typical tools that are used by deconstruction workers, adopted directly from FORA (1997).

2.1.3.12 Processing and Materials Handling

Macozoma (2001a) states that removal of a material from structure should be coordinated with processing and storage of materials to avoid pile-ups, blockages, double handling and potential hazards on site. The site layout should enable the stripping and processing of different types of materials in separate areas without conflict. Customers are willing to buy salvaged materials provided they have been accurately sized, stacked, cleaned, trimmed to remove defective parts, and stored in a manner that prevents further damage. Table 2.4 below gives information about processing and handling used building materials. Typical building components are listed in the first column while their market in column two. In subsequent two columns some advice on their processing and storage method is listed.

Table 2.4 Processing and handling used building materials

Component	Typical Market	Processing	Storage
Fixtures	Timber e.g. doors Metal e.g. window frame, wiring Ceramics	Cleaning and packing	Indoors
Roof	Timber e.g. rafters, truss Asphalt e.g. roof tiles Metal e.g. sheeting, gutters Gypsum e.g. ceiling board	De-nailing, sizing, stacking	Indoors - timber stored in stacked bundles Outdoors - metals in recycling containers, gypsum and asphalt will either be stored in recycling containers or disposed in dumpsters depending on the economics and markets
Walls	Timber e.g. framing, exterior walls Bricks e.g. exterior walls, interior walls, chimneys Gypsum drywall e.g. interior walls	De-nailing, sizing, stacking Cleaning	Indoors - timber stored in stacked bundles Outdoors - bricks stored in stacked piles, gypsum will either be stored in recycling containers or disposed in dumpsters, depending on the economics and markets
Floor	Timber - floor Concrete - floor Ceramics - finishing	De-nailing, sizing, stacking Crushing Cleaning	Indoors - timber stored in stacked bundles Outdoors - Concrete stockpiled for recycling and ceramics stored in recycling containers or disposed in dumpsters

Source: Macozoma, 2001a: p. 20-21.

2.1.3.13 Demolition Works

The actual demolition starts with demolishing the structural elements. There are three main types of structural demolitions: progressive demolition, deliberate collapse mechanisms, and deconstruction. The contractor decides one of the three alternative techniques in the tendering stage (Abdullah and Anumba, 2003). These techniques are briefly explained in the following.

a) Progressive Demolition

Progressive demolition is 'the controlled removal of sections of the structure while retaining the stability of the remainder, and avoiding collapse of all or part of the structure to be demolished'. Progressive demolition is particularly practical in confined and restricted areas. The progressive demolition is performed by hand, including hand tools such as an impact hammer, diamond disc cutter, and wire saw; by machine, including excavator attached with boom and hydraulic attachments, such as pulverisers, crushers, and shears; and by balling, involving the use of an iron ball that is suspended from a lifting appliance and then released to impact the structure repeatedly in the same or different locations (Abdullah and Anumba, 2003).

b) Deliberate Collapse Mechanisms

Demolition by deliberate collapse is 'the removal of key structural members to cause complete collapse of all or part of a building or structure'. This type of demolition is usually performed on detached, isolated, fairly level sites to demolish the whole structure. The demolition includes deliberate collapse by explosive and deliberate collapse by wire rope pulling. During the demolition it is important that a sufficient space be allocated to enable removal of equipment, and to keep workers at a safe distance. (Abdullah and Anumba, 2003).

c) Deconstruction

The technique of deconstruction can be used as part of renovation or modification work and to prepare the way for deliberate collapse. The deconstruction can be done by hand, machines, bursting, or hot cutting. It is possible to separate demolition debris with the current technologies, such as hydraulic excavators attached with pulverizers, concrete crushing, and screening machines. This process can both maximize the use of resalable materials and reduce waste produced, and accordingly waste disposal costs (Abdullah and Anumba, 2003).

2.1.3.14 Site Clearance

The final process of building deconstruction is the site clearance. The site should be left in a safe and secure condition. Any pits, sump, trenches, or voids must be left filled and securely covered, and the site drainage system must be thoroughly cleaned and tested to ensure that it continues to operate. All contaminants must be left or removed in a manner causing no hazard to health or the environment (Abdullah and Anumba, 2003).

2.2 Used Building Materials

According to Kim and Rigdon (1998), reuse of materials is a combination of four different aspects: technical, environmental, economic and regulatory. Although almost every material is disassembled with the current techniques, there are important points that define the deconstruction activity, i.e. feasibility, reduction of environmental impact, market demand for salvaged materials, in turn reuse and recycling of recovered materials. Reuse and recycling depends not only on effective recovery strategies and markets for recovered materials, but on the availability of recovered materials as well.

Reusable materials are materials that do not require any treatment apart from cleaning. Recyclable materials are materials that may be used as raw material for the production of new materials (Erkelens, 2003). According to Kim and Rigdon (1998), there are three main categories of building components derived from resources. The first is reused materials that are reused after minimal processing. The second category includes recycled-content materials that are highly processed composites, usually containing a post-consumer-recycled feedstock held together by some form of binder. The last is byproduct-based-materials that employ minimally processed agricultural or industrial byproducts.

According to Crowther (2001), in order to achieve environmentally responsible construction, it is very crucial to minimize resource consumption, maximize their reuse and use renewable or recyclable resources. Furthermore, protecting the natural environment, creating a healthy, non-toxic environment and pursue quality in creating the built environment is of importance.

Abdullah and Anumba (2003) state that materials, such as wood from windows or door panels, can be reused as building lumber, landscape mulch, pulp chip, and fuel. The bricks can be cleaned and reused, but this is rarely done. Aluminium, stainless steel panels, and copper are the typical recycled metals. Architectural artifacts, such as sinks, doors, bathtubs, and used building materials, are almost always resold. Even the industrial process equipment can be marketed both domestically and internationally.

2.2.1 Management of Used Building Material

Elias-Özkan (2002) states that in Turkey, demolition teams generally perform selective dismantling and concentrate on recovering those materials from the structure which provide the highest profit such as boards, rafters, battens and joists, steel reinforcement, aluminum components, corrugated roofing sheets, roofing-tiles, iron grill-work, doors, fenestration, bathroom fittings and fixtures, pipes, built-in cupboards, kitchen cabinets and sinks. In the yards, there is no enough space to storage all recovered items. That a material does not have resalable potential on-site may be a deciding factor for dumping those that have a market value since such a material is considered bulky and does not provide a quick profit. Therefore, yard owners prefer storing those materials that provide a quick profit and occupy less space.

According to Macozoma (2001a), the resale of salvaged materials is expected to offset the main cost of deconstruction. Salvaged materials can save costs and generate revenue. There are three basic types of salvaged building materials: low value, good quality and high value materials. Producing high quality second-hand material is as important as finding end use markets for the salvaged materials.

There are several ways of handling recovered building materials. The owner can keep salvaged building materials for future reuse on the same site or on another project. This would save costs and reduce the need for new materials. If there is no need for them, the client can also donate the recovered materials to charity. Another option is to sell the salvaged materials and generate revenue. There are different approaches for marketing secondary building materials. These include direct marketing to retailers and end users, site sale and auction, using a broker, regional/ periodic auctions, and the Internet (Macozoma, 2001a).

Sherman (1998) suggests a number of reuse and recycling options for recovered materials if local and state regulations allow doing so. These options have been given in Table 2.5 below. If a material has a reusable potential, it should be reused after cleaning or de-nailig processes; otherwise, it is necessary to find ways to recycle it before deciding to dispose of.

Table 2.5 Recovered material recycling options

Recovered Material	**Recycling Options**
Asphalt	Recycle into new asphalt pavement or use as clean fill on or off site.
Brick	Clean for reuse or sell for crushing or chipping into landscaping material.
Drywall and plaster	Grind up for use as a soil amendment or kitty litter, or recycle as feedstock for new drywall.
Earth/soil	Incorporate into new asphalt pavement or use as clean fill.
Electrical fixtures	Reuse if unique; recycle metal components.
Glass	Recycle as aggregate.
Masonry and rubble	Reuse on other structures or use as clean fill.
Metal	Sell to a scrap metal dealer.
Plastics	Send to a plastics recycler.
Roof materials (asphaltic)	Recycle as aggregate in asphalt pavement
Vinyl	Reuse if removed intact or send to a recycler.
Wood	Reuse in other structures or recycle as raw material for engineered building products, landscaping mulch, compost, animal bedding, or boiler fuel

Source: Sherman, 1998: p.3.

Elias-Özkan (2002) suggests that demolition contractors and yard owners should get together and form a cooperative that can help members and buyers to easily maintain a catalogue of material available at each yard. Such a cooperative can make yards specialize in certain components or fixtures, and it is also responsible for collecting and distributing materials from the demolished structures. Furthermore, a web site can be established and the advertisement and purchase of second hand materials can be ensured on-line.

2.2.2 End-of-Life Scenarios

There are several end-of-life scenarios suggested by different researhers around the world for buildings, materials and components. These scenarios are explained in the following. The first scenario suggeted by Macozoma (2001b) consists of three level of reuse: building reuse, component reuse, and material reuse. If a building can be moved to a new location as a whole, large quantities of waste and energy can be saved. There are examples of building reuse as in the United States and Australia. If a building cannot be moved, the next option should be to adopt it for a different use. Adapting a building for a different use means both changing the shell of building and changing the interior of a building. This is mainly renovating a building by removing certain sections and putting in new ones, which depends highly on the flexibility of a building. A flexible building can allow the easy removal of unwanted building components without affecting the rest of the structure. Such renovations also give an opportunity for the reuse of salvaged components and materials.

Durmusevic (2002) identifies the end-of-life scenario, which widely accepted in product manufacturing industries, involves four levels of recycling hierarchy. From the first level, the most desirable, to the least level: reuse and remanufacture, recycling, burn and landfill. In this scenario, Durmusevic assumes reuse and remanufacture together as the first level. She notes that there are other options of burning and landfilling (non-reuse scenario), for materials that have no potential for reuse, remanufacture or recycling.

Industrial ecology identifies many ways to reduce the environmental impact of a product or service. Also, one of the major strategies proposes to alter the once-through cycle to increase the rates of recycling. The scenario of recycling is often called as end-of-life scenario (Crowther, 2001). There many possible end-of-life scenarios suggested by several writers for any given product or building.

Young (1995) discusses the ‘3Rs’ model: reuse, remanufacturing and recycling. Young expands the 3Rs model and suggests a new end-of-life scenario including maintenance. Reusing involves a product being simply reused more than once for its intended propose, i.e. a milk bottle being returned to the dairy to be refilled with milk. Remanufacturing involves the product being returned to the place of manufacture to be disassembled into its base component that, if still serviceable, are then reused in the manufacture of new products. Recycling involves the collection of products for separation into their base materials, which can be reused as a resource to replace new materials in the production process. Maintenance involves the repair and servicing of a product to extent its initial service life.

Young (1995) also points out that some of scenarios are more environmentally favourable than other scenarios. From the point of view of conserving energy during manufacturing, the reuse is preferable to manufacturing, while manufacturing is in turn preferable to recycling. This hierarchy is based on the energy costs of collecting, transporting and processing products. In general the least processing means the least energy and the least environmental burden.

Ayres and Ayres (1996) propose a scenario of reuse, repair, remanufacture and recycling. They use term of repair, which is somewhat different from maintenance identified by Young. Ayres and Ayres (1996) use the term of repair that describes the mending of a product for reuse elsewhere rather than mending product for continued using its original application.

Graedel and Allenby (1995) suggest the end-of-life scenario of maintenance, recycle subassemblies, recycle components, and recycle materials. In this scenario, the recycling of components and subassemblies might alternatively be called remanufacturing since it involves the same process of disassembling components for using in new products. Recognizing the environmental hierarchy of the scenarios, Graedel and Allenby (1995) note that maintenance is preferable to remanufacturing, which in turn is preferable to recycling.

Kibert and Chini (2000) propose an explicit waste management hierarchy including levels of landfilling, burning, composting, recycling, reuse and reduction. In this hierarchy the level of recycling is further broken down in to down-cycling, recycling and up-cycling, each of which is slightly more environmentally advantageous than the previous. The level of reuse is broken into the reuse of materials and the reuse of components or products as more advantageous. They also mention about the level of reduction, which is an important waste management strategy with environmental benefits.

Crowther (2001) mentions the dominant lifecycle of the built environment, also known as cradle to grave, given in Figure 2.3. By changing demolition phase in the cradle to grave chart with disassembly, he proposes the possible end-of-life scenarios for the built environment in Figure 2.4, which enhances the four end-of-life scenario of building reuse, component reuse, material reuse and material recycling.

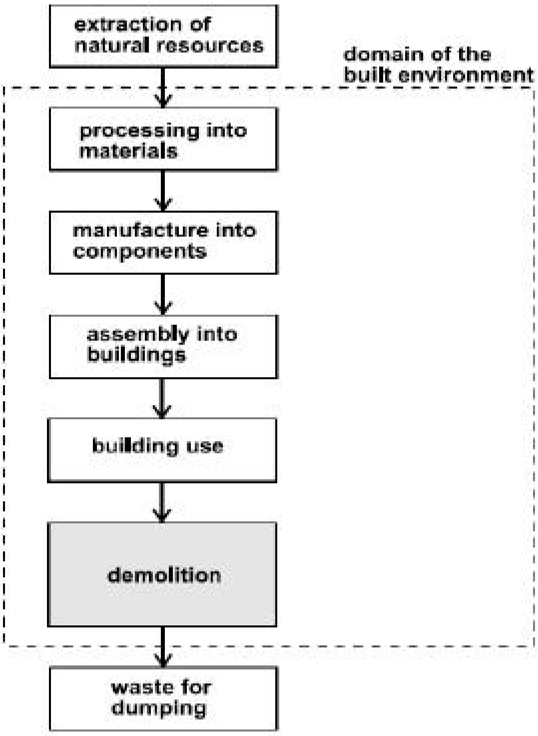

Figure 2.3 Dominant Life Cycle of the Built Environment (cradle to grave) (Crowther, 2003: p. 13)

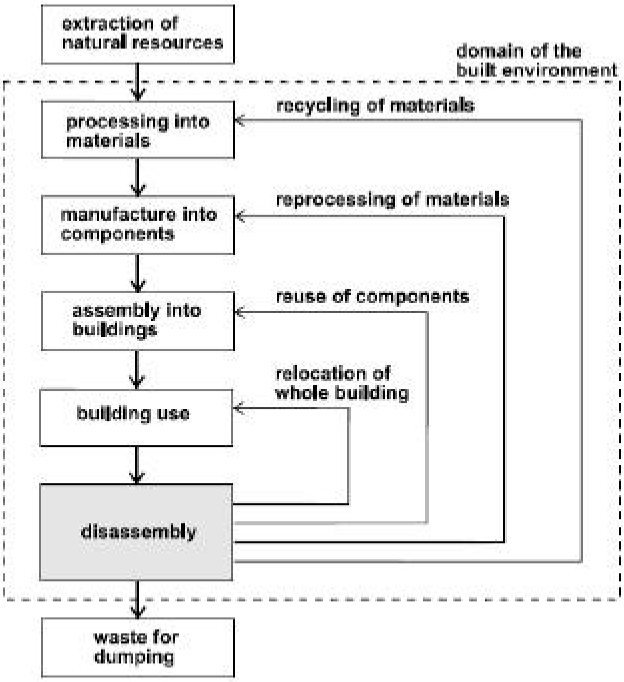

Figure 2.4 Possible End-of-life Scenarios for the Built Environment (Crowther, 2003: p. 18)

Crowther (2001) also points out levels of hierarchy of end-of-life scenarios suggested by different writers, and summarizes them in a table showing the most desirable scenario to the least one in Table 2.6.

Table 2.6 Levels of Hierarchy of End-of-life Scenarios

Reference	**Young (1995)**	**Ayres (1996)**	**Graedel (1995)**	**Magrab (1997)**	**Fletcher (2000)**	**Guequierre (1999)**	**Kibert & Chini (2000)**	**Crowther (2000)**
Most desirable ↑ End-of-life scenarios ↓ Least desirable					System level			Reuse building
	Reuse	Reuse		Reuse	Product level	Repair product	Reuse of product	Reuse product
	Maintain	Repair	Maintain		Product level	Repair product	Reuse of material	Reprocess material
	Remanufacture	Remanufacture	Recycle component	Remanufacture	Product level	Repair product		Reprocess material
	Recycle	Recycle	Recycle material	Recycle	Material level	Recycle material	Recycle	Recycle Material
							Compost	
				Burning		Burning	Burning	
				Landfill		Landfill	Landfill	

Source: Crowther, 2003: p. 17.

2.2.3 Market Demand

The biggest motivator for building deconstruction is market demand since it provides many opportunities for contractors. In order to offset the costs of deconstruction and make it profitable, marketability also increases the salvage value of materials. The nearer a main vehicular route or a center the site is, the greater the chance for public interest. In this context, the redistribution of salvaged materials increases, as well as the resale rate (Chini and Nyugen, 2003).

For deconstruction to be profitable, the recovered materials must be sold in order to cover and offset the additional costs of labour associated with salvaging materials. The estimation of materials to be recovered and the expected salvage values are crucial in determining whether a deconstruction project will be financially viable. Markets and uses for some materials are established, and therefore, easy to sell, such as large timbers, metals, concrete, fixtures, windows and doors. Two major issues need to be addressed for successful resale of these materials: cost and distribution (Kibert and Languell, 2000).

Selling materials from deconstruction can occurred either on-site, which is preferable, or off-site. By selling materials on-site, deconstruction firms save valuable time and money required to transport materials to another location. Selling materials on-site even before deconstruction begins, allows the deconstruction team to clear the site faster and collect sales revenue sooner. For materials that cannot be sold on-site, deconstructor should establish partnership with retail businesses like used building materials outlets and lumber yards. Therefore, the recovered materials can be transported off-site and sold to the public elsewhere (Kibert and Languell, 2000).

The success of secondary material markets depends on the demand for secondary materials and products. This success also relies on the ability of diverting waste materials from landfill sites in to the economy, and finding end markets for the secondary products made out of them (Macozoma, 2001b).

a) Internal Markets

Local for secondary building materials show a growth in the United States. This is proven by the increase in building deconstruction and material salvage activities. Many new businesses have been formed to use salvaged markets. For instance, Happy Harry's Used Building Materials has expanded into a multi-breach. Moreover, business and other institutions involved in the material salvaged area have formed partnership and alliance to lobby for increased waste material salvage and reuse in new construction, such as the Used Building Materials Association local markets; however, are not large enough to absorb all the secondary building materials feedstock that is in supply (Macozoma, 2001a).

Several companies in El Paso manufacture furniture out of recovered wood. They buy materials, with or without nails, directly from demolition sites. All types and sizes of used wood can be used as feedstock for the construction of furniture, including studs ranging in size from 2"x4" (approximately 5.08cm x 10.16cm) to 2"x12" (approximately 5.08cm x 30.48cm). These companies make large amount of revenues from the manufacture of furniture made from used wood (NAHBRC, 2001).

b) The Internet

The Internet has created an additional platform to obtain and sell used building materials. The majority of deconstruction-related businesses either has Internet access or is planning on Internet access in the near future. High-end materials are more likely to be sold over the Internet due to their unique characteristics or quality. The intense demand for high-end materials is increased due to an Internet-base national and international market for these materials. The increasing capacity for marketing and networking that the Internet creates an incentive for non-structural and structural deconstruction activities to meet the increasing demand for rare high-end markets. Low-end materials are more likely to be purchased at a local or regional level for property maintenance or renovation project. Low-end materials may not benefit from the Internet due to shipping and handling costs, but this can be avoided by using a local supplier (NAHBRC, 2001).

Elias-Özkan (2002) suggests that demolition contractors and yard owners should get together, form a cooperative and establish a web site, so the advertisement and resale of used building materials can be ensured on-line.

c) Export Markets

Export markets in border and port cities forms another market for the sale of used building materials. Small businesses that process and resell recovered materials could help support economic development in metropolitan areas. Non-profit organizations can ship donated used building materials to other countries for disaster relief efforts and rebuilding projects. Export markets provide a large consumer base for both high-end and low-end structural and non-structural materials (NAHBRC, 2001).

Export markets have some obstacles including high import tariffs and agreement limitations. Furthermore, environmental contamination issues may eventually threat the informal trade in used building materials, especially if the materials have a health hazard abroad. These obstacles usually seem to have a minor impact on the flow of used materials across the border (NAHBRC, 2001).

Export of used building materials is a strong market in Miami, where exporters form a major customer base. Several used building material markets sell about half of their material to exporters. Top selling items include windows, doors, iron bars, awnings, shutters, cabinets, toilets and sinks (NAHBRC, 2001).

Macozoma (2001b) states that the United States secondary material markets have been dominated by export markets compared to internal markets. Exporters have shipped secondary material feedstock to oversees countries. This is accepted the only solution because the local cannot absorb all secondary waste materials. Metals and paper are the most desired secondary materials exported to other countries. Other the US export materials that are small in comparison include plastic and glass secondary feedstock.

2.2.4 Buyers of Used Building Materials

Isik (2003) states that the main reason for choosing used building materials for new structures in Turkey is financial concerns rather than environmental benefits, since the price of second hand material is three times cheaper than that of virgin one.

According to Özkan (2000), there are several types of customers of recovered building materials as well as used timber elements. The most frequent customers are squatters and rural dwellers from the villages near Ankara. The main reused timber materials are load bearing and partition timber members, fenestration, doors, windows, floor and façade coverings. Besides these, boards, rafters, battens and joists, rebar, iron grill-work balcony and staircase balustrades, zinc components, roofing tiles, bathroom fittings and fixtures, pipes, built-in cupboards, kitchen cabinets and sinks are also preferred used building materials. Some building construction contractors also prefer used timber elements for formwork, scaffolding and roofing structure of new buildings. The craftsmanship of timber elements used in old Turkish houses is very precious. These valuable ornamentations include wooden gates, timber column, exposed joist and beams, wardrobes and ceiling paneling from traditional houses. Interior decorators use them in decoration of hotels, pubs, restaurants or office buildings. On the other hand, Isik (2003) has added that another type of customer is merchant for used building material, who comes from southeastern and eastern Anatolia to buy truckloads of salvaged materials. His customers are not different from that in Ankara.

2.2.5 Market Perception of Used Building Materials

Within the ideas of design for deconstruction there is a distinction between design for reuse and design for recycling based on components and types of materials used in the building. Deconstruction implies a high degree of refinement in the separation of building components. If a building were completely deconstructed, it would result in materials and components down to the level of their original form before construction. It is not practical to the design for deconstruction approach at the whole building level, such as a window that may be obsolete by the time the building is deconstructed, and that may be undesirable for reuse as an exterior window (Guy, 2002).

Consumer perception of used building materials has a strong influence on the feasibility of deconstruction. These perceptions are influenced by local conditions (NAHBRC, 2001).

Appendix C contains further information on market perception of used material recovery and reuse, which covers both positive and negative perception of recovery and reuse, adopted directly from NAHBRC (2001).

2.3 Design for Disassembly

Design for deconstruction (DfD) means ‘the design of a building and its components with the intent to manage its end-of-life more efficiently’. The approach of DfD encourages designers to incorporate DfD principles at the design stage of construction project to ensure to efficiently conduct the stages of remodeling, repair and building removal. Taking design for deconstruction principles during the design stage into consideration can assure easy disassembly of components and materials for reuse and recycling. It also ensures the conducting of building removal process more efficiently. Therefore, this reduces waste generation, resource consumption and environmental impacts, and maximizes the recovery of higher value secondary building materials and components (Macozoma, 2002).

According to Pulaski, Hewitt, Horman and Guy (2004), DfD should consider the issues of the rapid removal of a building from the site, simplified access to components and materials, material recovery with high efficiency of reuse and recycling, and eliminating toxicity in building materials. By meeting these goals, DfD facilities a ‘closed-loop’ material recovery and reuse process.

The success of building disassembly depends on the ability and ease of building component and material recovery in good condition. Since many existing buildings were not designed to be taken apart, there are many difficulties with building disassembly and retrievability of building materials and components. This depends mainly on the design approach employed at the beginning of a construction project (Macozoma, 2001a).

2.3.1 The Need for Design for Disassembly

Generally, existing buildings containing so many useful materials are considered as a resource pool for future building material need. It is important that these materials be accessible for reuse after the building has completed its useful service life. When considering existing buildings as a future source of raw materials, design for disassembly is a key element in material retrievability. Other issues include material durability, desirability and longevity. In this scenario, materials must be durable if they are to be used over several service lives (Kibert and Languell, 2000).

According to Durmusevic (2003), design criteria for the design for disassembly will have an impact on each life cycle phase of the building. During the design phase, as one of the first phases of the building's life cycle, the greatest potential lies in its capacity to influence the building's features during all the life cycle phases. This capacity can affect the cost-effectiveness and high-performance of the building.

Crowther (2001) claims that one of the major hindrances to successful deconstruction is the difficulty in recovering building components and materials in good condition. In architecture, DfD is not widely understood and not widely practiced; and modern construction methods are very dependent on permanent fixing methods. This generally gives no other option but destructive demolition. If buildings were initially designed for deconstruction, it would be possible to salvage much more material for reuse. This would provide significant opportunities both economically and environmentally.

In the short term, DfD may add economic and environmental costs, while in the long term, there will be much greater benefits. If design systems, construction methods, and building component and materials are carefully selected, and guided by sustainable construction and DfD principles, it will ensure efficient building disassembly. Furthermore, taking DfD principles into consideration at the design stage will enhance the success of building deconstruction (Crowther, 2002).

2.3.2 Principles of Design for Disassembly

Crowther (2001) combined twenty-seven principles of design for deconstruction from various information sources and he summarized them as follows.

1. *Use recycled and recyclable materials* - to allow for all levels of the recycling hierarchy, increased use of recycled materials will also encourage industry and government to develop new technologies for recycling, and to create larger support networks and markets for future recycling.
2. *Minimize the number of different types of material* - this will simplify the process of sorting during disassembly, and reduce transport to different recycling locations, and result in greater quantities of each material.
3. *Avoid toxic and hazardous materials* - this will reduce the potential for contaminating materials that are being sorted for recycling, and will reduce the potential for health risks that might otherwise discourage disassembly.
4. *Make inseparable subassemblies from the same material* - in this way large amounts of one material will not be contaminated by a small amount of a foreign material that cannot be easily separated.
5. *Avoid secondary finishes to materials* - such coatings may contaminate the base material and make recycling difficult, where possible use materials that provide their own suitable finish or use mechanically separable finishes.

6. *Provide identification of material types* - many materials such as plastics are not easily identifiable and should be provided with a non-removable and non-contaminating identification mark to allow for future sorting, such a mark could provide information on material type, place and time or origin, structural capacity, toxic content, etc.

7. *Minimize the number of different types of components* - this will simplify the process of sorting and reduce the number of different disassembly procedures to be undertaken, it will also make recycling and reuse more attractive due to greater numbers of fewer components.

8. *Use mechanical not chemical connections* - this will allow the easy separation of components and materials without force, reduce contamination of materials, and reduce damage to components.

9. *Use an open building system not a closed one* - this will allow alterations in the building layout through relocation of component without significant modification.

10. *Use modular design* - use components and materials that are compatible with other systems both dimensionally and functionally.

11. *Design to use common tools and equipment, avoid specialist plant* - specialist technologies will make disassembly difficult to perform and a less attractive option, particularly for the user.

12. *Separate the structure from the cladding for parallel disassembly* - to allow for parallel disassembly such that some parts of the building may be removed without affecting other parts.

13. *Provide access to all parts and connection points* - ease of access will allow ease of disassembly, allow access for disassembly from within the building if possible.

14. *Make components sized to suit the means of handling* - allow for various handling operations during assembly, disassembly, transport, reprocessing, and re-assembly.

15. *Provide a means of handling and locating components during the assembly and disassembly procedure* - handling may require points of

attachment for lifting equipment as well as temporary supporting and locating devices.

16. *Provide realistic tolerances for assembly and disassembly* - the repeated assembly and disassembly process may require greater tolerance than for the manufacture process or for a one-off assembly process.

17. *Use a minimum number of connectors* - to allow for easy and quick disassembly and so that the disassembly procedure is not complex or difficult to understand.

18. *Use a minimum number of different types of connectors* - to allow for a more standardized process of assembly and disassembly without the need for numerous different tools and operations.

19. *Design joints and components to withstand repeated use* - to minimize damage and deformation of components and materials during repeated assembly and disassembly procedures.

20. *Allow for parallel disassembly* - so that components or materials can be removed without disrupting other components or materials, where this is not possible make the most reusable or ‘valuable’ parts of the building most accessible, to allow for maximum recovery of those components and materials that are most likely to be reused.

21. *Provide identification of component type* - in a co-ordinated way with material information and total building system information, ideally electronically readable to international standards.

22. *Use a standard structural grid for set outs* - the grid dimension and orientation should be related to the materials used such that structural spans are designed to make the most efficient use of material type and allow coordinated relocating of components such as cladding.

23. *Use prefabrication and mass production* - to reduce site work and allow greater control over component quality and conformity.

24. *Use lightweight materials and components* - this will make handling easier and quicker, thereby making disassembly and reuse a more attractive option.

25. *Identify points of disassembly* - so as not to be confused with other design features and to sustain knowledge on the component systems of the building.

26. *Provide spare parts and on site storage for during disassembly* - particularly for custom designed parts, both to replace broken or damaged components and to facilitate minor alterations to the building design

27. *Sustain all information of components and materials* - efforts should be made to retain and update information such as ‘as built’ drawings including all reuse and recycling potentials as an assets register.

Macozoma (2001a) propose building design principles that can be used as a guide when considering DfD in projects. These include:

- incorporate flexibility into the design (durability, adaptability and building layers)
- consider using modular design (standardization and prefabrication)
- consider preparing designs for the disassembly of the building
- design buildings that can be easily converted to a different use
- consider designing demountable buildings
- choose materials based on life cycle costs and salvageability.

2.3.3 Building Systems

Building systems are of importance for ease of deconstruction work. Crowther (2004) suggests as a DfD principle, the use of an open building system where parts of the building are more freely interchangeable and less unique to one application. This will allow alterations in the building layout through relocation of component without significant modification.

Some of the building systems currently in use can ensure easy and successful disassembly. These systems are given below.

a) Open buildings

Open buildings (permanent core buildings) are designed according to the theory of building layers. This approach is intended to extend the functional lifespan of buildings and simplifies the building modification process (Macozoma, 2002).

b) Modular buildings

Modular buildings use components and materials that are compatible with other systems both dimensionally and functionally. This type of modular co-ordination has assembly advantages, as well as disassembly advantages (Crowther, 2004).

According to Macozoma (2002), modular construction is characterized by the industrial mass production of standardized modular building components. Modularized buildings allow for user specific building configuration and being assembled on or off site. There are three types of modular buildings that are available in the market today are: portable buildings, on site assembly buildings, and demountable buildings. Modular buildings increase the feasibility of buildings by standardizing processes and materials, as well as allowing for large-scale mass production.

2.3.4 Materials and Components

Durmusevic and Van Lersel (2003) state that interdependence among components usually necessitates demolition and costly renovation of buildings. Most projects are focused on the assembly process only in order to construct them with more ease and speed. Furthermore, all building components are being put together in a manner to reduce construction cost and time without considering what happens after they are erected. Once the building is constructed, it starts to experience different phases in use. This requires maintenance, modifications and disassembly. These aspects are usually not taken into account at the design stage. 100% deconstructable structures can be ensured via an open hierarchical structure, specification of the base element, provision of assembly/disassembly plan, and design of demountable connections.

Materials and components that comprise buildings have different functions, different service life and different technical life cycles. Designers that do not seriously take this criterion into account produce fixed structures. These fixed structures cannot be easily reconfigured during the operational phase of the building, and they are difficult and expensive to disassemble (Durmusevic and Van Lersel, 2003).

Crowther (2004) states that there is a need to reduce complexity when designing for deconstruction. One of the ways to reduce complexity is to minimize the number of different types of components and materials. This will simplify the process of sorting and reduce the number of different disassembly procedures to be performed. This will also make reuse and recycling more attractive due to greater numbers of fewer components. Another way is to make components and materials of a size that suits the intended means of handling. This allows various handling operations during assembly, disassembly, transport, reprocessing and re-assembly. The other way is to use lightweight materials and components. This will make handling easier and quicker, in turn make disassembly and reuse a more attractive option.

The choice of materials can affect the generation of waste during construction and demolition activities. To ensure easy building disassembly, when selecting materials, their impacts on the natural environment and waste generation should be taken into consideration at the design stage of buildings (Poon and Jaillon, 2002). According to Kernan (2002), material selection should emphasize durability, maintenance, flexibility, and recycled content. Kernan (2002) also points out that when choosing materials, designers should prefer:

- durable, long-life materials
- multifunctional materials
- adaptable materials and components
- larger components rather than smaller ones
- simple components rather than assemblies.

When designing for deconstruction, care should be taken in the selection of building materials. It is advisable that material selection process be guided by the principles of sustainable construction and design for disassembly. Key aspects in selecting building materials include (Crowther, 2004; Macozoma, 2001a; and Pulaski *et. a.l*, 2004):

- minimize the number of different types of materials
- use renewable, recyclable and recycled-content materials
- avoid toxic and hazardous materials, i.e. asbestos-containing materials, lead-based paint etc.
- avoid composite materials
- avoid secondary finishes to materials
- choose materials with low embodied energy
- use inseparable subassemblies from the same material.

According to Macozoma (2001a), the main aim of designing buildings for deconstruction is to ensure that at the end-of-life the building can be disassembled easily, that waste generation is minimized, and that salvaged materials are maximized. For buildings to be the resource pool for the future, designers should use materials that are fit for reuse and recycling, and construction methods that make disassembly easier. Table 2.7 gives a summary of some building material and component considerations for design for deconstruction. In the first column are given the building components while in the second column are given the building elements. In the subsequent two column, building materials and their reuse and recycling options to be considered in building design stage.

Table 2.7 Building material and component considerations for design for deconstruction

Component	**Elements**	**Materials**	**Comment**
Structural members and floor	Foundation Columns and beams Floor bed Floor finish	Concrete Steel Timber Ceramics Carpets	Concrete – cannot be reused immediately, but can be recycled into secondary materials. Precast flooring systems and prefabricated elements such as beams, columns and staircases are easy to dismantle for reuse Steel – needs extra care if immediate reuse is considered, mostly recycled material Timber – can be reused immediately and recycled into various products Ceramics – durable, cannot be reused immediately, but can be recycled Carpets – recyclable, but process complicated, small market
Walls	Frame Siding Wall finish	Timber Steel Concrete Brick Gypsum drywall Vinyl Wood Hardiplank ™	Timber *as above* Concrete *as above* Brick – high reuse potential, can be recycled into secondary materials Gypsum drywall – highest percentage of generated construction waste, recyclable if not contaminated, small market Vinyl – requires low maintenance, cannot be reused, recycling is difficult Wood – as siding requires more maintenance, can be reused if properly maintained Hardiplank™ – potentially 100% recyclable, but there is no current recycling process
Roof	Frame Sheeting Ceiling	Timber Metal Asphalt Concrete Polymers Gypsum Tiles Slates	Timber – *as above* Metal – durable, costly initially but cheaper in long term, most recycled category of materials, established secondary market Asphalt – affordable, not reusable initially, can be recycled to road materials depending on prevailing policy Concrete *as above* Polymers – usually composite, not reusable or recyclable Gypsum *as above* Tiles – high reuse potential, can be recycled into secondary materials Slates – most durable, very expensive, reusable if it is not cracked

Source: Macozoma (2001a); Kibert and Languell (2000); and Poon and Jaillon (2002).

2.3.5 Connections and Connectors

Mechanical fasteners such as screws, bolts, clips and nails are preferable to materials such as adhesives that make salvage or recycling of materials impossible. Screws and bolts are preferable to nails or staples. If components are designed with screws or bolted connections, it is important to ensure the fasteners to be sufficiently durable and protected from exposure to moisture. The type and number of connectors used also play a significant role. For example, spiral nails are difficult to remove and result in damage to the lumber. Also, corroded bolts cannot be easily disassembled (Poon and Jaillon, 2002).

Crowther (2004) states that joints and connectors should be durable to withstand repeated use, and be designed to minimize damage and deformation of components and materials during assembly and disassembly processes.

According to Pulaski *et. al.* (2004), complex and unique connections increase installation time and make deconstruction difficult. Simple and standardized structural connections can enhance easy assembly and disassembly. For instance, modular connections allow steel members to be easily disassembled and reused. Furthermore, fewer connections and consolidation of the types and sizes of connectors reduce the need for multiple tools in deconstruction site.

In attempting to design for future disassembly, it is necessary to consider these aspects on connections and connectors (Crowther, 2004; Macozoma, 2001a; and Pulaski *et. al.,* 2004):

- simplify and standardize connection details
- use a minimum number of connections
- use a minimum number of different types of connections
- avoid adhesives

- use standardized connections, i.e. connection points, connectors and building components
- use mechanical connections rather than chemical ones
- use easily removable, reusable and durable connectors.

CHAPTER III

MATERIALS AND METHOD

In this chapter are presented materials and methodology of the survey. To research local deconstruction and demolition practices being performed, as well as recovery tools, techniques and method used during the deconstruction and demolition processes, the city of Ankara was chosen as the study area. As a case study, deconstruction and demolition processes of three residential buildings were examined partially. Materials and methods used in this study are explained in sections 3.1 and 3.2, respectively.

3.1 Materials

In this study, deconstruction and demolition processes of three residential buildings in Ankara were observed partially, a masonry building in Kavaklidere, a reinforced concrete building in Oran, and a masonry building in Güzelevler quarter in Yenimahalle. Figure 3.1 shows where the demolished buildings observed were situated in Ankara.

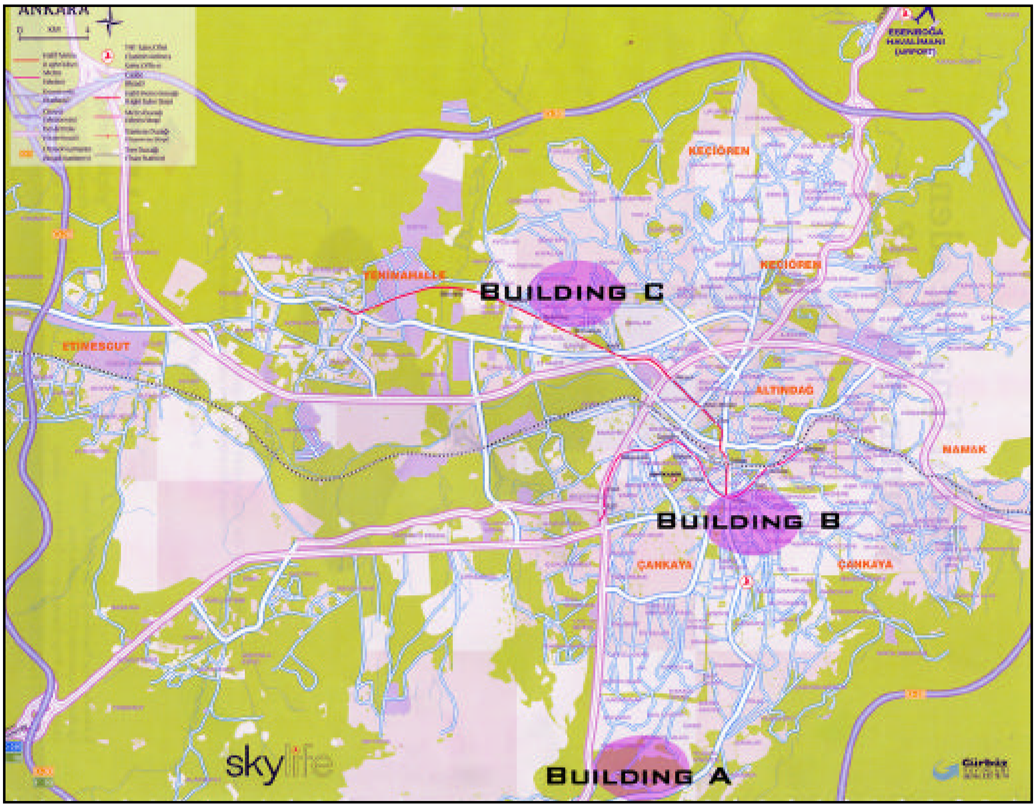

Figure 3.1 Ankara city map showing the demolished buildings observed (Source of the map: the Journal of Skylife, May 2005)

The main features of the observed buildings are given as follow:

The building was situated on Zühtü Tirgel Avenue in Oran, which will be referred to as ‘building A’. The residential building with seven storeys and 28 flats was built in 2003. In this building, there were four flats on each floor, and each flat had four rooms, a kitchen, a bathroom, a toilet and two balconies. The building with reinforced concrete skeleton consisted of hollow brick walls, which were plastered and painted. Timber skeleton of pitched roof was covered with standard roofing tiles and rain gutters were made of zinc. The windows were double glazed timber frame and doors were made of wood. Various sized ceramic tiles were used in kitchens, bathrooms, toilets and hallways on the floors. Its structure was determined by professionals to be weakening. Therefore, it had to be demolished. The deconstruction work of the building was started in April 2004 and the demolition finished in May 2004. Figures 3.2 and 3.3 show the photos of the building before and after demolition.

Figure 3.2 Before demolition of building A in Oran

Figure 3.3 After demolition of building A in Oran

The building was situated on Tunali Hilmi Avenue in Kavaklidere, which will be referred to as 'building B'. It consisted of four storeys and a basement. There were two flats on each floor, totally eight flats. It had been constructed as a residential building in 1950s and then two floors of the building were used as offices. The masonry building consisted of traditional brick walls, which were plastered and painted. The pitched roof with timber structure was covered with standard roofing tiles. Rain gutters were made of zinc. The windows and doors were made of wood. The rooms had glued parquet for flooring while bathrooms, toilets and hallways had ceramic tiles in varying sizes. Staircase was made of mosaic poured in-situ. It was an old building. Therefore, the owner of the building decided to demolish the building to erect a hotel instead of a residential building. The deconstruction work of the building was started in March 2004 and the demolition finished in April 2004. Figure 3.4 shows the photo during the deconstruction of the building.

Figure 3.4 During the deconstruction of building B in Kavaklidere

The building was situated on Kumkale Street in Yenimahalle, which will be referred to as 'building C'. The residential building with two storeys and a basement was built in 1966. It had a total of five flats, 2 each on the ground and 1st floor, and one in the semi-basement. Each flat consisted of three rooms, a kitchen, a bathroom and a toilet. Each of the two flats at the first floor had two balconies. The flat in the semi-basement consisted of two rooms, a kitchen and a bathroom. In the masonry building, traditional brick walls, which were plastered and painted, were used. The pitched roof was made of timber structure, and it was covered with standard roofing tiles. Rain gutters were made of zinc. The windows and doors were made of timber. The rooms had mosaic poured in-situ for flooring whereas the floors of the kitchens were covered with vinyl floor sheets. Ceramic tiles were used in bathrooms and toilets only. As a result of the modifications in the zoning plan, it became possible to construct four-storeyed buildings in this area. Although the masonry building was structurally in good condition, it had become obsolete and it could no longer meet the requirements of the inhabitants. The owner of the building wished to possess a bigger and newer building; therefore, he decided to demolish the building to erect a four-storey building with eight flats. The deconstruction work of the building was started in December 2004 and the demolition finished in January 2005. Figures 3.5 and 3.6 show the photos of the building before and after demolition.

Figure 3.5 Before demolition of building C in Yenimahalle

Figure 3.6 After demolition of building C in Yenimahalle

3.2 Method

In the light of information obtained from the literature survey on deconstruction and demolition practices, UBMs and design for deconstruction, research methods were decided. There was a need to perform a case study to observe building deconstruction practices and recovery of UBMs. The city of Ankara was selected as the study area. In this context, deconstruction and demolition works of two residential buildings in Ankara were observed partially, one each in Oran and Kavaklidere. Whole deconstruction and demolition processes of one residential building in Güzelevler quarter in Yenimahalle were observed and photographs were taken to visually record ongoing deconstruction and demolition processes.

First, in March 2004 was the author informed about an ongoing deconstruction work of a masonry building on Tunali Hilmi Avenue in Kavaklidere. Deconstruction works of the building was observed for three days. Observed works include recovery of windows and doors; built-in wardrobes and cupboards; bathroom fittings and fixtures; electric, natural gas and water meters; floor coverings; and roofing tiles. Interviews with demolition workers on the site were conducted to get information regarding deconstruction processes being performed in the building.

Second, when walking around in Oran in April 2004, ongoing deconstruction works of a reinforced concrete building were noticed. The deconstruction work of the building was started in April 2004 and demolition works were completed in May 2004. The building was visited ten times in a month, twice during the deconstruction and eight times during the demolition. Observed works include recovery of windows, doors, roofing tiles, pipes and rebar, and demolition of extruded hollow bricks and reinforced concrete components. The demolition workers on-site were interviewed to obtain information with regard to worker wages, deconstruction and demolition works, tools and techniques. In addition, the demolition contractor of the building was contacted and information about the work was obtained.

Third, the departmental head and two officials of the building permit section in the Building Control Authority of Yenimahalle Municipality were interviewed in December 2004, and January and May 2005 to get information about the official procedure for demolition works, such as building permits and landfilling of demolition rubble. The departmental head of the Building Control Authority[1] directed to a building contractor[2]. The building contractors were interviewed about the issues from hiring a demolition contractor, processes of deconstruction and demolition, to site clearance. The building contractor and the author searched ongoing deconstruction and demolition works in Yenimahalle, by walking and driving. Seven masonry building being demolished were found. The ongoing demolition works and recovery of bricks and rebar were observed briefly on 26-28 December 2004. Demolition contractors from the work sites were interviewed to get information regarding the deconstruction and demolition practices, types of contracts, and recovery and sale prices of UBMs. However, there was a need for an observation of whole deconstruction and demolition processes of a building both to follow whole process and to assess the feasibility of building deconstruction. Therefore, a demolition contractor[3] was asked about a building that would be demolished in the following days. He said his demolition team would begin a new demolition work of a building two days later. The address of the building in Güzelevler quarter in Yenimahalle was learned. Then whole deconstruction and demolition works of the building were observed by visiting the building everyday. The sub-contractor and his four workers engaged in the deconstruction and demolition of the building were interviewed.

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[1] The departmental head of the Building Control Authority of Yenimahalle Municipality was interviewed informally in December 2004.

[2] Ergun and Ercan Yilmaz, co-owners of a building contracting firm in Yenimahalle and have had buildings demolished and constructed new ones, were interviewed informally in December 2004 and January 2005.

[3] Hüseyin Koçak, a demolition contractor, was contacted on-site during the demolition of a residential building on Coskun Street in Yenimahalle on 28 December 2004.

Fourth, in December 2004 and January and May 2005, a survey was conducted to find out number of demolition works performed in Yenimahalle district in 2002, 2003 and 2004. The building permit is given for renovation and modification works as well as for building works. Separate demolition permits are not issued by the municipality. When a building permit is obtained, it also allows demolition of the existing building on the plot. Therefore, all building permits granted by the municipality in the named years were counted by examining the building permit sheets, and the register for building permit was checked for the type of work in the project. Two officials of the building permit section in the Building Control Authority in Yenimahalle Municipality were asked the names of the areas where new construction was being done, as well as the names of areas where demolition works were being performed before new construction. The building permit sheets were studied to learn what the type of the work was, whether rubble existed on the site, and the area where the building would be erected. According to the information gathered, number of demolition works that were performed in Yenimahalle was determined. The building permits were grouped in three; permits for new construction on an empty land, permits for demolishing old buildings to erect new ones, and permits for demolishing squatter's houses to construct a new building. The findings of the research were presented in the following chapter.

Fifth, the departmental head and two officials of the building permit section in the Building Control Authority of Çankaya Municipality were interviewed in May and June 2005 to gather information with regard to the official procedure for demolition works, such as obtaining a permit for demolition and landfilling the resulting rubble. A sample permit for demolition was obtained from the officials and given in Appendix D.

Sixth, since UBM yards are mostly situated on Bentderesi Avenue in Aktas, the yards on the avenue were visited in June 2005. Six demolition contractors were interviewed to obtain information about types of contracts; process, tools and techniques used in deconstruction and demolition of buildings; and work related accidents. In addition, prices, buyers, repairs, and problems in recovery of UBMs were investigated through interviews. Furthermore, two demolition contractors in Ilker and Mürsel Uluç were contacted and asked information with regard to the same issues mentioned above. In addition, a scrap dealer on Bentderesi Avenue was visited and interviewed regarding used rebar, scrap iron, copper, zinc, and aluminium sheets and components, and their prices.

It is important to note here that the building contractor of building C[4] and four[5] of the demolition contractors were not willing to declare prices of UBMs and costs of deconstruction and demolition works performed. Furthermore, they were not pleased with any kind of documentation such as taking notes during the interviews. On the other hand, all of the contractors interviewed were more open to sharing their knowledge and providing some information about the processes of deconstruction and demolition.

Lastly, to assess the feasibility of the deconstruction work, prices of UBMs were gathered from the demolition contractors who were contacted on the sites visited while the prices of new building materials were collected from the market, producing and/or selling these materials in Siteler, Kizilay and Ulus, Ankara. The data were compiled according to these figures and presented in tabular form in Chapter 5, in order to assess to what extent deconstruction work is an economically feasible job.

Appendix E gives a complete list of officials, contractors, demolition teams and companies were contacted for this research.

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[4] Cemalettin Çelik, building contractor of building C, was contacted on-site in January 2005.

[5] Ayhan Harmandar, a demolition contractor, was contacted on-site in Yenimahalle in December 2004.

Mehmet Aktepe, demolition contractor of building A, was contacted in Oran in April 2004.

Selçuk Dogan, a demolition contractor in Mürsel Uluç, was interviewed in his yard in June 2005.

Alparslan Dogan, a demolition contractor in Ilker, was interviewed in his yard in June 2005.

CHAPTER IV

SURVEY OF DECONSTRUCTION PRACTICES IN ANKARA

In this chapter are presented findings of surveys carried out in Ankara. The survey on dismantling and demolition works was conducted to investigate the conditions and ongoing practices for recovery of UBMs. The objective of this study was not only to provide information on the deconstruction and demolition practices, but also to observe these works in terms of economic aspect. For this reason, observations were made on the deconstruction sites and informal interviews were conducted with the following:

- eleven demolition contractors, to get information regarding the issues of types of contracts; processes, tools and techniques used in deconstruction and demolition of buildings; work related accidents on-site, as well as prices, buyers, repairs and problems in recovery of UBMs.
- seven demolition teams, to obtain information related to worker insurance, wages, tools and techniques.
- a scrap dealer, to get information about used rebar and scrap iron and their prices.
- a building contractor and co-owners of a building contracting firm, to gain information with regard to types of contracts and cost of the work.
- two departmental heads and four officials of the building permit section in the Building Control Authority of Yenimahalle and Çankaya Municipalities in Ankara, to obtain information related to the issues of

changes in zoning plans, official procedure for building demolition and landfilling the resulting debris.

Results of the survey are presented in the following sections.

4.1 Reasons for Demolition

There are a number of reasons for demolition of buildings. These reasons include building obsolescence, modifications in the zoning plans, structural problems and owner's requirements. These factors are explained as follow.

a) Building Obsolescence:

The departmental head of Building Control Authority of Yenimahalle Municipality[6] stated that reason for demolishing a building can be due to the end of its useful service life. For example, a building can structurally stand over a hundred years while its useful service life is only forty to fifty years. After that, it becomes old or obsolete. The average useful lifetime of a concrete building, usually being erected in our country, varies between thirty to fifty years.

Another reason for demolition of buildings can be that existing buildings no longer meet the variable and increasing requirements of the people living in them. For instance, some old buildings may not be convenient for renovation and not allow for making changes in the building due to the lack of flexibility. Therefore, buildings can become worn out, old or obsolete, and eventually they have to be demolished.

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[6] The departmental head of Building Control Authority of Yenimahalle Municipality was interviewed informally in December 2004.

b) Modifications in the Zoning Plans

The information given in this section was obtained through informal interviews, conducted in December 2004, with the officials of the Building Control Authority of Yenimahalle Municipality.

The most important factor making way for building demolition is changes in the zoning plan in response to housing demands. With the revised zoning plan, the following changes are incorporated in the existing settlement:

- Changes in the plot size
- Permission to build higher buildings. For example, the revised zoning plan gives permission to add two storeys to a existing two storeyed building. As a result, homeowners want their old buildings to be demolished and erect new ones as per the revised zoning plan.
- Regularizations of squatter settlements lead to the grant of permission for additional storeys and a rise in the land prices. Therefore, squatters want their sub-standard buildings to be demolished and construct new ones according to the zoning improvement plan.

Modifications in the zoning plans do not represent a direct reason for buildings to be demolished. However, they make way for building demolition. Because of the advantages created by the changes in the zoning plans mentioned above, building owners can decide on demolishing their old buildings to erect newer, larger and taller ones.

c) Structural Problems:

A building can become uninhabitable due to weakening of its structure or exposure to a natural disaster, such as an earthquake, a flood or a fire. A merchant of UBM in Sorgun in Yozgat reported that due to a fire incident in a prison in Sorgun, it had to be demolished. As another example, a seven-storey building in Oran, building A, was decided by professionals to be demolished.

The building A was never inhabited, but the reason for its demolition was given as its structural weakness.

d) Owner's Desires:

Besides building obsolescence, modifications in the zoning plan, and structural problems, another important factor for demolishing a building is owner's desires. A building owner can decide on demolishing his building due to various reasons. One of these factors is mainly because of the wishes of the owner to possess newer, bigger and taller buildings. Another significant factor can be the requirements of the owner to demolish an existing building and erect a building with different function such as hotel, business center etc. instead of a residential building. For instance, the owner of the building B in Kavaklidere decided to demolish his building to erect a hotel instead.

4.2 Building Deconstruction Process

The various stages of building deconstruction, as presented in section 2.1.5 based on the research conducted by Abdullah and Anumba (2003), Kibert and Languell (2000), and Macozoma (2001a), include permitting, building material inventory, environmental site assessment, planning for deconstruction, site security, field safety, labour, scheduling, field organization, building disassembly, tools, techniques and methods, processing and materials handling, and site clearance. The sequence outlined by the abovementioned authors was adapted to the building deconstruction process studied and presented in this thesis. Building deconstruction process is explained in the following sections.

Due to various reasons cited in section 4.1, a building or a structure can be decided to be demolished. This decision makes way for beginning the processes of deconstruction and demolition of a building. The first step of this process is obtaining a permit for demolition.

4.2.1 Permitting

The information given in this section was obtained through informal interviews with two departmental heads and four officials of the building petmit section in the Building Control Authority of Çankaya and Yenimahalle Municipalities, which were conducted in December 2004, and January, May and June 2005.

In building deconstruction process, after deciding to demolish a building, the first step is to get a permit for demolition of the building from the building control authority of the local municipality to erect a new building. According to the 18th clause of the regulation for 'the Control of Excavation Soil and Construction and Demolition Waste' enforced by the Ministry of the Environment and Forest, before starting demolition work, the owner/ enterprise/ firm has to obtain demolition permit from the local municipality. Çankaya Municipality gives a permit allowing for both deconstruction and demolition. Furthermore, before starting demolition work, the owner has to obtain demolition permit from the local municipality as per the 81st clause of Ankara major municipality zoning regulation enforced in 2004. Çankaya Municipality requires the owner to get demolition and new construction permission separately whereas Yenimahalle Municipality does not differentiate permits for demolition or new construction. Çankaya Municipality, firstly, grants only demolition permit. Only after checking the site whether demolition work has been done, new construction permit is given.

Official procedure for demolition generally requires certain documents to obtain a permit for demolition. At the end of the demolition process, it is required to landfill the resulting debris in areas determined by the municipality.

According to the 81st clause of Ankara major municipality zoning regulation enforced in 2004, it is required that the owner of the building has done the following before obtaining demolition permission:

- the building must be evacuated
- disconnection of electrical power,
- capping all gas, water and sewer lines,
- appointment of a professional person (architect/ civil engineer)

and obtained the following documents:

- site plan of the plot
- title deed
- TUS certificate (Technical Implementation Responsibility, called as *Teknik Uygulama Sorumluluk*)
- the documents showing there are no debt for electricity, water, natural gas and telephone used in the building
- an application for demolition permit.

The owner with the documents above applies to the municipality to obtain a demolition permit. An official of the building permit section in the Building Control Authority measures width and length of the building, and calculates approximate volume of the rubble and excavations to be generated. The calculated amount is divided by 8 since the volume of a truck is 8m^3. For each truck-full rubble 8 YTL (~ 6.00 $) is paid to the local municipality for solid waste disposal tax. Furthermore, demolition fee is paid to the local municipality. Demolition fee is 250 YTL (~ 185 $) for residential buildings whereas 360 YTL (~ 270 $) for commercial buildings[7]. For example, the calculation of approximate rubble amount for a building with 10 meters width, 20 meters length, and four storeys, is as below:

Rubble amount = width x length x number of storeys x rubble coefficient
Rubble amount = 10 x 20 x 4 x 0.40
Rubble amount = 320 m^3
320 m^3 / 8 m^3 = 40 trucks full rubble

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[7] These fees are valid for 2005 year.

Another requirement is taking site security measurements, such as security fence. After fulfilling these requirements and paying all fees and taxes, the owner can obtain a demolition permit.

Since the Yenimahalle Municipality does not issue separate permit for demolition work, a survey was conducted to find out number of buildings demolished in Yenimahalle district in 2002, 2003 and 2004. The findings of the survey are presented in Table 4.1. In the first column are presented the type of work. In the subsequent three columns are given the years of building permits granted by the municipality, the number of building permits and their proportion (%) to all building permits given in the same year.

Table 4.1 Building permits granted by Yenimahalle Municipality

Years	**2002**		**2003**		**2004**	
Type of work	**Number of permit**	**% of permit**	**Number of permit**	**% of permit**	**Number of permit**	**% of permit**
A	138	40%	222	56%	255	51%
B	132	39%	97	24%	141	28%
C	71	21%	81	20%	103	21%
Total	341	100%	400	100%	499	100%

- A is referred to as permit for new construction on an empty land
- B is referred to as permit for demolishing old buildings to erect new ones
- C is referred to as permit for demolishing squatter housing to construct a new building.

The survey indicated that 203 of 341 (60%) building permissions were given for demolishing old structures in 2002 while only 138 (40%) permissions for new construction on an empty land. In 2005, 244 of 499 (49%) building permit were given for demolishing old buildings whereas 255 (51%) permit were granted by Yenimahalle Municipality.

According to the departmental head of Building Control Authority of Çankaya Municipality[8], two demolition permits were given from May to December 2004 while eleven demolition permits were granted by the municipality from January to June 2005. The official stated that although owners have to get demolition permit as per the law and regulations, in many cases, building owners and squatters demolish their buildings without obtaining demolition permit and the municipality cannot control these activities. Therefore, it is difficult to find out the actual number of demolition works in Çankaya district.

4.2.2 Building Material Inventory

The information given in this section was obtained through informal interviews, conducted in December 2004 and June 2005, with four demolition contractors, Veli Biyik, Hüseyin Koçak, Sezai Dogan, and Fevzi Sanci.

After obtaining permission for demolition and construction, work is started for deconstruction and demolition process. The owners mostly transfer the responsibility of managing the deconstruction and demolition works to the building contractor. A demolition contractor is hired to assess the building, who assesses the building depending on some indicators determining whether a structure is suitable for deconstruction or not. These factors are given as follow:

a) Number of storeys and size of the building

In the building material inventory stage, the most important factor is the investigation of number of storeys and size of the building. This determines the method of deconstruction and demolition works to be performed as well as

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[8] The departmental head of the Building Control Authority of Çankaya Municipality was interviewed informally in May and June 2005.

required tools, equipment and machinery to be used during the deconstruction and demolition processes. These factors affects the costs of the work.

b) Methods of construction

Construction method of a building is a determinant factor since it will impact the ease or difficulty of the work. In the case of a building that was constructed using the masonry technique, the building is considered to have traditional bricks and reinforced concrete beams and slabs. To remove bricks from the structure, mortar has to be weaker than bricks, that is, mortar has to start to crumble. Otherwise, they have to be demolished. In this context, the age of the masonry building is an important factor since lime mortar starts to crumble at least thirty or forty years later, which is not the case for cement mortar. In the case of a building that was constructed with reinforced concrete skeleton, the building is considered to have extruded hollow bricks and concrete elements such as columns, beams and slabs. Extruded hollow bricks cannot be recovered since they are not suitable for recovery. In addition, it is considered that reinforced concrete structures have more rebar in concrete elements to be recovered than masonry structures have. It should be noted here that deconstruction of a reinforced concrete building requires more time, labour, tools and equipment than a masonry building.

c) Type and condition of building materials, components and connections

The material inventory is intended to identify the cost effectiveness of the work. The investigation of type, quality, quantity and condition of building materials, components and connections used in the building is the last issue of the building assessment step since feasibility of building deconstruction is mostly dependent on these factors. Furthermore, historical buildings in Turkey are traditional Turkish houses. They usually have materials and components with high-quality architectural features. Deconstruction of this type of structures is considered to return more profit. However, this type of structures is very rare at present time.

4.2.3 Planning for Deconstruction

The information given in this section was obtained through informal interviews, conducted in December 2004, with two building contractors, Ergun and Ercan Yilmaz and Cemalettin Çelik, and five demolition contractors, Fevzi Sanci, Veli Biyik, Bekir Acar, Hüseyin Koçak, and Sezai Dogan.

According to the results of the building inventory, the demolition contractor decides on whether deconstruction is a suitable technique for the building or not. The outcomes of the assessments gives an idea of the amount of recoverable building components and materials depending on their type, condition, assembly technique, and ease of recovery. Taking into consideration these factors, demolition contractor estimates costs and revenue, which can be derived from the project, and tends a bid for the job.

If the building contractor comes to an agreement with the demolition contractor, demolition work can be undertaken in several ways. If a building has materials and components that are of good quality, demolition contractor makes a high estimate for the work. If materials and components do not have good quality and/or enough quantity, estimate for the job is low. The other way is that the demolition contractor recovers materials that provide high profit and demolishes the building; however, he neither gives nor takes money for the job. This is also known as no fee contract. These three types of contracts were also stated by Özkan (2000). In addition, if the demolition contractor has another demolition job at hand or does not have a demolition team, he gives the job to another demolition team. In this case, the demolition team only dismantles the building in return for an agreed price and the recovered materials will belong to the demolition contractor. The demolition work can also be done according to the directions of the building contractor; if he wants the building to be demolished speedily to start construction immediately, destructive demolition is performed without consideration for building materials and components with reusable potential to be recovered. In this case, the building contractor gives a fee to the demolition contractor to demolish the building. If the work is accepted, the process starts depending on decisions of construction and/or demolition contractors, suitable time for workers, as well as weather conditions.

4.2.4 Site Security

Security of a deconstruction site is intended to protect the workers as well as the public. Furthermore, deconstruction requires the protection of salvaged components and materials on the site during the deconstruction process. Recovered materials are usually stored on the site. If these materials are left unprotected on the site they can be stolen easily. For this reason, simple security measures were taken to protect workers, passage byes and the recovered UBMs such as the erection of a perimeter fence with a lockable gate, and lockable storage areas to protect the salvaged materials from being smuggled.

For the security of the sites observed, simple measures were taken. For the security of a masonry building in Yenimahalle, removal of windows and their balustrades on the ground floor was left to the last and the entry door was kept locked at nights until the end of deconstruction work. Another security measure was to demolish the staircases in order to prevent thieves from going up. Yet anther example, for the security of building C in Yenimahalle, entry door was kept locked at nights during the deconstruction process.

For building B on Tunali Hilmi Avenue, besides keeping the entry door locked during the nights, a guard was watching over the building. Furthermore, since the building was situated on a busy avenue it was required to erect a protective envelope around the building in order to prevent objects in the building from falling and causing a hazard.

For the site security of building A in Oran, since there was no boundary wall, a fence was erected. Furthermore, a protective envelope around the building covered with canvas was built. The entry door was also kept locked at nights during the deconstruction process.

4.2.5 Labour

The Ministry of Works published a 'Risk Group List', declared construction and demolition of buildings and ships as a dangerous job type and published in Official Gazette (13.04.2004). For example, the ship breakers' association of Turkey provides ship breakers with job training, regular health check twice a year, and special equipment for safe removal of asbestos from ships; however, such training and others are not available for workers engaged in building demolition. Furthermore, the 'Dangerous and Risky Works Regulation' was enforced by the Ministry of Works and published in Official Gazette (16.06.2004). According to the regulation, demolition works and works involving asbestos are considered as dangerous and risky works. In addition, women and young workers, who are boys under 18-year-old, are not allowed to be engaged in such works. The regulation of 'Control of Excavation Soil, Construction and Demolition Waste (CDW)', enforced by the Ministry of the Environment, involves the issues of excavation soil, CDW, hazardous CDW, waste management as well as selective dismantling, recovery and recycling of CDW. There are also laws, rules, regulations and circulars enforced by the Ministry of Works and the Ministry of the Environment. They include 'Work

Law' (22.05.2003) involving contracts, wages, worker health and safety, administrative punishment rules etc., 'Health and Safety Measures While Working with Asbestos' (26.12.2003), 'Method and Principles of Worker Health and Safety Training' (07.04.2004), 'Solid Waste Management' (enforced in 14.03.1991 and last modified in 25.04.2002) and '2003 Solid Waste Circular' involving waste management and recovery, reuse, recycling and disposal of solid waste.

Although these laws, rules, regulations and circulars are present, there is a lack of enforcement and/or lack of awareness. People engaged in deconstruction and demolition works are generally unskilled workers. Demolition workers contacted stated that they have no health insurance. Furthermore, those observed did not wear protective equipment such as safety belts, safety glasses or hard hats, but gloves.

A demolition contractor, Fevzi Sanci, reported a work related accident on a demolition site. While working with a sladgehammer, a demolition worker injured his leg. He had health insurance; therefore, medical treatment and its expenses were covered by Social Insurance Institute (SSK - *Sosyal Sigortalar Kurumu*). Another work related accident was reported by a demolition contractor in Yenimahalle, Veli Biyik. During the demolition of a masonry wall, the wall fell over a worker who was demolishing the wall, which led to his death.

4.2.6 Dismantling Tools, Techniques and Methods

Demolition contractors prefer to use simple tools, such as pickaxes, sledgehammers and long handed wrenches, to break down the masonry structures. On the other hand, to pull down the reinforced concrete structures, it is preferred to use more complex tools and equipment, such as pneumatic drills and excavators. Other special excavator attachments can also be used such as hydraulic breakers and excavator breakers to tear down reinforced concrete components. Below are listed the names of tools and machinery used in deconstruction and demolition of buildings:

- Adze
- Cutting torch
- Excavator
- Breaker attachments
- Hammer
- *Manila*, a long handed wrench
- Pickaxe
- Pneumatic drill
- Rope
- Saw
- Screwdriver
- Shovel
- Sledgehammer

These tools are given in Figures 4.1-7 below.

Figure 4.1 Adze used for cleaning bricks

Figure 4.2 Excavator used for digging

Figure 4.3 Breaker attachments used for breaking reinforced concrete components

Figure 4.4 Pneumatic drill used for breaking reinforced concrete components

Figure 4.5 *Manila*, a long handed wrench, used in recovery of bricks

Figure 4.6 Sledgehammer used for breaking masonry and reinforced concrete components

Figure 4.7 Pickaxe used for breaking masonry and reinforced concrete components as well as in recovery works

Processes of deconstruction and demolition of a building generally take one or more week to be completed. This depends on the size and complexity of the project, as well as type, quantity and condition of building materials, components and connections in a building. Selective deconstruction and demolition works are done manually. In building deconstruction process, building materials and components with reusable and resalable potential were firstly removed from the structure, and then structural system including walls and slabs was demolished.

The deconstruction and demolition plan for a building is decided and followed by the demolition team in view of their experience. Demolition teams generally adopt the following sequence for building deconstruction.

- Firstly, doors and windows are removed from the structure.
- Next, built-in wardrobes, kitchen cabinets, built-in cupboards, sinks, bathroom fittings and fixtures, balcony and staircase balustrades, and zinc components are salvaged.
- Then roofing tiles, boards, rafters, battens and joists are dismantled.

- Finally, the demolition work is started and bricks, rebar, pipes and electric cables are recovered at this stage.
- Once the demolition has been completed, resulting debris is left on the site to be sent by building contractor to the landfill area determined by the municipality.

4.2.7 Deconstruction Process of Building C

Building C in Yenimahalle was observed from the start of deconstruction works to finish of demolition works. The deconstruction process of the building C was undertaken by following almost the same sequence as cited in section 4.2.6.

a) Recovery of Windows

The job was started with the removal of windows. Before recovering windows from the structure, window sashes are taken out and put aside. Since the windowsills are made from pre-cast mosaic, it is not possible to reuse them. For this reason, firstly, the sill was broken down with a sledgehammer and its remains were cleaned with a pickaxe (Figure 4.8). Next, the walls alongside the other three sides of the window were chipped. Then, the wooden anchors fixing the window to the walls were removed with a pickaxe. The wall below the window was broken down. After that, the frame was shaken loose and was taken out (Figure 4.9). Finally, the sashes were re-fixed to the frame and thus, the recovery of the window frame was completed. This process took fifteen to twenty minutes depending on the worker experience and size of the window. Other windows were removed from the structure in the same way.

Figures 4.8-9 Disassembling the window (building C)

b) Recovery of Doors

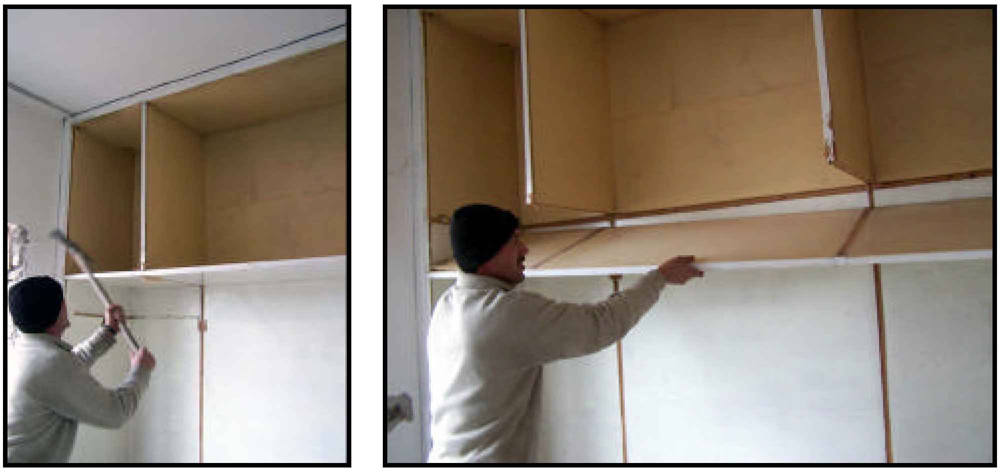
Dismantling of the doors is different from that of windows. Firstly, the door wing was taken out and put aside. The beading on the external side of the frame was removed first with a pickaxe (Figure 4.10). The ends of the door stiles that are embedded in the flooring were freed by breaking the mosaic around it (Figure 4.11). By striking the frame with a sledgehammer, it was pushed towards the inside to remove it intact, as shown in Figures 4.12-13. The frame was detached from the anchors. Finally, the door wing was re-attached to the door. This process took fifteen to twenty minutes depending on the worker experience. Other doors were recovered from the structure in the same way.

Figures 4.10-11 Taking out the door frame from building C

Figures 4.12-13 Removal of the door frame from building C

c) Dismantling of Built-in Wardrobes and Kitchen Cabinets

Two workers disassembled the fenestration and door units, and this job took a half a day to be completed. Two other workers dismantled the built-in wardrobes, kitchen cabinets, built-in cupboards, sinks, bathroom fittings and fixtures. During the recovery of these built-in wardrobes, firstly any nails were taken apart with a pickaxe (Figure 4.14), and then the wooden elements were shaken loose and were taken out (Figure 4.15).



Figures 4.14-15 Dismantling of the built-in wardrobe (building C)

Recovery of kitchen cabinets was performed as the same method. Firstly nails are removed with a pickaxe, and then kitchen cabinet was handled by two workers. Next, it was shaken loose and taken out as shown in Figures 4.16 and 4.17. Bathroom fittings and fixtures were removed from the structure by getting screws out with a screwdriver. Salvaged components were first left in the rooms, and later taken to the garden and stored there properly.

Figures 4.16-17 Taking apart the cupboard (building C)

d) Dismantling of Balcony and Staircase Balustrades

One worker started to dismantle the wrought iron balcony balustrades. Firstly, he broke down the cast mosaic sill with a sledgehammer, and then pulled out the edges from the walls (Figure 4.18). After that, he connected a rope to the balustrade and held tightly. The other worker pushed it with a pickaxe, and then the balustrade was lowered down slowly on to the garden with the help of a rope (Figure 4.19). Dismantling of staircase balustrades was performed using the same technique used in removal of balcony balustrades.

Figures 4.18-19 Dismantling the wrought iron balcony balustrade (building C)

e) Deconstruction of Roof Structure

Roofing tiles were put one on the top in batches of eight or ten each, on the roof. Then, zinc downspouts and sheets below roofing tiles were removed as shown in Figure 4.20. After that, a simple pulley was set up on the roof and the roofing tiles were moved towards it. While one worker on the roof was lowering the tiles via the pulley, the other one on the ground picked them up and stored them on the site in a proper manner (Figure 4.21-22). Next, timber components, such as rafters, battens and boards, were removed from the roof structure with the help of a pickaxe.

Figure 4.20 Pulling out the zinc sheets (building C)

Figures 4.21-22 Recovery of the roofing tiles (building C)

4.2.9 Demolition Process of Building C

Building C in Yenimahalle was observed from the start of deconstruction works to finish of demolition works. The demolition process of the building C was undertaken by following almost the same sequence as cited in section 4.2.6.

a) Demolition of the Roof Slab

After these deconstruction works, the destructive demolition phase started with demolishing the roof slab. While two workers were breaking down the roof slab by means of sledgehammers, the other one was cleaning the remains with a shovel (Figure 4.23-26).

Figures 4.23-24 Demolition of the roof slab (building C)

Figures 4.25-26 Demolition of the roof slab of a masonry building in Yenimahalle

b) Recovery of Bricks

After demolishing the roof slab, demolition work continued with pulling down the masonry walls. Bricks can be removed from the structure if mortar has started to crumble otherwise they are demolished. Mortar was suitable for bricks to be dismantled. Therefore, bricks were dropped on the floor with the help of a *manila*, which is a long handed wrench (Figure 4.27). After that, they were cleaned with an adze (Figure 4.28), and then cleaned bricks were transferred to the truck.

Figure 4.27 Removal of bricks from the structure with a *manila*

Figure 4.28 Cleaning of bricks with an adze

c) Demolition of the Floor Slabs

After dismantling of the upper walls, floor slab was demolished manually. While two workers were demolishing the slab with a pickaxe and a sledgehammer, the other worker was shoveling the debris generated through the holes opened on the floor (Figure 4.29-30). Meanwhile, the fourth one was removing the rebar carefully from the concrete with the help of a pickaxe and pincers (Figure 4.31-32). During the demolition, pipes and electric cables were also recovered (Figure 4.33-34).

Figures 4.29-30 Demolition of floor slab (building C)

Figures 4.31-32 Recovery of rebar (building C)

Figures 4.33-34 Recovery of pipes and electric cables (building C)

d) Recovery of Floor Coverings

Since the floor of the building C in Yenimahalle was made of mosaic poured in-situ, there was no other option but to be demolished. Small holes were opened first on the floor to let the rubble fall through. While the work advanced, the holes were enlarged and the whole floor slab was demolished. On the other hand, the floor of the building B in Kavaklidere was covered with glued parquet, so the floor coverings were recovered and then demolition of floor slabs was performed using the same technique as above (Figure 4.35).

Figure 4.35 Glued parquet coverings were removed from building B

There is no difference between deconstruction and demolition processes of masonry and reinforced concrete buildings. However, masonry buildings are generally demolished with simple tools while demolition of reinforced concrete buildings are performed with the help of more complex tools and equipment to tear down reinforced concrete components such as columns, beams and slabs.

4.2.10 Site Clearance

The final step of building deconstruction process is site clearance. After completing deconstruction and demolition works, the site is cleared out and made ready for new construction. The resulting rubble must be landfilled in areas determined by the local municipalities.

The demolition team of the building C completed the job and left the site without clearing out since the building contractor was responsible for this job. The resulting rubble was removed from the site by the building contractor. The rubble was transferred to the trucks with the help of an excavator to be sent to the landfill area in Atatürk Orman Çiftligi determined by the Yenimahalle Municipality. Therefore, the site was cleared out.

CHAPTER V

RESULTS AND DISCUSSIONS

In this chapter are presented the information regarding demolition contractors; different types of UBMs and their management; and problems in deconstruction works. This chapter also includes feasibility, profitability and viability of deconstruction works, and contains tables and comparisons on prices of UBMs with that of new materials.

5.1 Demolition Contractors

In 1954, the first demolition contractor's yard in Ankara was built on Bentderesi Avenue in Aktas. After that, number of UBM yards increased over the years. In 1974, the Demolition Contractors' Association was established by Fevzi Sanci[9], still the head of the association. The head of the association reported that there are 65 demolition contractors in Ankara, who are registered to the association. They are also enrolled to Ankara Chamber of Commerce (ATO - *Ankara Ticaret Odasi*) and Ankara Chamber of Trades (ANKESOB - *Ankara Esnaflari Odalar Birligi*). There are also llegal demolition contractors in Ankara, who are neither registered to the association nor ATO and ANKESOB. Demolition contractors are also merchants of used building materials. They have UBM yards, about 50 of which are situated on Bentderesi

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[9] Fevzi Sanci, a demolition contractor and the head of the Demolition Contractors' Association, was interviewed informally in June 2005.

Avenue and the others in different settlements in Ankara. Figure 5.1 shows where UBM yards visited are situated in Ankara. On the map:

‘A’ shows Bentderesi Avenue on which most of the UBM yards are situated,

‘B’ shows a UBM yard, which is situated on 1st Avenue in Ilker, and

‘C’ shows a UBM yard, which is situated on 3rd Avenue in Mürsel Uluç.

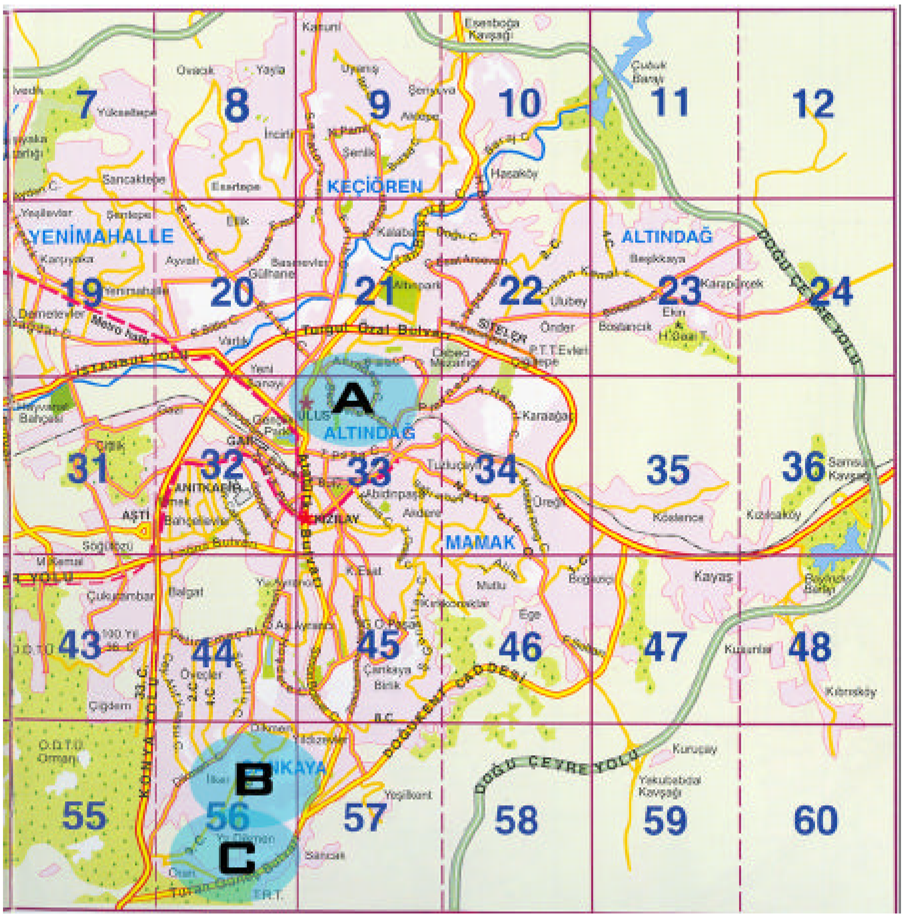

Figure 5.1 Demolition contractors’ yards are situated in Ankara

(Source of the map: Çelik, 2003)

Demolition contractors mostly concentrate on timber elements such as windows, doors, rafters, boards, battens and joists since these materials both bring high profit and have a high resalable potential. In addition, in the used building materials outlet are sold kitchen cupboard, sinks, lavatories, commodes, wrought iron balcony and staircase balustrades, rebar, aluminium and zinc sheets and components, roofing sheets, bricks, roofing tiles and waste timber as fuel to burn. Figures 5.2-6 show photos of demolition contractors’ yards in Ankara, situated on Bentderesi Avenue in Aktas , on 1st Avenue in Ilker and on 3rd Avenue in Mürsel Uluç.

Figures 5.2-3 Demolition contractors' yards, which are situated on Bentderesi Avenue in Aktas

Figure 5.4 A UBM yard, which is situated on 1st Avenue in Ilker

Figures 5.5-6 A UBM yard, which is situated on 3rd Avenue in Mürsel Uluç

On Bentderesi Avenue, three UBM yards specialize in recovered bricks (Figure 5.7), whereas a UBM yard sells only wrought iron balcony and staircase balustrades. Other yards sell most of UBMs cited above. In addition, there are merchants of recovered bricks. On the avenue, merchants' trucks, which are full of recovered bricks, are waiting for potential buyer (Figure 5.8). Furthermore, demolition companies in Ilker and Mürsel Uluç both sell UBMs and new construction materials.

Figure 5.7 A demolition contractor's yard specializes in recovered bricks, on Bentderesi Avenue

Figure 5.8 Truck of used brick, waiting for potential buyer on Bentderesi Avenue

5.2 Used Building Materials

Recovered building materials include windows and doors (Figures 5.9-10), bathroom fittings and fixtures, built-in wardrobes (Figures 5.11-12), kitchen cabinets and sinks, aluminium components, zinc sheets and components, rebar (Figure 5.13), roofing tiles (Figure 5.14), timber components recovered from roof structure (Figure 5.15), electric cables, pipes, bricks, wrought iron balcony and staircase balustrades, floor coverings, radiator, switches, and natural gas, electric and water meters.

Figures 5.9-10 Windows and doors recovered from building C in Yenimahalle

Figures 5.11-12 Built-in wardrobe (building C)

Figure 5.13 Rebar recovered from building C

Figure 5.14 Roofing tiles of building C

Figure 5.15 Timber components recovered from building C

Some material cannot be reused due to its damage caused during the use or dismantling. Some of wasted timber components can be used as fuel to burn while others have to be landfilled. Furthermore, damaged materials and components need to be landfilled if the damage cannot be repaired. Lastly, some materials can neither be recovered nor reused. For instance, ceramic tiles cannot be recovered and reused. These are shown in Figures 5.16-20.

Figure 5.16 A commode damaged during the dismantling (building B)

Figures 5.17-18-19 Items damaged during use (building ‘C’)

Figure 5.20 Timber components damaged during dismantling can be used as fuel to burn (building C)

On the other hand, some materials were wasted although they have reusable potential. This depends on various reasons. For instance, bricks from masonry walls of the building C in Güzelevler would have been recovered if there had been a buyer. There were neither buyers nor storage area for bricks. Furthermore, demolition work was performed in winter and bricks are usually sold in summer months, thus instead of removing them from the structure for resale, they had to be demolished and landfilled. In another example, brick of masonry walls of building B in Kavaklidere would also have been recovered. However, the owner of the building wanted the building to be demolished as soon as possible to erect a hotel. Therefore, materials and components in building B that bring highest profit such as windows, doors, floor coverings, roofing tiles, rafters, battens and joists, and gas, electric and water meters were removed from the structure, and then the others were demolished.

5.2.1 Management of Used Building Materials

The information given in this section was obtained through informal interviews with a building contractor[10], four demolition contractors[11], and a scrap dealer[12].

Approximate quantities of recovered building materials from a two-storey masonry building with four separate house units are summarized in table 5.1 below. The data were obtained from a demolition contractor, Sezai Kilinç, contacted on-site in Yenimahalle.

Table 5.1 Approximate quantities of UBMs from a two-storey building

Material	**Quantity**
Window	28 units (7 units / a house unit)
Door	36 units (9 units / a house unit)
Brick	4 - 5 trucks full (2500 - 3000 pieces = 1 truck full)
Roofing tiles	1000 - 1500 pieces
Zinc sheet and components	80 - 100 kg
Rebar	4 - 5 tones
Timber elements	1 truck full
Debris	8 - 9 trucks full (including foundation excavation)

The salvaged materials and components are either sold during the deconstruction in progress on-site, or taken to the demolition contractor's yard where they are sorted, repaired, if required, displayed and sold in the following months. These materials are explained as follow.

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[10] Ergun and Ercan Yilmaz, co-owners of a building-contracting firm, were interviewed in December 2004 and January 2005.

[11] Sezai Kilinç, a demoltion contractor, was contacted on-site in Yenimahalle in December 2004.

Hüseyin Koçak, a demoltion contractor, was contacted on-site in Yenimahalle in December 2004 and January 2005.

Veli Biyik, a demoltion contractor, was contacted on-site in Yenimahalle in December 2004 and January 2005.

Bekir Acar, a demolition contractor and owner of a warehouse on Bentderesi Avenue, was interviewed in June 2005.

[12] Abdullah Güney, a scrap dealer, was contacted on Bentderesi Avenue in June 2005.

a) Windows and Doors

Recovered building materials are sold on-site provided that they do not need processing, or taken to a warehouse, which is called as '*ardiye*' in Turkish. Some are treated according to their condition such as repair, painting and polishing. Small defects of door and windows' border, frame and wings are repaired, polished or painted, if required, window panes are also attached. If they are broken, that is, severely damaged, they are changed with another ones removed from the same or another building, and then they are polished and painted for resale as shown in Figures 5.21-24.

Figures 5.21-22-23-24 A door recovered from a demolished building being repaired in a warehouse on Bentderesi Avenue

b) Timber

A warehouse owner on Bentderesi Avenue stated that timber elements, which are recovered from roof skeleton such as roof trusses, rafters, battens and joists can be reused in roof structure or in new production. In the warehouse, doorframes and windows are manufactured from recovered timbers (Figure 5.16-17). Recovered timbers have nail defects, which are filled with wood filler (Figure 5.18). Salvaged timber can also be used as framework and erecting scaffolding. It should be noted here that if recovered timber elements have decay and /or worm-eaten defects, this type of timbers is not suitable to use in scaffolding. Worm-eaten timbers may not have enough strength to carry the load. If they cannot be reused, they are sold on-site as fuel to burn.

Figures 5.25-26 Doorframes and windows made of recovered timber elements

Figure 5.27 Timber elements recovered from a military building in Fatih, Ankara.

c) Metal

Zinc components such as zinc sheets and rain gutters are removed from the structure. Recovered zinc components have a strong market in used building materials' outlet since zinc components used in old buildings have both a good quality and thickness. This type of zinc components is today more valuable and so more expensive.

Recovered rebar falls into two groups as damaged and undamaged. If rebar is not bent and twisted, so they are taken to scrap dealer's site to be sold as scrap iron. They are mostly sold to low-income communities from villages and squatter's to be used in construction works. Scrap iron costs 35 - 40 Ykr/ kg (~ 0.25 - 0.30$/ kg) whereas new one costs 75 Ykr/ kg (~ 0.55$/ kg). If rebar is damaged much, they can be recycled. Scrap metal elements, including rebar, onduline, cupper wire and plates, aluminium and zinc sheets and components, are sold for a price of 25 Ykr/ kg (~ 0.19$/ kg) to scrap dealers in Ivedik, Ankara, where they are pressed, packaged and taken to factories in Istanbul and Izmir to be melted and used in new production.

d) Brick

Bricks are also removed from the structure then they are cleaned with an adze. After that, they are sold for a price of 10 - 20 Ykr/ piece (~ 0.08 – 0.15$/ piece) to be used in traditional oven and chimney construction. Recovered bricks provide good heat insulation. Therefore, they are used to cover natural gas pipes under the ground to protect them from getting frozen. After cleaned and polished, used bricks can also be used for several decorative purposes. They are used in gardens as border at edges of footpaths. Furthermore, they can be used for cladding façades. Finally, a demolition contractor, Veli Biyik, claimed that salvaged bricks are exported to France, Japan and England for a price of 25 Ykr (~ 0.19$/ piece) to be used as decorative element such as in garden arrangements and cladding façades.

5.2.2 Buyers of Used Building Materials

In order to gather information about buyers of UBMs interviews were conducted with five demolition contractors[13]. They stated that using salvaged materials in new structures arises from economic concerns, since the price of second-hand material is three times cheaper than that of new one. As stated by Özkan (2000) and Isik (2003), the most frequent customers in Ankara were squatters. However, the Squatter's law was issued in 2003 and the law forbids building squatter's houses in Ankara. Therefore, squatters are no longer buyers of UBMs.

There are mainly four types of buyers of UBMs in Ankara. At present time, the most frequent buyers of UBMs are rural dwellers from the villages and people from provinces near Ankara, such as Bala, Gölbasi, Haymana, Kizilcahamam and Polatli. They mostly purchase windows, doors, lavatories, sinks, bathroom fittings and fixtures, roofing tiles, rebar and bricks. Another type of customer are merchants of UBM, who come from especially eastern and south-eastern Anatolia, such as Çorum, Eskisehir Gaziantep, Kahramanmaras, Samsun, Sivas, Sanliurfa and Yozgat. They buy truckloads of salvaged materials, and then sell them in their hometowns. Their customers are squatters, people from provinces, and villagers, customers who want to build houses near their fields. The other customer of UBMs are antique dealer who are looking for historic components and materials recovered from traditional Ankara houses in Hacettepe, Haci Bayram, Hamamözü, and Ulus. The houses have valuable materials and components such as ceiling panels, windows and doors.

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[13] Sezai Kilinç, a demoltion contractor, was contacted on-site in Yenimahalle in December 2004.

Hüseyin Koçak, a demoltion contractor, was contacted on-site in Yenimahalle in December 2004 and January 2005.

Veli Biyik, a demoltion contractor, was contacted on-site in Yenimahalle in December 2004 and January 2005.

Fevzi Sanci, a demolition contractor and the head of the Demolition Contractors' Association, was interviewed informally in June 2005.

Ali Batman, a demolition contractor on Bentderesi Avenue, was interviewed in June 2005.

5.3 Problems in Deconstruction of Buildings

During the dismantling processes observed, several problems were determined. These are explained as follow.

a) Building System:

Main problem arises from the overall design of the whole building since they were not designed for eventual disassembly. In our country, buildings are generally erected with reinforced concrete and masonry walls, which are plastered and painted. Pipes and cables go through the plaster. Since there is neither a technique nor equipment to deconstruct this type of structures, they have to be demolished.

b) Materials and Components:

Types of materials and components constituting a building are of importance to deconstruct a building. Materials and components that give rise to difficulties during the building deconstruction are explained as follow:

- Traditional bricks can be removed from the structure if mortar has started to crumble. Because mortar should be weaker than bricks to be recovered. On the other hand, extruded hollow bricks usually used in reinforced concrete structures cannot be recovered since they are thin and brittle materials. Furthermore, since they are built in a wall using cement mortar, it is not possible to recover extruded hollow bricks from the structure. Therefore, they have to be demolished.
- Timber components of roof structure can be recovered and reused for different purposes. However, the use of extra nails causes many holes at the edges of timber elements. These elements have to be cut and sized for reuse. Furthermore, timber elements that have decay and worm-eaten defects cannot be reused; therefore, they are sold as fuel to burn.

- Ceramic tiles cannot be recovered since they are laid on the floors with strong plaster or glues. Furthermore, they are thin materials; therefore, ceramic tiles have to be demolished.
- Reinforced concrete elements such as columns, beams and slabs cannot be recovered and reused; therefore, they are wasted. Mosaic poured in-situ is another material that gives rise to difficulties during the deconstruction activities. Mosaics poured in-situ cannot be recovered for reuse.

c) Adjoined Houses:

Such buildings represent another obstacle to building deconstruction. Since walls and reinforced concrete elements such as columns, beams, slabs and foundation of adjoined houses next to each other, these components are damaged during the demolition works.

d) Connections:

Connection types of the components are of significance. Windows and doors are usually installed with wooden anchors inside the walls to fix the frame to the wall. In building C, while the wooden anchors fixing the window/door to the walls were removed with a pickaxe (Figure 5.28), some defects occurred on the window frame/ doorframe were observed as shown in Figure 5.29.

Figure 5.28 Recovery of wooden anchors, which were used to fix the window to the walls (building C)

Figure 5.29 The window was damaged due to the use of wooden anchors fixing it to the walls (building C)

Furthermore, the ends of the door stiles are usually embedded in the flooring. In building C, while the ends of the door stiles were freed by breaking the mosaic poured in-situ around it, they were damaged. Therefore, the ends of the door stiles have to be cut to reuse in a new structure. This process causes the door to be shorter, which is a drawback for reuse of the door.

In addition, in building C there were windows and door produced as a unit. To deconstruct this unit, doorframe had to be cut with a saw and severed from the window to resale it as a window as shown in Figure 5.30. In this process, pieces of the doorframe were wasted. It was required to find or re-produce a doorframe for the recovered door wing to resale it as a door unit.

Figure 5.30 The windows and door produced as a unit (building C)

Furthermore, welded connections make deconstruction works difficult. Metal components that are welded cannot be deconstructed; therefore, they have to be demolished. In building C, a welded metal separator between two balconies could not be recovered; therefore, it was demolished with the help of a sledgehammer.

e) Worker's Inexperience:

In deconstruction, worker ability and experience is of paramount importance. For example, an inexperienced worker engaged in dismantling of building C spent more than forty minutes to disassemble a glazed-2-bays window while other workers deconstructed the same sized window about fifteen to twenty minutes. Furthermore, the beginner worker not only broke down whole windowpanes, but also severely damaged the timber frame of the window as shown in Figure 5.31. Therefore, the fenestration was wasted.

Figure 5.31 The window was wasted due to damage caused by lack of worker experience (building C)

f) Wrong Use/ Lack of Tools:

During the deconstruction of buildings, simple tools are used to recover materials and components from the structure, such as sledgehammer, pickaxe, adze, long handed wrenches, pincers and hammer. If they are not used properly, this causes materials and components in a building to be damaged. Furthermore, selection of tools that are suitable to recover the material is important. Wrong use of tools, and use of inappropriate tools and excess force damage the materials and components, and cause them to be broken or cracked thus to be wasted. Lack of appropriate tools to recover materials is another reason for increasing damage to the components during the deconstruction or extending the duration of the work. For instance, if pneumatic drill had been used to demolish reinforced concrete beams and slabs of building C, the deconstruction of the building would have taken less time.

g) Lack of Storage Space and Transport Costs

Lack of storage space and transport costs can be a reason for not recovering some building materials from the structure, such as brick. Demolition contractors prefer selling the recovered materials on-site. They do not want to take them to their yards because of transport expenses and the lack of storage space. Since there were neither potential buyer nor enough storage space to keep them in good condition, bricks of masonry walls in building B and building C were not salvaged. Therefore, they had to be landfilled.

5.4 Feasibility of Building Deconstruction

To assess the feasibility and profitability of the deconstruction and demolition works of the building C in Güzelevler quarter in Yenimahalle was selected as a case. The demolition contractor paid 1.250 YTL (~ 925$) to the construction contractor for deconstruction of the building. Since the demolition contractor had another job at hand, so he sublet the job to another demolition team to perform the deconstruction and demolition work for the agreed price of 1.450 YTL (~ 1075$). Therefore, the demolition contractor paid the sum of 2.700 YTL (~2000$) to the construction contractor and the demolition team. Clearly, the demolition contractor expected to earn more than 2.700 YTL (~ 2000$) and make a profit on this job.

The deconstruction work was started on 30 December 2004 and completed on 10 January 2005, that is, this job took twelve days to be completed. Most of the recovered materials were sold on-site during the dismantling process. The components that were sold on-site included windows, doors, roofing tiles, kitchen cabinets, bathroom fittings and fixtures, and timber elements from the roof. Recovered rebar was taken to the scrap dealer’s site to be sold as scrap iron. Recovered materials and their sale prices are given in Table 5.2 below. In the first column are the names of the used building materials recovered from the building C in Güzelevler listed, while their sizes and quantities are given in the subsequent two columns. In the fourth and fifth columns, sale prices of the used building materials are given in New Turkish Lira and US Dollar. The last two columns show calculation of minimum and maximum expected revenue from the project in New Turkish Lira and US Dollar. These prices were obtained from the demolition contractor of the building C on 1 January 2005.

Demolition contractor’s net income from deconstruction and demolition works can be calculated by using the equation 5.1 as given below.

Equation 5.1

Net income = (Income from Sales of UBMs) – (Fees for Deconstruction + Demolition + Repairs + Transportation) $\underline{+}$ (Fee Paid to/ by Building contractor)

As it is seen from the equation 5.1, determining factor of feasibility of the deconstruction work is income from sales of UBMs. Income from sale of UBMs is dependent on several factors like quality, quantity and condition of used components and materials. On the other hand, the condition of the recovered materials and components depends on worker experience and sufficient time to perform dismantling.

Table 5.2 Sale prices of used building materials recovered from the building C (January 2005)

Material	**Size**	**Quantity**	**Price in YTL**	**Price in US $**	**Expected revenue in YTL**		**Expected revenue in US**	
					Minimum	**Maximum**	**Minimum**	**Maximum**
Door	Standard unit	35 units	30 - 40	22.20 - 29.60	35 x 30	35 x 40	35 x 22.20	35 x 29.60
Window (glazed-3-bays)	2m x 1.2 m	6 units	25 - 35	18.50 - 25.90	6 x 25	6 x 35	6 x 18.50	6 x 25.90
Window (glazed-2-bays)	1.4m x 1.2 m	22 units	20 - 30	14.80 - 22.20	22 x 20	22 x 30	22 x 14.80	22 x 22.20
Kitchen sink-ceramic	Standard unit	3 pieces	5 - 10	3.70 - 7.20	3 x 5	3 x 10	3 x 3.70	3 x 7.20
Washbasin	Standard unit	4 pieces	8 - 10	5.90 - 7.40	4 x 8	4 x 10	4 x 5.90	4 x 7.40
Washbasin	Small	4 pieces	5 - 8	3.70 - 5.90	4 x 5	4 x 8	4 x 3.70	4 x 5.90
Commode	Standard unit	3 pieces	10 - 15	7.40 - 11.10	3 x 10	3 x 15	3 x 7.40	3 x 11.10
Wrought iron balcony balustrade	0.90 x 3.5 m	3 units	7 / 0.90 x 1.0m	5.20 / 0.90 m x 1.0 m	3 x 7	3 x 7	3 x 5.20	3 x 5.20
Cupboard	2.50 x 0.80 m	3 pieces	50 - 70	37 - 52	3 x 50	3 x 70	3 x 37	3 x 52
Wardrobe (built-in)	3 m x 2.70 m	3 units	50 - 70	37 - 52	3 x 50	3 x 70	3 x 37	3 x 52

Table 5.2 Sale prices of used building materials recovered from the building C (January 2005) (continued)

Material	**Size**	**Quantity**	**Price in YTL**	**Price in US $**	**Expected revenue in YTL**		**Expected revenue in US $**	
					Minimum	**Maximum**	**Minimum**	**Maximum**
Roofing tile	Standard unit	2500 pieces	0.10 - 0.20 /piece	0.08 - 0.15 /piece	2500 x 0.10	2500 x 0.20	2500 x 0.08	2500 x 0.15
Rebar	Various sizes	5300 kg	0.35 /kg	0.25 /kg	5300 x 0.35	5300 x 0.35	5300 x 0.25	5300 x 0.25
Zinc components	Various sizes	80 kg	1.25 - 2.50 /kg	0.74 - 0.93 /kg	80 x 1.25	80 x 2.50	80 x 0.74	80 x 0.93
Timber elements	Various sizes	4 m³	100 /m³	74.00 /m³	4 x 100	4 x 100	4 x 74	4 x 74
Brick	5 x 9 x 19 cm	2500 pieces	0.20 /piece	0.08 /piece	2500 x 0.20	2500 x 0.20	2500 x 0.08	2500 x 0.08
					5240	**6390**	**3880**	**4730**

(1.35 YTL ~ 1.00 $)

Furthermore, while assessing the feasibility of deconstruction, the costs of deconstruction, processing of UBMs, storage facilities and transportation are of significance. The deconstruction and demolition processes are performed by unskilled workers. Furthermore, the demolition workers have no health insurance; therefore, the labour cost is very low. Due to time constraints processing of UBMs is conducted in warehouses. This reduces labour time on site. Moreover, transportation fees can be decreased by selling UBMs on site. Finally, price paid to /by building contractor is dependent on quality, quantity and condition of materials and components constituting the building.

On the other hand, the job was performed by a sub-contractor; therefore, the sub-contractor's net income from the deconstruction and demolition of the building D was calculated by using the equation 5.2 as shown below.

Equation 5.2

Net income = (Expected income from Sales of UBMs) – (Fee Paid to Sub-contractor) – (Fee Paid to Building contractor)

According to equation 5.2;

Minimum net income for the building D = 5240 YTL – 1450 YTL – 1250 YTL [3880$ – 1075$ – 925$]

Minimum net income for the building D = 2540 YTL [1880$]

Maximum net income for the building D = 6390 YTL – 1450 YTL – 1250 YTL [4730$ – 1075$ – 925$]

Maximum net income for the building D = 3690 YTL [2730$]

This equation and Table 5.2 clearly show that the demolition contractor expected to make a profit between 2540 - 3690 YTL (1880 - 2730$). This figure also shows that the demolition work is a profitable job.

It is important to note here that the demolition contractor was not pleased with questions related to the prices of used building materials and he did not want to declare how much he sold them. Instead, he preferred to give their average prices. Therefore, recovered materials were counted and approximate prices were calculated by the author. When the author was incapable of predicting the quantity of some recovered material, workers engaged in dismantling of the building D were asked for the quantities of some materials such as the quantities of rebar, aluminium and zinc components and roofing tiles. Therefore, it was preferred to calculate maximum and minimum net income for the building separately. For minimum net income calculation, lowest prices of the UBMs from Table 5.2 were used, while calculating maximum net income, highest prices of the UBMs from Table 5.2 were used.

To compare the prices of UBMs with new materials, a price investigation was conducted in Ankara. Prices of used building materials and components were obtained from demolition contractors[14] while prices of new materials and components were gathered from several markets producing and/or selling these materials in Kizilay, Ulus and Siteler, Ankara[15]. These prices were compiled and given in Table 5.3. In the first column are the names of materials listed while their sizes are presented in the second column. In the subsequent two columns, prices of UBMs and new materials are given. The last column shows savings (%).

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[14] Hüseyin Koçak, demoltion contractor of building C, was contacted on-site in Yenimahalle in December 2004 and January 2005.

Sezai Kilinç, a demoltion contractor, was contacted on-site in Yenimahalle in December 2004.

Veli Biyik, a demoltion contractor, was contacted on-site in Yenimahalle in December 2004 and January 2005.

[15] Appendix E gives the contacted companies producing and/or selling new building materials in Kizilay, Ulus and Siteler, Ankara.

Table 5.3 Prices of used building materials and new materials

Material	**Size**	**Price of UBM in YTL**	**Price of new material in YTL**	**Savings (%)**
Door	Standard unit	30 - 40	80 - 160	63-75
Window	Various sizes	20 - 30	60 - 120	66-75
Kitchen sink	Standard unit	5 - 10	40 - 80	88
Washbasin	Standard unit	8 - 15	30 - 50	70-73
Washbasin	Small	5 - 8	20 - 30	73-75
Commode	Standard unit	10 - 15	50 - 75	80
Commode with reservoir	Standard unit	25 - 35	75 - 100	65
Roofing tile	Standard unit	0.10 - 0.20 /piece	0.25 - 0.30 /piece	33-40
Brick	5 x 9 x 19cm	0.10 - 0.20 /piece	0.25 - 0.35 /piece	40
Rebar	Various sizes	0.25 - 0.40 /kg	0.75 /kg	46-66
Zinc sheet & rain gutter	Various sizes	1.25 - 2.50 /kg	5.50 - 7.00 /kg	60-77
Parquet	Various sizes	10.00 /m^2	16 - 25 /m^2	38-60
Copper wiring	1.5 - 2.5 cm diameter	3.00 /kg	7.08 /kg	58
Roofing sheet	Standard unit	2.00 /m^2	6.00 /m^2	66
Wrought iron heating radiator	Various sizes	10.00 /m^2	40 - 50 / m^2	75-80
Timber components	Various sizes (5x5, 5x10, 10x10, and 2x20 cm)	100 /m^3	From 160 /m^3 for poplar From 260 /m^3 for pine	38 62

As it is seen from the Table 5.3, UBMs are 33-80% as cheap as new materials. From the economical point of view, the use of UBMs in new construction projects can provide significant savings while reducing negative environmental impacts and the need for new materials and resources. If the factors affecting the feasibility of deconstruction as mentioned earlier are handled well, better salvage value can be achieved for UBMs as well as feasibility and profitability of the deconstruction work can be attained.

CHAPTER VI

CONCLUSIONS

To assess current deconstruction and demolition activities in Turkey the city of Ankara was chosen as the study area. Information pertinent to deconstruction and demolition, recovery of UBMs as well as market prices of UBMs was obtained through informal interviews with two building contractors, eleven demolition contractors, seven demolition teams from the work sites observed, and five companies producing and/or selling new building materials. Information with regard to official procedure for demolition was gathered from two departmental head and four officials of Building Control Authority of Çankaya and Yenimahalle Municipalities in Ankara. Deconstruction and demolition processes of three residential buildings were observed. Of these, whole deconstruction and demolition processes of one building were observed and selected as the case study. To assess the feasibility of the building deconstruction a market survey was conducted. Findings of the survey indicated that deconstruction is a feasible and profitable job.

The following situations were determined as a result of this study:

- Most of UBMs are reused as either it is or after modifications, and waste timber components are sold for fuel, while only metals are recycled to be used in new production.
- Traditional bricks are mostly removed from the structure provided the mortar has started to crumble, whereas extruded hollow bricks have to be demolished.
- Reinforced concrete components, such as columns, beams and slabs, can neither be reused nor recycled; therefore, they are demolished.

- Resulting debris is mostly left on the site to be sent later to landfill areas by the building contractor. Sometimes resulting debris is not sent to landfill areas; instead, it is used for filling the site.
- Safety measurements on the work sites are not taken into consideration.
- Due to lack of storage space for UBMs, brick/ masonry has to be demolished and landfilled.
- Workers engaged in dismantling practices have no health insurance. This is considered to reduce both the labour cost and the cost of UBMs, although it is neither legal nor ethical.

Some problems in deconstruction of buildings were determined. These are related to:

- Building systems, which are not designed for disassembly,
- Materials and components, such as extruded hollow bricks, ceramic tiles, reinforced concrete elements, mosaic poured in-situ, give rise to difficulties during the deconstruction of buildings,
- Adjoined houses,
- Connection types of components used in a building,
- Lack of worker experience,
- Wrong use of tools, lack of appropriate tools, and use of inappropriate tools and excess force,
- Lack of storage space and transport costs.

There are laws, rules and regulations issued by the Ministry of Works and the Ministry of the Environment in Turkey, related to construction and demolition works, worker training, health, safety and employment conditions as well as reuse and recycling of demolition waste and solid waste management. Furthermore, as cited in literature, ‘Technical Contract for demolition and Dismantling’ prepared by the Ministry of Development and Housing is present and it deals with all technical aspect of deconstruction and demolition works. However, demolition contractors are not aware of it. For example, such a contract was not drawn between the parties of building A, B and C, nor was there a definite price for demolition works.

Some steps are recommended to promote and improve deconstruction of buildings. These are as follow.

- Techniques should be developed, and required tools and equipment should be provided to deconstruct existing buildings that are not designed for disassembly.
- Type, quality and quantity of materials and components used in a building affects the feasibility of building deconstruction. In this context, standardization of building materials and components should be achieved both to increase and make easy the use of used, modified and recycled materials and components in new construction projects.
- Architects have an important role in designing of buildings for future disassembly; therefore, they should be informed about the subject.
- For new construction projects, demountable, modular, prefabricated and open building systems should be improved and promoted especially for walls and slabs for ease of deconstruction.
- During the deconstruction and demolition process, care and experience of the workers are of paramount significance. Due to the lack of worker experience, some materials were wasted during the deconstruction. In this context, training programme should be provided for workers engaged in the deconstruction and demolition job.
- For a safe demolition work, demolition contractors should employ structural /civil engineers to assess the building to be demolished.
- Demolition workers should take safety precautions such as wearing safety belts, protective helmets and safety glasses.

Based on the literature survey, the following suggestions are also found to be important. Further legislation is needed to encourage deconstruction of buildings, and recovery, reuse and recycling of UBMs. The government should promote dismantling activities such as by doing the following:

- increasing taxes for landfilling of demolition waste.
- giving more control to local authorities to check demolition activities.
- enacting further laws, rules and regulations to encourage dismantling activities as well as the use of used, modified and recycled building materials in new construction projects.
- promoting establishment of facilities, in which processing and recycling of UBMs can be done.
- developing a certification system to certify UBMs. The use of UBMs in new construction projects is not allowed since the Turkish Standards Institute (TSE - *Türk Standartlari Enstitüsü*) does not certify such materials.

REFERENCES CITED

1. Abdullah, A. and Anumba, C.J., Decision Tools for Demolition Techniques Selection, Proceedings of the 11th Rinker International Conference, Deconstruction and Materials Reuse, CIB Publication 287, Gainesville, Florida, USA, May 7-10 2003, pp. 55-72.

2. Ankara city map, the Journal of Skylife, Dogan Ofset Yayincilik ve Matbaacilik A.S., Istanbul, May 2005.

3. Ayres, R.U. and Ayres, L.W. Industrial Ecology: Towards Closing the Materials Cycle, Edward Elgar, Cheltenham, 1996, pp. 13-15.

4. Bart, J.H. and Kowalczyk, T., State of Deconstruction in the Netherlands, Proceedings of the CIB Task Group 39, Overview of Deconstruction in Selected Countries, Report 5, CIB Publication 252, August 2000.

5. Chini, A.R. and Acquaye, L., Grading and Mechanical Properties of Salvaged Lumber, Proceedings of the CIB Task Group 39, Deconstruction and Materials Reuse: Technology, Economic, and Policy, Wellington, New Zealand, 6 April 2001, pp. 138-162.

6. Chini, A.R. and Bruening, S.F., Deconstruction and Materials Reuse in The United States, Proceedings of the CIB Task Group 39, Overview of Deconstruction in Selected Countries, Report 10, CIB Publication 252, August 2000.

7. Chini, A.R. and Bruening, S.F., Deconstruction and Materials Reuse in the Unites States, Special article in: The Future of Sustainable Construction, IeJC, 14 May 2003.

8. Chini, A.R. and Nguyen, H.T., Optimizing Deconstruction of Lightwood Framed Construction, Proceedings of the 11th Rinker International Conference, Deconstruction and Materials Reuse, CIB Publication 287, Gainesville, Florida, USA, May 7-10 2003, pp. 311-321.

9. Crowther, P., The State of Building Deconstruction in Australia, Proceedings of the CIB Task Group 39, Overview of Deconstruction in Selected Countries, Report 1, CIB Publication 252, August 2000.

10. Crowther, P., Developing an Inclusive Model for Design for Deconstruction, Proceedings of the CIB Task Group 39, Deconstruction and Materials Reuse: Technology, Economic, and Policy, Wellington, New Zealand, 6 April 2001.

11. Crowther, P., Design for Buildability and the Deconstruction Consequences, Proceedings of the CIB Task Group 39, Design for Deconstruction and Materials Reuse, CIB Publication 272, Karlsruhe, Germany, 9 April 2002, pp. 6-14.

12. Crowther, P., Design of Buildings and Components for Deconstruction, Queensland University of Technology, Australia, http://web.dcp.ufl.edu/ckibert/DeconstructionBook/Chapters/Crowther-Chap-7.doc, accessed on 1 May 2004.

13. Çelik, S., Ankara City Map 2003, ÇS Haritacilik, Ankara, 2003.

14. Durmusevic, E. and Brouwer, J., Design Aspects of Decomposable Building Structures, Proceedings of the CIB Task Group 39, Design for Deconstruction and Materials Reuse, CIB Publication 272, Karlsruhe, Germany, 9 April 2002, pp. 81-103.

15. Durmusevic, E. and Van Lersel, T.M., Life Cycle Coordination of Materials and their Functions at Connection Design for Total Service Life of Buildings and its Materials, Proceedings of the 11th Rinker International Conference, CIB Deconstruction and Materials Reuse, CIB Publication 287, Gainesville, Florida, USA, May 7-10 2003, pp. 285-294.

16. Elias-Özkan, S.T., An Overview of Demolition, Recovery, Reuse and Recycling Practices in Turkey, Proceedings of the CIB Task Group 39, Design for Deconstruction and Materials Reuse, CIB Publication 272, Karlsruhe, Germany, 9 April 2002, pp. 128-138.

17. Elias-Ozkan, S.T., The State of Deconstruction in Turkey, Proceedings of the CIB Task Group 39, Overview of Deconstruction in Selected Countries, Report 8, CIB Publication 252, August 2000.

18. Erkelens, P.A., Re-Use of Building Components (Towards Zero Waste in Renovation), Proceedings of the 11th Rinker International Conference, CIB Deconstruction and Materials Reuse, CIB Publication 287, Gainesville, Florida, USA, May 7-10 2003, pp. 125-137.

19. Fort Ord Reuse Authority (FORA), Fort Ord Pilot Deconstruction Project, Final Report, Monterey Peninsula, California, USA, December 1997.

20. Futaki, M., The State of Deconstruction in Japan, Proceedings of the CIB Task Group 39, Overview of Deconstruction in Selected Countries, Report 4, CIB Publication 252, August 2000.

21. Graedel, T.E. and Allenby, B.R. Industrial Ecology, Prentice Hall, Englewood Cliffs, New Jersey, 1995, pp. 260-275.

22. Guy, B., Building Deconstruction Assessment Tool, Proceedings of the CIB Task Group 39, Deconstruction and Materials Reuse: Technology, Economic, and Policy, Wellington, New Zealand, 6 April 2001, pp.125-137.

23. Guy, B., Design for Deconstruction and Materials Reuse, Proceedings of the CIB Task Group 39, Design for Deconstruction and Materials Reuse, CIB Publication 272, Karlsruhe, Germany, 9 April 2002, pp. 189-209.

24. Guy, B., Creating Business Opportunities Through the Use of a Deconstruction Feasibility Tool, Proceedings of the 11th Rinker International Conference, CIB, Deconstruction and Materials Reuse, CIB Publication 287, Gainesville, Florida, USA, May 7-10 2003, pp. 36-47.

25. Hobbs, G. and Hurley, J., Deconstruction and the Reuse of Construction Materials, Proceedings of the CIB Task Group 39, Deconstruction and Materials Reuse: Technology, Economic, and Policy, Wellington, New Zealand, 6 April 2001, pp. 98-124.

26. Hurley, J., Design for Deconstruction Tools and Practices, Proceedings of the CIB Task Group 39, Design for Deconstruction and Materials Reuse, CIB Publication 272, Karlsruhe, Germany, 9 April 2002, 139-174.

27. Hurley, J. and Hobbs, G., UK Country Report on Deconstruction, Proceedings of the CIB Task Group 39, Overview of Deconstruction in Selected Countries, Report 9, CIB Publication 252, August 2000.

28. ILSR (Institute for Local Self-Reliance), Deconstruction at Work, http://www.ilsr.org/recycling/decon/deconatwork.html, accessed on 9 July 2004a.

29. ILSR (Institute for Local Self-Reliance), Economic Benefits, http://www.ilsr.org/recycling/economicbenefits.htm, accessed on 9 July 2004b.

30. ILSR (Institute for Local Self-Reliance), Environmental Benefits, http://www.ilsr.org/recycling/environmentalbenefits.htm, accessed on 9 July 2004c.

31. Isik, A., Disassembly and Reuse of Building Materials: a Case Study on Salvaged Timber Components, unpublished Master Thesis, Middle East Technical University, Ankara, 2003.

32. Kernan, P., Design Guide: Salvaged Building Materials in New Construction, under contract to the Greater Vancouver Regional District and Policy & Planning Department, 3rd Edition, Greater Vancouver, January 2002.

33. Kibert, C.J. and Chini, A.R., Introduction: Deconstruction as an Essential Component of Sustainable Construction, Proceedings of the CIB Task Group 39, Overview of Deconstruction in Selected Countries, Report 7, CIB Publication 252, August 2000.

34. Kibert, C.J. and Languell, J.L., Implementing Deconstruction in Florida: Materials Reuse Issues, Disassembly Techniques, Economics and Policy, Prepared for the country status report of the CI:B Task Group 39 on Deconstruction, ME Rinker SR School of Building Construction, Centre for Construction and Environment, University of Florida, Gainesville, Florida, USA, June 14, 2000.

35. Languell, J.L., Development of a Prototype Assessment Tool to Evaluate the Potential to Successfully Implement Deconstruction as a Regional Waste Reduction Strategy, Unpublished PhD Thesis, University of Florida, Florida, USA, 2001.

36. Lassandro, P., Deconstruction Case Study in Southern Italy: Economic and Environmental Assessment, Proceedings of the 11th Rinker International Conference, Deconstruction and Materials Reuse, CIB Publication 287, Gainesville, Florida, USA, May 7-10 2003, pp. 115-124.

37. Macozoma D.S., Building Deconstruction, CSIR Building and Construction Technology, South Africa, CIB publication, December 2001a.

38. Macozoma D.S., Review of the US Secondary Construction Materials Market: Any Lessons for South Africa and other Developing Countries?, CSIR Building and Construction Technology, South Africa, CIB publication, December 2001b.

39. Macozoma, D.S., Understanding the Concept of Flexibility in Design for Deconstruction, Proceedings of the CIB Task Group 39, Design for Deconstruction and Materials Reuse, CIB Publication 272, Karlsruhe, Germany, 9 April 2002, 118-127.

40. NAHB Research Center, Deconstruction: Building Disassembly and Material Salvage: The Riverdale Case Study, Prepared for U.S.

Environmental Protection Agency and The Urban and Economic Development Division, by the NAHB Research Center Inc., Upper Marlboro, MD, USA, June 1997.

41. NAHB Research Center, A Guide to Deconstruction, Prepared for U.S. Department of Housing and Urban Development Office of Policy Development and Research Washington, D.C., by the NAHB Research Center Inc., Upper Marlboro, MD, USA, February 2000.

42. NAHB Research Center, A Report on the Feasibility of Deconstruction: An Investigation of Deconstruction Activity in Four Cities, Prepared for U.S. Department of Housing and Urban Development Office of Policy Development and Research, Washington, D.C., by the NAHB Research Center Inc., Upper Marlboro, MD, USA, January 2001.

43. Özkan, S.T.E., Recovery and Reuse of Demolition Waste: Recycling Rubble for Concrete Components, unpublished PhD Thesis, Middle East Technical University, Ankara, 2000.

44. Poon, C.S. and Jaillon, L., A Guide for Minimizing Construction and Demolition Waste at the Design Stage, Department of Civil and Structural Engineering, The Hong Kong Polytechnic University, February 2002.

45. Pulaski, M., Hewitt, C., Horman, M. and Guy, B., Design for Deconstruction, Journal of Modern Steel Construction, June 2004.

46. Schultmann, F., Deconstruction in Germany, Proceedings of the CIB Task Group 39, Overview of Deconstruction in Selected Countries, Report 2, CIB Publication 252, August 2000.

47. Seldman, N. and Jackson, M., Deconstruction at Work, http://www.ilsr.org/recycling/decon/deconatwork.html, accessed on 9 July 2004.

48. Sev, A. and Özgen, A., Yüksek Binalarda Sürdürülebilirlik ve Dogal Havalandirma, the Journal Yapi, vol. 262, p. 92-99, Istanbul, September 2003.

49. Sherman, R., Deconstruction: Giving Old Buildings New Lives, North Carolina Cooperative Extension Service, College of Agriculture and Life Sciences, North Carolina State University, North Carolina, USA, 1998.

50. Storey, J.B., Gjerde, M., Charleson, A. and Pedersen, M., The State of Deconstruction in New Zealand, Proceedings of the CIB Task Group 39, Overview of Deconstruction in Selected Countries, Report 6, CIB Publication 252, August 2000.

WEB SITES

1. 3R Demolition, http://www.3rdemolition.com, accessed in July 2004.

2. A Guide for Managing and Minimizing Building and Demolition Waste, http://www.cse.polyu.edu.hk/~cecspoon/lwbt/Guide_Book/Guide_Book_01/ Guide_Book_01.htm, accessed in July 2004.

3. A Guide for Minimizing Construction and Demolition Waste at the Design Stage, http://www.cse.polyu.edu.hk/~cecspoon/lwbt/Guide_Book/Guide_Book_02/Guide_Book_02.htm, accessed in July 2004.

4. A Guide to Deconstruction, http://www.deconstructioninstitute.com/files/learn_center/45762865_guidebook.pdf, accessed in July 2004.

5. A Report on the Feasibility of Deconstruction, http://www.huduser.org/Publications/PDF/deconstruct.pdf, accessed in July 2004.

6. Build for Disassembly, Reuse & Recycling, http://www.greenbuildings.santa-monica.org/materials/matreuserecycling.html, accessed in July 2004.

7. Builders' Guide to Reuse & Recycling, http://www.stopwaste.org/2003bg.pdf, accessed in July 2004.

8. Buildings Designed for Disassembly, http://www.shef.ac.uk/architecture/research/postcur/slf/build.html, accessed in October 2004.

9. Construction and Demolition Materials, http://www.ciwmb.ca.gov/ConDemo/Materials/, accessed in July 2004.

10. Costello Dismantling, http://www.costellodismantling.com, accessed in July 2004.

11. Deconstruction and its Benefits, http://www.ilsr.org/recycling, accessed in July 2004.

12. Deconstruction, Design for Deconstruction and Materials Reuse, http://www.cce.ufl.edu/pdf/, accessed in July 2004.

13. Deconstruction: Techniques, Economics, and Safety, http://web.dcp.ufl.edu/ckibert/DeconstructionBook/, accessed in July 2004.

14. DEXPAN Non-Explosive Demolition Agent for Concrete Cutting, http://www.archerusa.com/Product_Dexpan_En1.html, accessed in July 2004.

15. Design for Deconstruction and Materials Reuse, http://www.deconstructioninstitute.com/files/downloads/75508728_DesignforDeconstructionPaper.pdf, accessed in July 2004.

16. Design for Disassembly, http://www.buildsmart.ca/pdfs/DesignGuideMaster-section5.pdf, accessed in July 2004.

17. D. Litchfield Demolition, Recycling, and Building Supply Specialists, http://www.dlitchfield.com, accessed in July 2004.

18. International Council for Research and Innovation in Building Construction (CIB), http://www.cibworld.nl, accessed in July 2004.

19. Salvaged Building Materials in New Construction, http://www.buildsmart.ca/pdfs/DesignGuideMaster-section1-2.pdf, accessed in July 2004.

20. Strategies for Waste Reduction of Construction and Demolition Debris from Buildings, http://www.ilsr.org/recycling/buildingdebris.pdf, accessed in July 2004.

21. The Green Institute, http://www.greeninstitute.org/, accessed in July 2004.

22. Zero Waste - A New Vision for the 21st Century, http://www.grrn.org/zerowaste/articles/21st_cent_vision_zw.html, accessed in July 2004.

APPENDIX A

HAZARDOUS SUBSTANCES

Adopted directly from NAHB Research Center Report (1997) and Kibert and Languell, (2000).

Asbestos Containing Materials

A list of asbestos containing materials

- Window Glazing
- Stucco
- Cement Pipes
- Cement board/transite
- Duct tape/paper
- Furnace insulation
- Vinyl sheet flooring/mastic
- Vinyl floor tile/mastic
- Poured Flooring
- Pipe insulation/fittings
- Incandescent light fixture backing
- Textured paints/coatings
- Ceiling tiles/panels/mastic
- Spray-applied insulation
- Blown-in insulation
- Base flashing
- Rolled roofing
- Caulking/putties
- Nicolet (white) roofing paper
- Sub flooring slip sheet
- Fireproofing
- Sink insulation
- Packing materials
- High temperature gaskets
- Lab hoods/table tops
- Fire blankets
- Fire curtains/hose
- Sink insulation
- Elevator brake shoes
- Asphalt flooring
- Paper on backside of fiberglass insulation
- Elevator brake shoes
- Asphalt flooring
- Paper on backside of fiberglass insulation
- Erkot roofing material
- Plaster/wall joints
- Joint compound/wallboard
- Brick mortar
- Vinyl wall covering
- Laboratory fume hoods
- Paper firebox in walls
- Fire doors
- HVAC Duct insulation
- Boiler/tank insulation
- Breaching insulation
- Roofing shingles
- Construction mastics
- Acoustical ceiling textures
- Electrical panel partitions
- Mudded pipe elbow insulation
- Electrical wiring insulation
- Chalkboards
- Ductwork flexible connections
- Built-up roofing
- Vapor barrier
- Cement roofing shingles
- Gray roofing paint
- Electrical cloth

Identification

There is no definitive way to determine the presence or absence of asbestos in the field. While experienced abatement contractors often have a good sense of which building components are suspect, identification and asbestos content can only be accomplished using polarized light microscopy and quantification of asbestos content must be done by certified laboratories following exacting standard procedures.

US Environmental Protection Agency (EPA) Regulations

According to EPA rules, the removal and disposal of all friable ACM must be accomplished prior to any building removal work. The techniques and equipment required for asbestos (full-mask respirators, negative air pressure systems) mean that only licensed, professional abatement firms handle these materials. EPA rules identify two other types of ACM: category I non-friable (materials such as asphalt roofing shingles and floor tiles) and category II non-friable (materials such as asbestos siding shingles and transite board). Category I ACM need only be removed prior to building removal if the material's condition is such that the material has become friable. Category II ACM need only be removed if the material is likely to become friable during the building removal process.

US Occupational Safety and Health Administration (OSHA) Regulations

According to OSHA rules, handling any ACM without asbestos abatement techniques and equipment is based on a permissible exposure limit (PEL) of no more than a 8-hour, time weighted average (TWA) of 0.1 fiber per cubic centimeter or an excursion limit of 1.0 fiber per cubic centimeter in a sampling period of thirty minutes. Exposure to workers above this limit requires asbestos abatement measures (including full respirators, negative pressure systems, etc.). Typically the measurement of these exposures is handled by an industrial hygienist obtaining filter samples from workers wearing powered air supplies and respirators.

Disposal of friable asbestos is the responsibility of the licensed abate contractor. The disposal of non-friable ACMs such as mo mg shingles and resilient floor coverings is not regulated at the federal level. In most cases, these materials can be disposed of in a construction and demolition (C&D) or municipal solid waste (MSW) landfill, but check local landfill policies beforehand.

Lead Based Paint

Identification

There are several different tests for lead-based paint. Understanding the nature and reason for each test is important in understanding how to handle LBP.

1. LBP Test Sticks: The general presence or absence of lead can easily be determined in the field using paint sticks (the stick or "crayon" or swab is part of a rhodizonate spot test kit). The stick must come in direct contact with each layer of paint being tested. These test kits are relatively inexpensive (less than $20), are readily available, and can be used by anyone. This test should only be used as an initial determination of the magnitude of the LBP problem on a project, positive results suggest more detailed analysis and negative results from test sticks are not accepted by regulatory agencies as conclusive evidence of the absence of lead.

2. X-ray Fluorescence (XRF) and Atomic Absorption Spectroscopy (AAS): Determination of the *concentration of lead in paint or coatings* can be accomplished in the field by XRF equipment, milligrams per square centimeter, or in a laboratory by AAS, % by weight. These tests must be performed with highly trained technicians with equipment ranging in cost from $4,000 to $40,000. These tests have limited utility for the building removal industry (see discussion following number 4) and are most useful for large HUD or other rehabilitation projects.

3. Toxicity Characteristic Leaching Procedure (TCLP): Determination of the *lead leaching potential in mixed debris* is accomplished by a TCLP. A TCLP must be conducted according to standard procedures with the sample sent to a certified laboratory for analysis. TCLP tests cost approximately $50 or less. A TCLP test determines whether or not a load of demolition debris must be handled as hazardous waste (5 parts per million or greater).

4. Air Monitoring of Workers: The determination of *lead concentration in the air* is done by collecting respiratory filter samples over a specific time period that are subsequently analyzed by a lab--micrograms per cubic meter. Usually, an industrial hygienist collects the samples and sends the samples out for laboratory analysis. Air sampling and testing can cost several hundred dollars. This test is required by OSHA to forego extensive worker protection practices for specific demolition activities such as plaster removal.

There is considerable discussion regarding the relationships between XRF (field test) and AAS (lab test) determinations of lead concentration, between XRF/AAS (concentrations of lead on surfaces) and TCLP determinations (concentrations of lead in mixed debris), and between XRF/AAS (surface concentration tests) and air sampling determinations (concentration of lead in air in work settings).

1. Uncertainties in XRF field determinations can require verification by AAS analysis.
2. No study has ever established a statistically satisfactory relationship between XRF/AAS and TCLP results.
3. The number of variables affecting the relationship between XRF/AAS and air sampling results lead to little if any relationship between concentrations of lead in materials and lead in the air during demolition or deconstruction activities.

The final result of all these uncertainties is that the best information most likely to be available on lead-based paint in a building, XRF or AAS test results-will provide little help and certainly no conclusive evidence that can be used in complying with EPA disposal regulations and OSHA worker protection requirements.

US EPA Regulations

EPA rules on the disposal of LBP building materials require that the material be handled as hazardous if a Toxicity Characteristic Leaching Procedure (TCLP) reads more than 5 parts per million in lead. The TCLP is a test performed by certified laboratories. Building demolition debris, mixed plaster, masonry, roofing shingles, and LBP wood, generally passes the TCLP and so litt1e demolition debris is, from a disposal perspective, handled as hazardous. Any time building components with significant lead levels (1.0 mg/cm^2 or greater) are segregated for disposal, a TCLP test should be considered.

Although unlikely to result in a failed TCLP, it is possible that salvage of building materials could change the overall concentration of lead in the fraction of the building destined for the landfill. The important points here are that you may not intentionally dilute your disposal mix to pass a TCLP but you are also not required to intentionally segregate LBP building materials. Recent research suggests that the long term leaching characteristics of LBP materials are such that disposal of these materials in either a C&D or a MSW landfill is appropriate.

US OSHA Regulations

All of OSHA rules pertaining to LBP materials are based on exposure levels--the concentration of lead in the air. There is an action level (AL), 30g/m^3 for an 8-hour time weighted average, and a permissible exposure limit (PEL), 50 g/m^3. The action level triggers compliance measures, respirators, protective work clothing, change areas, hand washing facilities, biological monitoring (blood level checks), and training. The PEL sets an absolute level of exposure for an 8-hour workday. It is the responsibility of the employer to observe the compliance measures if workers are conducting activities at or beyond the AL. Research data or data from other work projects can be used to demonstrate that specific activities and or materials do not lead to conditions at or beyond the action level. Except for specific activities identified by OSHA as an activity that is assumed to involve exposure levels at or above the AL. One of the activities so cited is manual demolition.

Other Information

Both EPA and OSHA have rules governing the management of lead-based paint in buildings. The language of EPA disposal regulations makes no distinction between a deconstruction and demolition approach. OSHA rules identify manual demolition of any material containing lead as an activity that is presumed to require lead exposure worker protection measures, regardless of absolute levels of lead in painted surfaces.

OSHA and EPA both recognize that deconstruction is a less invasive destructive process than mechanical demolition, but conversely that it has the potential for greater exposure by workers to ACM and LBP. The following protocol has been established for deconstruction in an interior LBP environment:

1) All workers receive an ACM and LBP awareness approved training course.

2) All exterior windows and doors are opened or removed to allow ventilation and prevent accumulation and concentrations of LBP particulate matter during deconstruction activities.

3) All workers in the LBP environment are provided personal fit-tested and approved respirators and protective clothing until personal air samples are analyzed and record lead levels below the acceptable threshold for worker exposure.

4) A HEPA vacuum is utilized throughout the building interior to remove all dust and particulate matter to the maximum extent feasible.

5) Indoor air quality analysis is completed using approved personal air sampling devices to determine TWA-PEL of lead within the work environment.

6) At such time as air sampling is recorded which shows airborne lead levels below OSHA thresholds, respirators and protective clothing will be removed.

7) In all cases, workers will be rotated out of LBP environments on a short-cycle and regular basis.

8) Job-site hand washing station will be provided.

9) Smoking is prohibited inside the structure and near any salvaged materials. Workers are required to wash hands before breaks and lunch breaks.

10) Sanding, cutting, grinding, abraded, burning and heat-gun stripping of LBP surfaces is not permitted.

11) Workers are provided with uniform T-shirts and required to change them at the completion of the work shift and before leaving the job-site.

If LBP building materials are to be reused, steps must be taken to minimize lead hazards. The painted surface may be stripped using stripping solutions, recoated with non-LBP, or coated with some other protective coating. It the LBP building material is to be used for energy recovery, it may only be burned in combustors operated in compliance with air pollution prevention requirements. The use of LBP building material as mulch or ground cover is not appropriate since it may result in exposure to lead through inhalation or ingestion.

Lead abatement should always be cleared with authorities at a local level to ensure compliance with all applicable regulations.

APPENDIX B

DISMANTLING TOOLS

Adopted directly from NAHB Research Center Report (1997) and FORA Report (1997).

Deconstruction tools are generally simple construction tools that are intended to provide easy, low-level skill building material disassembly and produce minimal damage to salvaged materials. The tools should represent the simplest form of deconstruction and should enable deconstruction to be easily reproducible at low-cost in other projects.

Typical deconstruction tools include, but are not limited to:

Individual worker tools:

- Too1 belt
- "Bear Claw" style nail puller
- Hammers (c1aw and masonry)
- Screwdrivers
- Wire-cutting pliers
- Utility knives
- Air purifying, half face respirator
- Safety boots
- Long pants
- Hard hat

Shared too1s and equipment:

- Generator
- Hepa-vac
- Extension cords
- Saws (reciprocating saw and circular saw)
- Sawhorses
- Reversible drill, drill bits and extension cords
- Sledgehammer
- Axe
- Wrecking bar
- Ropes and chains
- Crowbars (various lengths)
- Mechanical nail puller
- Hydraulic pallet jack
- Wheel barrows
- Shovels (various types), forks and rakes
- Brooms (various types)
- Scrapers
- Wrenches
- Ladders (various lengths)
- Truck (light loads)
- Tape measures
- Fire extinguisher
- First aid kit
- Masonry chisels

Supporting equipment:

- Dumpsters
- Chutes
- Fork lift
- Pallets
- Recycling containers

Heavy-duty equipment such as cranes, waste disposal trucks, heavy-duty trucks etc. may sometimes be required depending on project specific conditions.

APPENDIX C

MARKET PERCEPTIONS OF RECOVERY AND REUSE

Adopted directly from NAHB Research Center Report (2001).

Consumer perception of used building materials has a strong influence on the feasibility of deconstruction. These perceptions are influenced by local conditions. The following discussion on market perception of used material recovery and reuse, based on interviews and discussions with a broad range of deconstruction industry participants, covers: negative perception of recovery and reuse; and positive perception of recovery and reuse.

Negative Perception of Recovery and Reuse

Contractors view the recovery of building materials negatively for the following reasons:

- *expense* - too expensive due to labor costs, transportation, and storage issues.
- *economy of scale* - not cost effective for demolition contractors unless there is a large quantity of material that can be resold.
- *market* - inconsistent resale market for materials.
- *safety and environmental concerns* - handling material manually may increase company worker compensation rates and liability.
- *competition* - demolition contractors and salvage businesses compete over project time and the revenue generated from material salvage.

A fundamental problem with building material reuse raised by many contractors is that customers do not want used material in new buildings. Other common problems concerning building material reuse include:

- *dimension problems* - rehabilitating a house may require finding the right cabinet to fit existing walls. Locating reused materials that fit into an existing space may be more difficult than purchasing a new product.
- *inconsistency in supply* - building new houses with used materials requires customization, which results in extra costs due to the varying dimensions and characteristics of used materials.
- *time and cost* - matching cabinets, doors, or other materials requires extra time and labor. This is impractical for low-income housing projects.
- *appearance* - lack of matching colors and decors will lead to a lower perception of the home's value.
- *code acceptance* - can be not feasible due to strict code requirements in some regions[16].

Positive Perception of Recovery and Reuse

Construction industry participants view the recovery of building materials for reuse as beneficial for the following reasons:

- *profit* -recovery can allow the contractor to either win a job and/or maximize profit;
- *lower disposal costs* - building salvage lowers overall disposal cost; competency -several demolition firms viewed their high recovery rates as demonstrating their professionalism with regard to the competition;
- *environmental responsibility* -several demolition contractors stated that, given the financial opportunity to make a choice, they would increase their recycling and recovery efforts.

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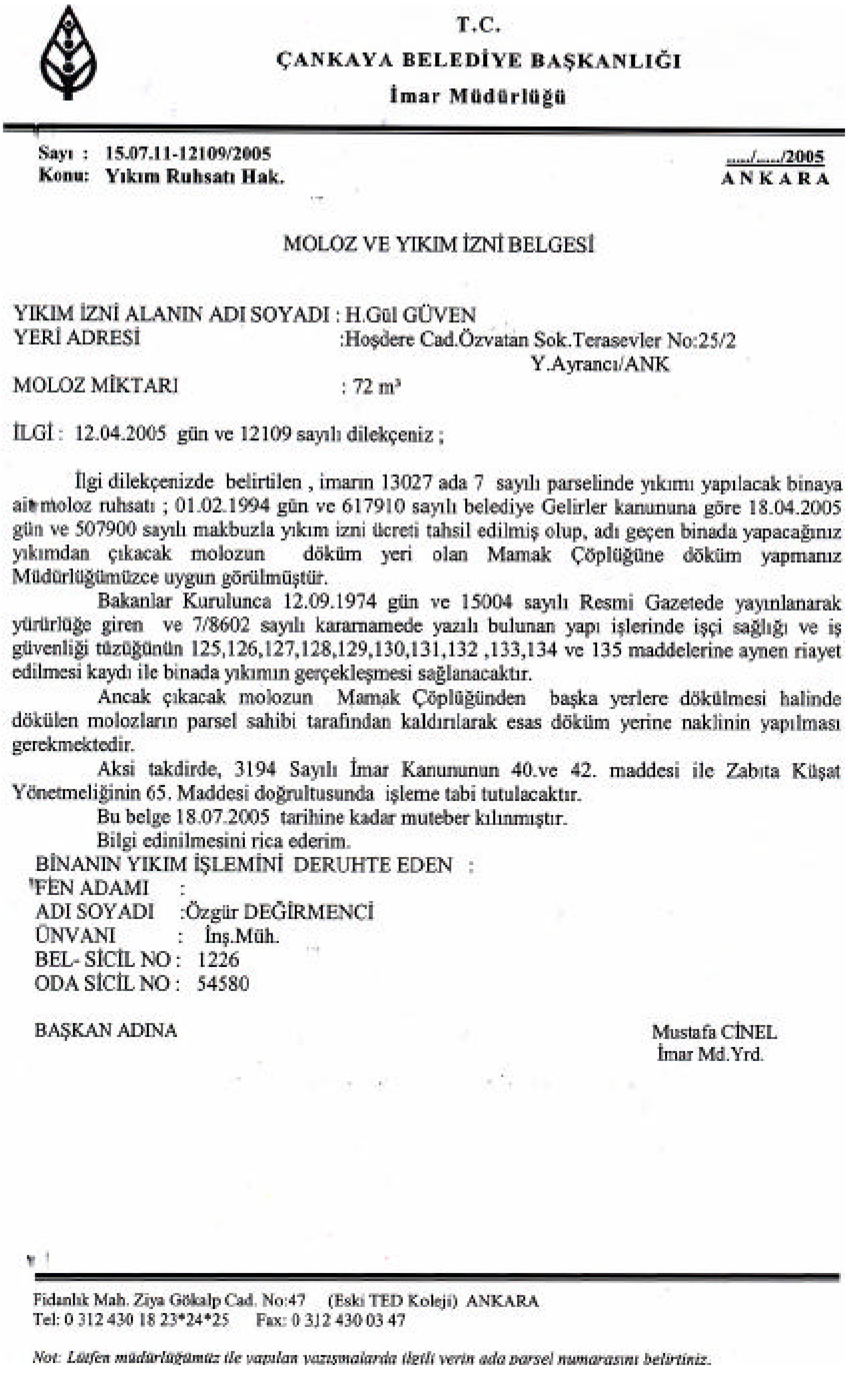
[16] This was especially true in Miami due to hurricane codes.

- *lower cost for replacement materials* -property management companies incorporate reuse programs to save costs;
- *dimension and appearance* - renovation and remodeling contractors often replace doors and windows due to the ability to match sizes and appearance with the existing structure. “Aged” appearance can create value especially with the used wood flooring and used brick market;
- *low cost for renovation* -in El Paso, one remodeling contractor described the residential market as having the view that “cheaper is better”;
- *exclusivity* -high-end customers of architectural antiques seek materials that are unique, with a historical value that cannot be replicated; and
- *environmental benefits* -one timberwright in Wisconsin exemplifies the idea of sustainable reuse in his construction practice by using only recovered wood and creating zero wood waste on the jobsite.

APPENDIX D

SAMPLE PERMIT FOR DEMOLITION WORKS



T.C.
ÇANKAYA BELEDİYE BAŞKANLIĞI
İmar Müdürlüğü

Sayı : 15.07.11-12109/2005
Konu: Yıkım Ruhsatı Hak.

...../...../2005
ANKARA

MOLOZ VE YIKIM İZNİ BELGESİ

YIKIM İZNİ ALANIN ADI SOYADI : H.Gül GÜVEN
YERİ ADRESİ :Hoşdere Cad.Özvatan Sok.Terasevler No:25/2
Y.Ayrancı/ANK
MOLOZ MİKTARI : 72 m^3

İLGİ : 12.04.2005 gün ve 12109 sayılı dilekçeniz ;

İlgi dilekçenizde belirtilen , imarın 13027 ada 7 sayılı parselinde yıkımı yapılacak binaya ait moloz ruhsatı ; 01.02.1994 gün ve 617910 sayılı belediye Gelirler kanununa göre 18.04.2005 gün ve 507900 sayılı makbuzla yıkım izni ücreti tahsil edilmiş olup, adı geçen binada yapacağınız yıkımdan çıkacak molozun döküm yeri olan Mamak Çöplüğüne döküm yapmanız Müdürlüğümüzce uygun görülmüştür.

Bakanlar Kurulunca 12.09.1974 gün ve 15004 sayılı Resmi Gazetede yayınlanarak yürürlüğe giren ve 7/8602 sayılı kararnamede yazılı bulunan yapı işlerinde işçi sağlığı ve iş güvenliği tüzüğünün 125,126,127,128,129,130,131,132 ,133,134 ve 135 maddelerine aynen riayet edilmesi kaydı ile binada yıkımın gerçekleşmesi sağlanacaktır.

Ancak çıkacak molozun Mamak Çöplüğünden başka yerlere dökülmesi halinde dökülen molozların parsel sahibi tarafından kaldırılarak esas döküm yerine naklinin yapılması gerekmektedir.

Aksi takdirde, 3194 Sayılı İmar Kanununun 40.ve 42. maddesi ile Zabıta Küşat Yönetmeliğinin 65. Maddesi doğrultusunda işleme tabi tutulacaktır.

Bu belge 18.07.2005 tarihine kadar muteber kılınmıştır.

Bilgi edinilmesini rica ederim.

BİNANIN YIKIM İŞLEMİNİ DERUHTE EDEN :
FEN ADAMI :
ADI SOYADI :Özgür DEĞİRMENCİ
ÜNVANI : İnş.Müh.
BEL- SİCİL NO : 1226
ODA SİCİL NO : 54580

BAŞKAN ADINA

Mustafa CİNEL
İmar Md.Yrd.

Fidanlık Mah. Ziya Gökalp Cad. No:47 (Eski TED Koleji) ANKARA
Tel: 0 312 430 18 23*24*25 Fax: 0 312 430 03 47

Not: Lütfen müdürlüğümüz ile yapılan yazışmalarda ilgili yerin ada parsel numarasını belirtiniz.

Figure D.1 A sample of demolition permit (in Turkish)

REBULIC OF TURKEY
ÇANKAYA MAYORALTY
DEVELOPMENT DIRECTORATE

No: 15.07.11-12109/2005 **…/…/2005**
Subject: Demolition Permit **ANKARA**

DEBRIS AND DEMOLITION PERMIT

CONCERN: Application no: 12109, 12.04.2005

THE PERSON TO GET DEMOLITION PERMIT: H. Gül GÜVEN
ADDRESS : Hosdere Avenue Özvatan Street Terasevler No: 25/2
Y. Ayranci/ ANKARA
AMOUNT OF DEBRIS: 72 m^3

Debris permit of the building to be demolished in 13027 section and 7 plot in the zoning plan, as indicated in your application: according to the municipality income law no: 617910 enacted on 01.02.1994, demolition permit fee was collected with the receipt no: 507900, 18.04.2005; it was approved by the municipality that the resulting debris is to be landfilled in Mamak landfill area.

The building is demolished with the condition of exactly obeying the 125, 126, 127, 128, 129, 130, 131, 132, 133, 134, and 135 clauses of worker health and safety in building works rules and regulations in the written decree no: 7/8602 inured and published by the Council of Ministers in Official gazette no: 15004 on 12.09.1974.

However, in the case of that the resulting debris is landfilled in another area instead of Mamak landfill area, the owner of the plot must transferred the landfilled debris to the determined landfill area.

Otherwise, it is subjected to the directions of the 40th and 42nd clauses of the Development Law no: 3194 and 65th clause of the Police Regulation.

This certificate is validated until 18.07.2005.

It is required to get information.

THE PERSON TO UNDERTAKE THE DEMOLITION PROCESS
TECHNICAL PERSON:
NAME SURNAME : Özgür DEGIRMENCI
TITLE : Civil Engineer
CERTIFICATE REGISTER NO: 1226
CHAMBER REGISTER NO : 54580

IN THE NAME OF MAYOR Mustafa CINEL
Asst. Manager of Development

Fidanlik District Ziya Gökalp Avenue No: 47 ANKARA
Tel: 0 312 430 18 23* 24* 25 Fax: 0 312 430 03 47

Figure D.2 A sample of demolition permit (English translation)

APPENDIX E

LIST OF CONTACTS

1 Officials of Building Control Authority

1. The departmental head of the Building Control Authority of Yenimahalle Municipality was interviewed informally in December 2004, and January and May 2005.
2. Two officials of the Building Permit Section in the Building Control Authority of Yenimahalle Municipality were interviewed informally in December 2004, and May 2005.
3. The departmental head of the Building Control Authority of Çankaya Municipality was interviewed informally in May and June 2005.
4. Two officials of the Building Permit Section in the Building Control Authority of Yenimahalle Municipality were interviewed informally in May 2005.

2 Building Contractors

1. Ergun and Ercan Yilmaz, co-owners of a building-contracting firm, were interviewed in December 2004 and January 2005.
2. Cemalettin Çelik, building contractor of building C, was interviewed on-site in January 2005.

3 Demolition Contractors

1. Ali Batman, a demolition contractor on Bentderesi Avenue, was interviewed in June 2005.
2. Alparslan Dogan, a demolition contractor in Ilker, was interviewed in his yard in June 2005.
3. Ayhan Harmandar, a demolition contractor, was contacted on-site in Yenimahalle in December 2004.
4. Bekir Acar, a demolition contractor and owner of a warehouse on Bentderesi Avenue, was interviewed in June 2005.
5. Davut Acar, a demolition contractor on Bentderesi Avenue, was interviewed in June 2005.
6. Fevzi Sanci, a demolition contractor and the head of the Demolition Contractors' Association, was interviewed informally in June 2005.
7. Hüseyin Koçak, demoltion contractor of building C, was contacted on-site in Yenimahalle in December 2004 and January 2005.
8. Mehmet Aktepe, demolition contractor of building A, was contacted in Oran in April 2004.
9. Selçuk Dogan, a demolition contractor in Mürsel Uluç, was interviewed in his yard in June 2005.
10. Sezai Kilinç, a demoltion contractor, was contacted on-site in Yenimahalle in December 2004.
11. Veli Biyik, a demoltion contractor, was contacted on-site in Yenimahalle in December 2004 and January 2005.

4 Demolition Teams

1. Demolition team of building A was contacted on-site in Oran in April 2004.
2. Demolition team of building B was contacted on-site in Kavaklidere in March 2004.

3. Demolition team of building C was contacted on-site in Yenimahalle in December 2004 and January 2005.

4. Demolition team of a masonry building on Coskun Street in Yenimahalle building was contacted on-site in December2004.

5. Demolition team of a masonry building on Gürler Street in Yenimahalle building was contacted on-site in December2004.

6. Demolition team of a masonry building on Özen Street in Yenimahalle building was contacted on-site in December2004.

7. Demolition team of a masonry building on Taskin Street in Yenimahalle building was contacted on-site in December2004.

5 Scrap Dealer

1. Abdullah Güney, a scrap dealer, was contacted on Bentderesi Avenue in June 2005.

6 Companies Producing/ Selling New Building Materials

1. Akce Insaat Malzemeleri Ltd. Sti., Ulus, Ankara.
2. Akdag Kereste ve Kiremit Ticarethanesi, Siteler, Ankara
3. Maslak Insaat Malzemeleri Tic. San. A.S., Siteler, Ankara.
4. Önel Elektrik Ltd. Sti., Kizilay, Ankara
5. Irfan Sunar Yapi Malzemeleri, Ulus, Ankara.