

**ADDIS ABABA UNIVERSITY**

**GRADUATE STUDIES**



**ADDIS ABABA INSTITUTE OF TECHNOLOGY**

**SCHOOL OF CIVIL & ENVIRONMENTAL ENGINEERING**

**Investigation of Building Demolition Practices and Safety Precautions  
on Selected Sites of Addis Ababa**

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**By;**

**Yirgalem Gebreamlak**

**Advisor: Dr. Girmay Kahssay**

**A Thesis Submitted to School of Graduate Studies in Partial  
Fulfillment of the Requirements for the Degree of Master of Science in  
Civil Engineering (Construction Technology and Management)**

**March, 2016**

**Addis Ababa**

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## DECLARATION

**Title of Thesis:**

**“Investigation of Building Demolition Practices and Safety Precautions on Selected Sites of Addis Ababa”**

I, the undersigned, declare that this thesis is my own and original work and has not been presented for a degree in any other university, and that all sources of material used for the thesis have been duly acknowledged.

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## ACKNOWLEDGEMENTS

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Above all, I thank the almighty God, for what he has done to me till today, blessing my life and giving me the patience and strength to accomplish my educational career one step further. Next, I wish to express my sincere appreciation to my direct supervisor Dr. Girmay Kahssay for his friendship, assistance and valuable comments in reviewing the draft repeatedly throughout the research paper. I am extremely grateful and deeply indebted to him for helping my thesis writing up.

Thanks also to Prof. Dr.-Ing. Abebe Dinku who gave the opportunity to me undertaking this study and he made me inspired to study my research on the „Building Demolition Practice in Addis Ababa“, when he was my instructor for the course of “Building Industrialization and Maintenance”.

I would like to extend my deep gratitude to staffs at the school of civil and environmental engineering as well as staffs of Addis Ababa city land development & urban renewal agency, planning & information institute, (Arada, Addis Ketema, Lideta, Kirkos and Yeka) sub city and woreda housing development & construction for their great support during my research study.

Finally, I want to thank you to my beloved family who has given their supports and encouragement for me to complete my study. Lastly but not least, I want to thank all of my beloved friends who show their support and helping hands in order for me to complete my research study.

## ABSTRACT

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Over the last few years, building demolition projects had been increasing throughout the inner city of Addis Ababa toward achieving new developments. However, the demolition execution was done through non-professionals without proper work procedures and awareness's. As a result risks associated with the demolition and environmental issues have become a matter of concern. This research is aimed at assessing the extent of demolition as well as investigating demolition techniques, awareness of parties and impact of demolition on safety and environment. To achieve the aims, various methodologies were adopted. Literatures on demolitions were first reviewed, then questionnaires, semi structured interviews, physical observation and case studies were adopted. Descriptive statistics involving the use of tables, charts and percentages were used to analyse the data. Though results of the analysis reveal that, demolition by using traditional hand held tools is the merely demolition technique, but demolishers were incapable of managing the demolition projects in terms of project planning, health and safety precautions as well as environmental issues. Furthermore, the executed building demolitions had no any aspect to encounter requirements of standards and codes due to absence of local legislations. In order to overcome the barriers presently faced, local authorities or professionals needed to look beyond and consider other countries experience. Hence, active participations of concerned government employees were extremely necessary in certain areas to provide long term and effective solutions. Therefore, the results of this study recommended, the need to develop cost effective and environmentally friendly demolition practices, increase the level of awareness to health and safety, promote recycling and reusing demolition debris and impose laws and environmental regulations that bans improper handling and support recycling of wastes.

**Keywords:** Demolition, Environment, Health, Safety, Waste Management.

## ABBREVIATIONS/ACRONYMS

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AHP	=	Analytical Hierarchy Processes
AIA	=	American Institute of Architects
AS	=	Australian Standard
BEPCON	=	Building, Electrical and Plumbing Control
BOQ	=	Bill of Quantities
BS	=	British Standard
EPA	=	Environmental Protection Agency
HCB	=	Hollow Concrete Block
HSE	=	Health and Safety Executive
ICE	=	Institute Of Civil Engineers Protocol
JPDR	=	Japan Power Demonstration Reactor
JPDRI	=	Japan Atomic Energy Research Institute
LRT	=	Light Rail Way Transit
MSE	=	Micro & Small Enterprise**
NADC	=	National Association of Demolition Contractors
NOC	=	Get the Notice of Construction
OHS	=	Occupational Health and Safety
OSHA	=	Occupational Health and Safety Act
PPE	=	Personal Protective Equipment
SWMP	=	Solid Waste Management Plan
WSH	=	Work Health and Safety

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# CHAPTER 1: INTRODUCTION

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## 1.1 GENERAL

The era of demolition began centuries ago as construction had started. Nowadays, the industry brings a lot of potentials and become highly sophisticated business requiring expertise and competent persons across the world. People have demolished structures to make room for new structures, to rehabilitate the existing ones, and to create new buildings with materials taken from existing structures. When demolition occurs, it is usually a sign of new growth, expansions and inner city urban renewals. Major cities found in Washington DC, London and elsewhere are constantly renewing old buildings and converted in to new structures (Diven and Taylor, 2006).

Building demolition Act (1984) further explained that, a building can be demolished when it is deemed to be of no further use, dangerous and in a disastrous or neglected state, especially in city centers or out of town shopping facilities. Demolition acts completely remove a building or cleans a site in order to release the potential value for redevelopment or use the land as an open space for recreational purposes. Buildings are changed in harmony with the needs of the age. Almost all of the residential building and commercial building in developed countries nowadays are constructed with reinforced concrete. As the complexity in construction increases, it is obviously important to consider the overall demolition work is as being important as construction work.

Demolition works become more common in order to eliminate the aged buildings and unsafe structures in urban areas. New buildings which satisfy the modern requirements have been constructed after the demolition of unused buildings. As a result, rapid developments in building constructions have contributed to the growth of demolition techniques due to the constructed materials and methods (Thong, 2010). In addition to materials and methods, it is also required the knowledge of labor costs associated with removing and disposing of building materials, value of removed assets, and opportunities for landfill diversion through recycling and reuse of materials as well as regulatory requirements that govern demolition work. Understanding of these issues are important for determining the most appropriate way to remove, handle, and dispose of materials for a project (AIA, 2006).

As time passes the method of demolition changed. Most of the demolition projects undertaken nowadays are complex in nature, demanding greater skill and experience than ever before. In addition, more legislations that are strict and growing commercial and environmental pressure have made a major impact on the selection of demolition techniques. Furthermore, various types of new demolition techniques are available in the demolition industry, which make the selection more complex. Before selecting any type of demolition technique, the demolition engineer has better to consider a set of criteria and assess their relevance to the demolition work to be undertaken in order to arrive at the most appropriate demolition technique (Arham, 2008).

As Thong (2010) states, the selection of demolition techniques for structure is greatly affected by the structural forms like reinforced concrete, pre stressed concrete, plain concrete or masonry and the size of constructed structural members. Moreover, the location of the building, extent of demolition either the whole or partial demolition, grade of safety in work and the time taken to demolish the structure will greatly affect the evaluation or selection of demolition techniques. The evaluation of demolition method is a very complicated as parameters such as operation, application fields, nuisance, safety measurement, and performance of work are interacted with each other.

Thong adds that, many demolition techniques have been invented and applied in this world until today such as using machinery method, hand method, chemical agent, explosion and hydraulic demolition. Those techniques are still in upgrading especially to evaluate a more suitable method to demolish structural buildings. In fact, even the most advanced demolition technique does not guarantee a safe and successful demolition. Thus, the determination and employment of the safest strategy to bring down a building is the key to ensure the safe demolition operation.

Unless proper methods and techniques are handled, demolitions of buildings or structures give rise to many hazards. During demolition projects, the potential risks of a fatal or serious harm accident are high to employees, contractors and even to the public. Hazard identification and the promotion of safe methods of work are therefore essential, and these should also be reflected in responsibilities to third parties (Green and Gracious Guide, 2010). However demolition work is very high risk and complex, it requires knowledge and strict regulation and precaution measurement that must be followed to avoid any damage to human life and environment.

Currently to ensure the health and safety of stakeholders in combination to methods and techniques, the demolition practice is restricted by numerous factors, budget of the project, location of the building subject to demolition, size of the building, regulations, economics, new technology, management and so on (Liu et al., 2005). Methods can vary depending on the area where it will be held on, the building material, the purpose of the demolition and the way that debris is going to be disposed. The future of building demolition also predicated by the availability and cost of new resources and by the scarcity of energy for machine operation, as well as by heightened environmental awareness (Gordon, 1997).

## **1.2 RESEARCH BACK GROUND**

The trend of demolition in Addis Ababa has undergone because of rapid inner city redevelopments and infrastructural development by demolishing existing buildings and become a common practice. Buildings under demolitions have been seen almost everywhere in the inner city. According to the government scheme for city renewal, local development plans are realized for the total demolition of some of the old shanty neighborhoods in various districts, including Lideta, Kirkos, Addis Ketema and Arada as well as large number of houses, which the railway is going to cross, were being hastily demolished (Hailegiorgis and Alemayhu, 2014).

The Addis Ababa City Administration's Land Development and Urban Renewal Agency cleaned up many hectares of land in the inner city districts for the redevelopment. The larger portions of the land were allotted for 40/60 housing schemes, with the remaining were to be on tender for large investments. Such investments include high rise buildings up to 20 storey height for business purposes. On the other hand buildings were demolished for right of way expansion due to the construction of light railway transit that runs east to west starting from Ayat down to Tor-Hailoch and north to south from Menelik Square to Kality district (Fortune, October 20, 2013).

However, the current demolition approach here in Addis Ababa gives little emphasis to demolition participants from the occurrence of a demolition concept to the implementation of demolition activities. Unlike of other countries such as United States, United Kingdom and Australia, Ethiopia does not have proper demolition code of practices that are shaped the practical guidance on achieving health, safety and welfares in order to fulfill the requirements as

stated in the Occupational Health and Safety Act (OSHA) and its regulations for particular areas of work.

Furthermore, the demolition practice is typically performed in an unstructured instinctively manner with considerable reliance on the experience, skill and knowledge, of the daily laborer or other individuals responsible for the demolition project. Numerous workers were involved in the operations and exposed to risks arising from the demolition process. Besides that, it also may involve others civilians nearby (Fortune, July 28, 2013). In addition to this newspaper, according to the researcher observations, nobody is aware of the dusts and other pollutions from demolition wastes can impact greatly on the health and quality life of people working on and living close to these sites.

Though, the trend of building demolition in Addis Ababa is booming in recent years, research papers, and demolition code of practices no longer available to use as an experience in this research except “unprofessional demolitions on expense of human life and chaos of light railway transit construction” that were published in fortune newspaper, that really signify the ground problems of building demolition. But why all these absences happen? Is that due to the extent of demolition is small and give little emphasis? or any other case will be discovered by the researcher. So for the purpose of filling the gap where to start and end up the research, this study starts with the general concepts and trends of other countries demolition experiences, guidelines and research papers.

This research work will therefore, attempt to realize the importance of the building demolition practice with a need to address the problems in the inner city of Addis Ababa. However as an initial step towards the work execution, it acquires knowledge through reviewing experiences as well as gathering information and perspectives from the local industry for better understanding of the issue.

Finally, it is anticipated that the findings of this research will contribute towards ensuring the process that will provide a systematic approach to manage health and safety at the work place for all workers involved in the practice. Further, this is also realized through the investigation of methods and techniques of demolition, stakeholders’ level of awareness and environment concerns.

### 1.3 STATEMENT OF THE PROBLEM

The practice of demolition in Addis Ababa relies on the knowledge and experiences of the daily laborers and their supervisors without particular procedure and guidelines to ensure safety at the workplace. The Ministry of Works and Urban Development issues construction licenses, but it has no license for demolition. A demolition along the roads where the railway line passes and inner city renewals, neither the laborers nor their supervisors has any licensing for demolition. Individuals, who are engaged in small enterprises at woreda level, are welcomed as so long as they can demolish the buildings within a short period of time, in whatever methods to deconstruct or demolish. Daily labors only need the power to destroy and get the job (Fortune, July 28, 2013).

The newspaper also added that in July 2013 following the partial collapse of Nur building in Lideta demolition, one daily laborer was died in the accident. At the same year a similar accident occurred on a street wereda 07 of Addis Ketema district former Assefa Geleta Hotel which was being demolished, suddenly collapsed and more than seven people were died. Among them were a heavily pregnant woman, children, a taxi assistant and an elderly female street side vendor. When demolition was under way and pieces of concrete debris is flying around; pedestrian users pass along the road near to or below and others were waiting for taxis without any fence. Even after the horrible incidents that had happened in Nur building and Assefa Geleta hotel, neither the workers nor their coordinators concerned about the damage that the pieces they were throwing would cause.

The result of these accidents both directly and indirectly reflected that, the overall demolition practice for buildings and the level of demolition stakeholders' awareness in the inner city of Addis Ababa need to be improved. This is because; in the last few years the unsafe execution of demolitions were caused impacts to human life and environment especially due to rapid development of constructions by demolishing existing structural and non-structural buildings.

Demolition of structures and in particular, demolition of large portions of a single neighborhood should keep safety of workers and members of the public as well as decrease environmental effects related to air pollution from dusts. However, the demolition process that is practiced in Addis Ababa is so primitive, substandard and workers were not involved in to safe working

environment. So demolition, as construction should be regarded as a professional job. But it is hardly to see any professionals involved in this business. Hence, professionalism would not only protect human lives, but also enable reuse of materials salvaged from demolition. These problems therefore, initiating the research questions which are listed below. Unless systematic building demolition practice is formulated and awareness of stakeholders created, the issue will continue to influence the stakeholders directly and indirectly and significantly affect the future demolition endeavors.

#### **1.4 RESEARCH QUESTIONS**

The research should address the following questions:

- What is the extent of demolishing practice in the inner city of Addis Ababa?
- What are the method and techniques used in building demolition?
- To what extent are the various stakeholders aware of the demolition practice?
- Are there any accidents or risks associated with demolition?
- What can be done to improve the demolition practice and its safety precautions?

#### **1.5 OBJECTIVES OF THE STUDY**

The objectives of this research are;

- To assess the extent of demolition practice in the inner city of Addis Ababa
- To investigate methods of building demolition practices and procedures
- To examine stakeholders level of awareness on the practice
- To investigate safety and environmental impacts of demolition
- To explore contributions that will improve the demolition practice

#### **1.6 SCOPE AND LIMITATIONS OF THE STUDY**

The research focuses on demolition practices that are applied to buildings in the inner city sites of Addis Ababa. During the last few years the city undergoes considerable amount of demolitions for the purpose of new constructions related to administrative offices, public services, urban redevelopments and infrastructural developments. However, the scope of

investigation has been limited to selected demolition sites from five sub cities which share the inner city parts and demolition activities are dominantly noticeable. These project sites are owned by the government and demolished for urban renewal and right of way expansion due to light railway transit constructions since 2013. The survey sample has been also limited to micro and small enterprise contractors and individual demolishers who directly involve in the demolition practice. Besides, questionnaires were distributed to government employees who were participating on demolition decisions and the researcher was used appropriately in the discussions.

### 1.7 THESIS LAYOUT

This thesis is compiled to reflect the way in which the research investigation was undertaken. So, the work consists of six discrete chapters and the following figure 1.1 shows the summary of thesis layout.

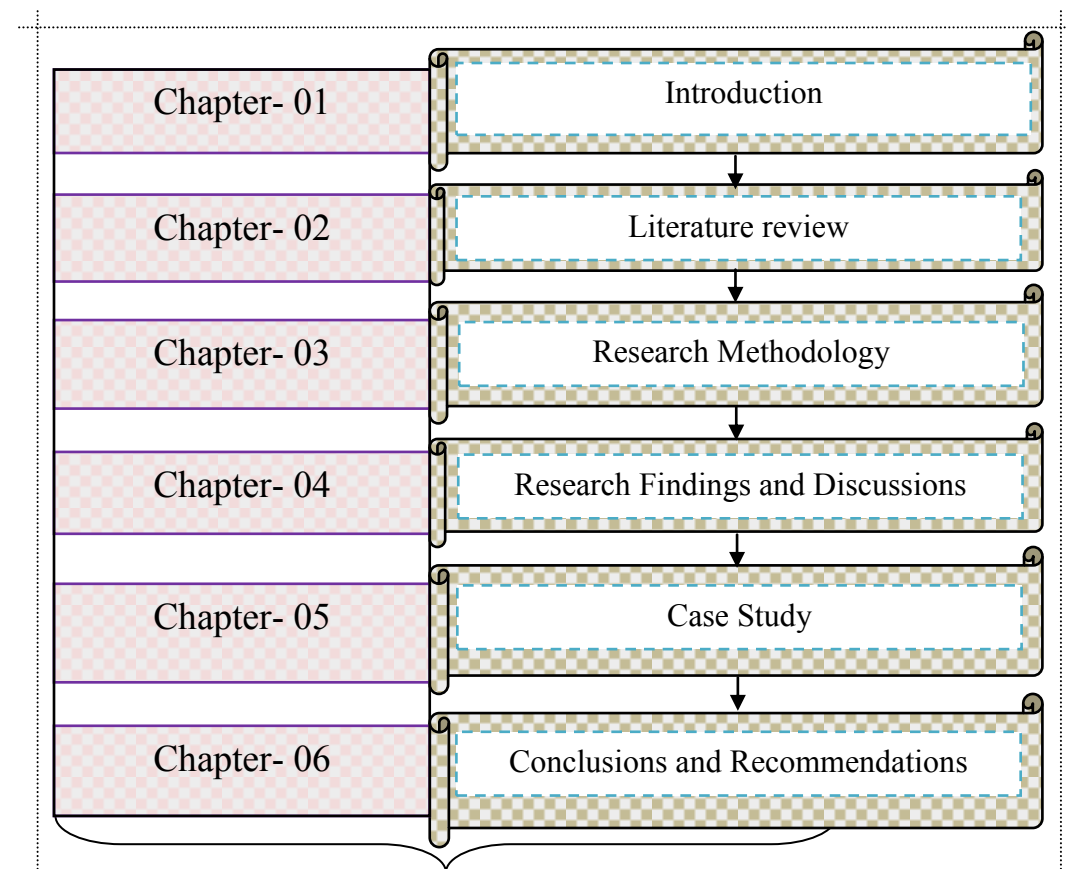


Figure 1.1: Flow chart of the thesis layout

## **CHAPTER 2: LITERATURE REVIEW**

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### **2.1 INTRODUCTION**

The practice of demolitions in Addis Ababa was commenced for plenty of new construction activities. The constructions that carried out in the city were built on the land acquired by demolishing existing old houses and buildings. Small to medium buildings were dismantled, demolished and ongoing demolition for infrastructural development, investments and housing programs. However, the practice is relied on the daily laborers experience and they are exposed to accidents, and causes environmental pollution due to improper handling of wastes. Generally, the current practice lacks professionalism and difficult to access available documents that involve records, demolition code of practices, research papers regarding the trend of demolition work.

Therefore, the literature is intended to achieve through exploring overviews of the demolition industry including recent developments of other countries. Consequently, it discusses the demolition processes, methods and will help in identifying the criteria's for the selection of demolition techniques. Then, it is also reviewing on the demolition stakeholders' responsibilities, health and safety as well as waste management and environment issues for better understanding of the practice.

### **2.2 DEFINITIONS OF KEY TERMS**

Various definitions of the term 'demolition' have been found in the literature. Some of the common definitions include:

„Demolition“ “means dismantling, demolish, destroying or wrecking any building or structure or any part thereof by pre-planned and controlled methods” (Hong Kong Code, 2004). Building demolition represents the process in which an erected structure is purposely destroyed to form a diversity of components and fragments of mixed materials. From a lifecycle viewpoint, the demolition stage for buildings is achieved after the sequential stages of planning, design, and execution.

„Demolition“ as being conferred in this study also can be defined as: "The complete or partial dismantling of a building or structure". It excludes refurbishment, provided this work does not involve alteration of any existing structural components (OHSA, 2000). When combined the two definitions, „demolition“ can be summarized as removing, dismantling, destruction, razing, wrecking, pulling down or knocking down of any building or structure by pre-planned and controlled techniques to cause complete collapse of the whole or part of the building or structure.

In order to have a smooth working condition at demolition sites the issue of safety and health should be given due attention like safety in construction. Health and safety precautions are the responsibility of every one at work. The term „safety“ is defined as a relative freedom from danger, risk, or threat of harm, injury, or loss of personnel and property, whether caused deliberately or by accident. „Safety“ can also be defined as the control of recognized hazards to achieve an acceptable level of risk. As titled in this study, „safety“ is freedom from danger, harm, and injury to the person involved in demolition activities whereas the term “health” refers to the freedom from the immediate and long term effects of exposure to unhealthy working condition (Sarah, 2012).

Environment is also an important aspect in the execution of demolition in which individuals are working. Besides, demolition sites are complex system with a lot of stakeholders working together to accomplish the demolition project. So the „Cambridge dictionary online“ defines „environment is the condition that once can live or work in and the way that it influence how once effectively can work“.

### **2.3 DEVELOPMENT OF DEMOLITION**

The history of building demolition tracked back to several thousand years, including the effects from various ancient wars. Until the 1950s, buildings were mostly dismantled by hand at the ends of their lives due to structural or functional obsolescence. The mechanization of demolition work started in the late 1950s with the introduction of pneumatic hand hammer breakers and steel balls as far as building structures are concerned. During the 1960's and 1970's the trends of demolition demand on the skills and working techniques of demolition contractors. From 1967, chemical expansive demolition agents were developed in Japan. In 1979, a study of the demolition of the Japan Power Demonstration Reactor (JPDR) by the Japan Atomic Energy

Research Institute (JPDR) resulted, in many useful developments for the demolition of structural buildings by explosives, core boring machines, large diamond cutters, and abrasive water jetting techniques (Kasai (1988) as recited by Abdullah (2003)). In the Later, in the 20th century, the shaped charge technology combined with manageable seismology and non-electric delay systems were developed, allowing an ever-expanding variety of structures to be explosively felled by demolition experts specially countries like Japan (Liss, 2000).

Therefore, the nature and change of demolition had been undergone through major transformation. Traditionally it was labor intensive, low skill, low technology, poorly regulated and mainly dealing with deconstruction of simply constructed buildings. Then it was developed to mechanization, replacing labor with machines. This is because of increased complexity in building design, financial pressures from clients, health and safety issues, regulatory and legal requirements and advances in plant design (Abdullah, 2003). After that the emphasis was also arisen in increasing environmental pressure, particularly the disposal of demolition waste (Liu et al., 2003). This situation, along with more strict legislation and growing commercial and environmental pressures has had a major impact on the selection of demolition techniques. In addition, demolition is becoming a more complex and demanding process, as contract periods become shorter, legislation more demanding, and the competition even tougher. Thus, the trends were changed through considerable researches, trainings, preparation and introduction of new techniques.

## **2.4 THE DEMOLITION PROCESS**

Principally, the sequence of demolition is carried out in reverse order to the construction process and the general execution of the demolition process can be classified as comprising four main work phases as illustrated in Figure 2.1 of the sequential flow of activities involved (Abdullah, 2003).

- Tendering stage
- Pre-demolition stage
- Actual demolition stage and
- Post-demolition stage

These are discussed below to provide a better understanding of the demolition process and the selection of demolition techniques.

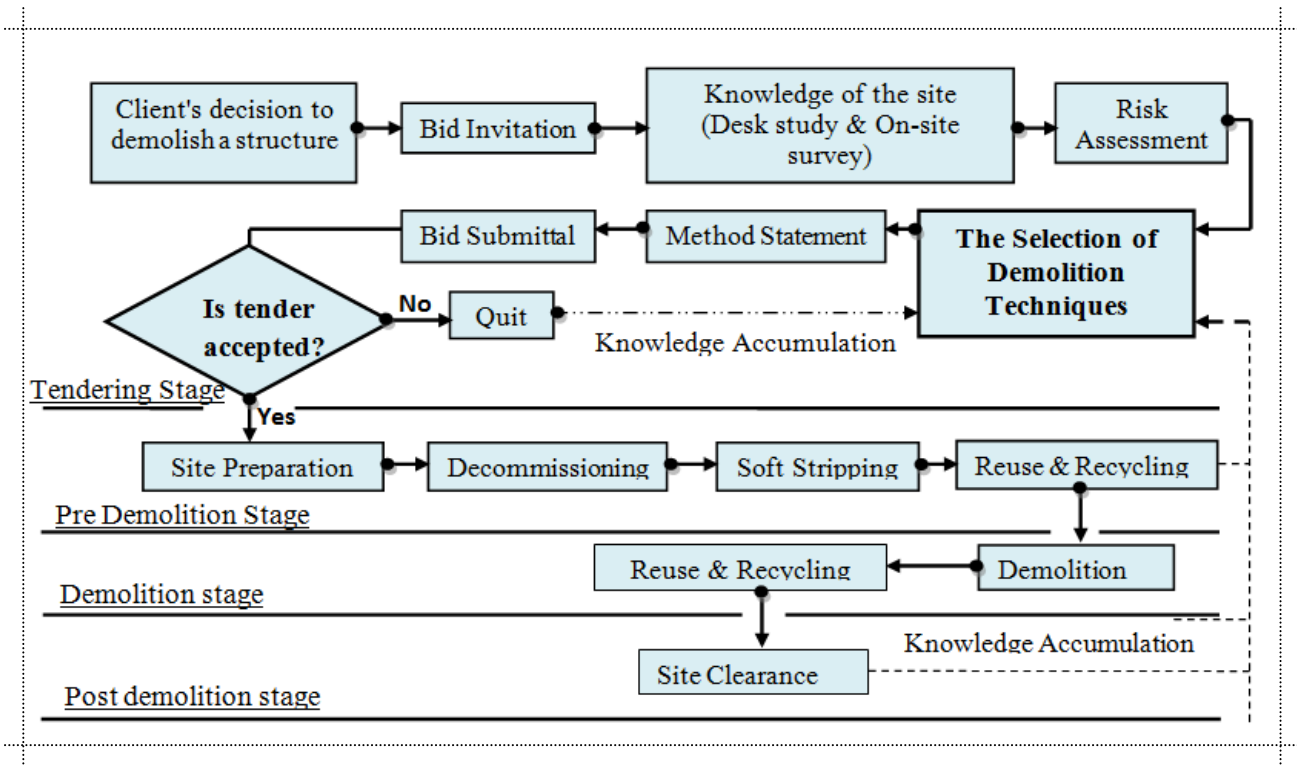


Figure 2.1: Demolition process flow chart (Abdullah, 2003)

### 2.4.1 Tendering Stage

In this stage, the demolition process starts when the client makes a decision to demolish a structure and demolition contractors are invited to bid their offers. The early selection of contractor proceeds either by evaluating the contractor's previous performance, or on the basis of competitiveness of an estimated preliminary cost given by the contractors. Next, contractors have to find out about the site before he/she can prepare a risk assessment. As the British standard code of practice for demolition BS 6187 (2000) section 7.1 states, knowledge of the site should be produced by an initial desk study and followed by an on-site survey to supplement the desk study. Off-site features that can affect work on site should also be determined. Then, risk assessment has to be carried out which identifies risks associated with work and planning of the removal or reduction of risks before work commences.

After that, the demolition engineer needs to select the demolition technique based on risk assessment and other contributing factors such as technical and economic aspects. It is also produces a method statement which addresses the site's particular needs (i.e. site preparation) and details of the planned sequences and demolition techniques selected in the previous process. Finally the tender document with the method statement will then be submitted to the client. If the contractor is selected by the client to do the job, he/she will continue to the next stage, which is the pre-demolition stage. If the client was not selected the contractor, then the contractor has to abandon the project and bid for another job.

### **2.4.2 Pre-Demolition Stage**

The first process in the pre demolition stage is site preparation. The process may include the erection of security fencing and setting-up welfare facilities (e.g. site office, washing facilities and toilet). Decommissioning is the second step and it can be defined as the "process whereby an area is brought from its fully operational status to one where all live or charged systems are rendered dead or inert and reduced to the lowest possible hazard level" (BS 6187, 2000). The decommissioning activities include for example, removal of all asbestos, chemicals (e.g. battery acids, oils) and controlled release of stored energy in strong springs or suspended counterweights.

Soft stripping is the third process for the removal of non-structural items such as fixtures and fittings, windows, doors, frames, suspended ceilings and partitions. Product from the soft stripping process can be reused and recycle in the fourth. Materials such as wood from windows or door panels can be reused as building lumber, landscape covering, pulp chip and fuel, as these can be cleaned and reused. Aluminum and stainless steel panels and copper are the typical recycled metals. Architectural artifacts such as sinks, doors, bathtubs and used building materials are usually resold. Even the industrial process equipment can be marketed both domestically and internationally (NADC, 2004).

### 2.4.3 Actual Demolition Stage

The actual demolition stage is when structural elements are started to demolish. There are three main types of structural demolitions which involve the actual stage. These are: Progressive demolition, deliberate collapse mechanisms and deconstruction (BS 6187, 2000). These alternative techniques can be selected by the contractor at the tendering stage. Reuse and recycling process can be also done after or concurrently with the structural demolition process. With current technologies such as hydraulic excavators attached with pulverize, concrete crushing and screening machines, contractors are able to separate demolition debris. This process can maximize the use of resalable materials and subsequently reducing waste disposal costs. Metals and concrete debris are typical examples of recycled materials. Recycled metals include scrap iron, reinforcement bars in concrete, aluminum, stainless steel and copper. Concrete debris or crushed aggregates can be used as fill material, lean for sub-bases and used to build non-structural partitions (NADC, 2004).

### 2.4.4 Post-Demolition Stage

Site clearance is the last process which executes under the post demolition. Site should be left in a clean, safe and secure condition. All contaminants must be left or removed in a condition such that they represent no hazard to health or the environment. Finally, the planning supervisor should ensure that the health and safety file has been compiled and handed to the client on completion of the work.

Other researchers (Arham, 2008; Nassar, 2014) also divided the demolition process in to three phases which are; pre-demolition phase, demolition phase, post demolition phase. These phases are further explained in the following sections. Figure 2.2 below illustrates the sequential flow of activities involved in each phase.

The **pre-demolition** phase focuses on works that are conducted prior to the actual demolition and consists of activities such as;

**Site survey;** carried out in form of desk study and on-site investigations. It is also surveyed with respect to topographical features, ground conditions, locations and type of existing services as well as adjacent properties. In addition core samples from structural elements are taken for testing to ascertain the structures strength and integrity.

**Site preparation and mobilization;** site is prepared to receive demolition works. It includes fencing and hoarding, site offices as well as site facilities. Mobilization comprises of features such as conducting temporary works, erecting scaffolds and safety signage. Diversion and protection of existing services and property as well as establishment of plant and machinery are also executed under Site preparation and mobilization.

**Decommissioning;** it is done to bring the structure from its fully operational state to one where all charged systems are terminated or reduced to the lowest hazardous level. This includes disconnection of electrical, water, gas, plumbing and telecommunication cables as well as removal of hazardous chemicals.

**Soft stripping;** it is done to remove all non-structural items such as fixtures, fittings, windows, doors, roof tiles and ceilings same as Abdullah's explanation.

**Recycling and reuse;** soft stripping materials are collected and stored to be reused, sold or recycled.

**Environmental monitoring;** initial water and air quality as well as noise and vibration levels are monitored by a team of specialists.

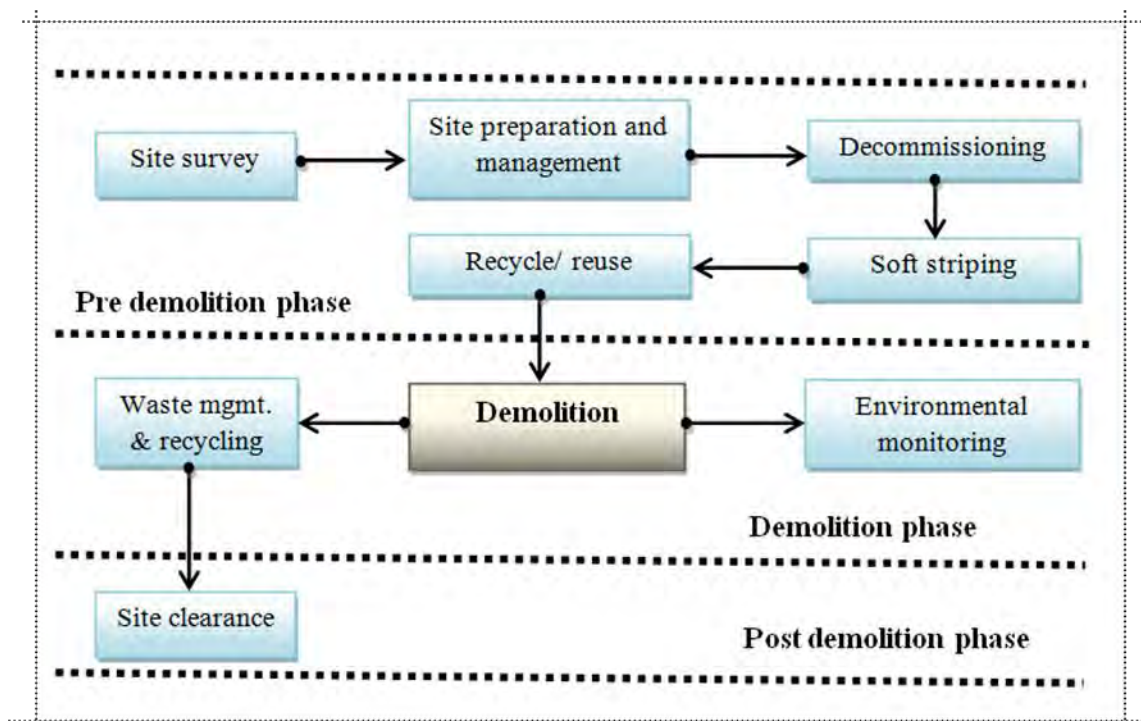


Figure 2.2: Activities involved in the execution of demolition operations (Arham, 2008).

The **Demolition phase** concentrates on the actual demolition operation and comprises of activities such:

**Demolition is executed** using heavy equipment and machinery depending on the technique selected.

**Waste management and recycling** is carried out to properly manage all wastes and debris generated from the demolition. It is planned and monitored to avoid possible environmental contamination and pollution.

**Environmental monitoring;** water and air quality as well as noise and vibration levels are monitored during the works to ensure that they do not exceed the allowable limits.

The **post-demolition phase** pay attention to activities implemented after the major demolition works and includes;

**Site clearance;** up on completion the overall work, the project site is cleared to eliminate any potential hazards. Existing temporary drainages systems are inspected and cleaned to ensure proper flow and function.

**Environmental monitoring;** water and air quality as well as noise and vibration levels are monitored during the works to ensure they are at acceptable levels.

The difference between the researchers are, (Abdullah, 2003) has been included the tendering stage which is including clients decision to demolish a structure, bid invitation, prior risk assessment, selection of demolition technique, method of statement and bid submittals for the overall selection of contractors with regard to previous performance and estimated preliminary cost which are excluded under the demolition phases of (Arham, 2008; Nassar, 2014). Whereas unlike of Arham and Nassar, Abdullah did not look at the environmental monitoring like water, air, noise and vibration during all phases. On the other hand, Arham and Nassar excluded the tender stage, but they tried to ensure monitoring the environment through team specialists to control and not to exceed the allowable limit at all the demolition phases and lastly ensuring for they are executed at acceptable level. Therefore this research study combines the two researches" indication and used as appropriately to enable better understanding of the execution of demolition.

## **2.5 DEMOLITION TYPES, METHODS AND TECHNIQUES**

### **2.5.1 Demolition Types**

Depending on the structural elements to be removed or demolished and applying the principles of structural demolition as reported in BS 6187 (2000) 'British Standard Code of Practice for Demolition', demolition types can be classified in to three.

1. Progressive demolition
2. Deliberate collapse mechanism
3. Deliberate removal of elements or Deconstruction

#### **2.5.1.1 Progressive Demolition**

The 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 (BS 6187, 2000). It is particularly practical in confined and restricted areas and may be considered for the majority of sites. The progressive demolition includes:

- Progressive demolition by hand (hand tools such as an impact hammer, diamond disc cutter, and wire saw)
- Progressive demolition by machine (Excavator attached with boom and hydraulic attachments, such as pulverize, crushers, and shears) and
- Progressive demolition by balling, involves the progressive demolition of a structure by 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.

Therefore, when this type of method is employed, the key structure members of the structure and their sequence of removal should be clearly indicted in the proposed method statement.

#### **2.5.1.2 Deliberate Collapse Mechanism**

Deliberate collapse mechanism is considering the removal of key structural members to cause complete collapse of the whole or part of the building or structure (BS 6187, 2000). This technique usually employed on detached, isolated, fairly level sites where the whole structure is

to be demolished. This requires sufficient space in order to move and place equipment and personnel at a safe distance. Furthermore, deliberate collapse should not have the potential instability of the remaining structure to cause the hazards to surrounding people and properties. When this method is employed, the key members to be removed and the sequence of work should be clearly indicated in the method statement. This is to make sure workers work up follow the procedures of work to ensure their safety during the demolition. The demolition by deliberate collapse includes deliberate collapse by explosive and deliberate collapse by wire rope pulling.

### **2.5.1.3 The Deliberate Removal of Elements (Deconstruction)**

The deconstruction technique is the removal of selected parts of the structures by dismantling or deconstruction (BS 6187, 2000). It is also known as a top down technique or, in general terms, the demolition proceeds from the roof to the ground. Thong (2010) further explained that it is a demolition carried out using manual and machines on a floor by floor basis in a top to bottom downward sequence. This method is carried out manually using hand-held electric and pneumatic crushers or breaking away the structure by machine mounted with percussive breaker or hydraulic attachments.

The advantages of this method are salvaging reusable building materials and minimize the release of hazardous materials into the air. This top-down method is applicable for most sites, especially those situated in busy inner city urban areas. The reuse and recycling process can be done after or concurrently with the structural demolition process. With the current applicable technologies such as hydraulic excavators attached with pulverize, concrete crushing, and screening machines, contractors are also able to separate demolition debris (Anumba and Abdullah, 2002).

### **2.5.2 Demolition Methods**

As building technology is evolving constantly, demolition keeps developing in equipment and techniques. In the past, most demolition works were involved minor and simple structures with few cases of fire damaged buildings and dilapidated structures. Today, major buildings are being demolished including infrastructure such as bridges and highways. The methods of demolition have also improved from hand tools to the advanced use of machineries and tower crane (Arham, 2008).

The sequence in which a building or other structure is demolished can be critical for the health and safety of workers and the general public. The demolition sequence will depend on the type of construction, location, and demolition methods selected. Buildings and other structures has been demolished in reverse order to their construction, that is, by „sequential demolition (AS, 2012).

Generally, there are several types of demolition methods that usually used in demolition practices all over the world. The selection of demolition methods concern about project and site condition, public safety and sensitivity, availability of tools and equipment and many others requirement and regulations that must be followed. The complex situation in the demolition site demands specialized skill, knowledge and also expertise from the people that involved in the industry.

According to the Australian standard (AS, 2013) code of practice for building demolition classified the method of demolition in to;

1. Manual demolition
2. Mechanical demolition, and
3. Induced collapse

### **2.5.2.1 Manual Demolition**

Manual demolition includes any technique where hand tools such as jackhammers, sledge hammers and picks are used. Manual demolitions are shared many of hazards that are present in other major demolition activities including unexpected collapse, falls, falling objects, manual handling and exposure to noise, dust and hazardous chemicals. To manage the risk of unplanned collapses, the condition of roofs, walls and floors of the building should be assessed by a competent person before commencing of the demolition work. Where pre and post-tension demolition work is undertaken competent person advice should be sought as to demolition sequence. Areas where debris will fall should be barricaded off and signs erected to prevent persons from entering before demolition starts (AS, 2013). As indicated in the figure 2.3 below, demolition workers are used scaffolds and personal protective equipment“s while executed manually. Scaffolds are used to protect demolishers from sudden collapse and material falling to adjacent buildings.



Figure 2.3: Manual demolition ([www.demolitionsquad.co.uk](http://www.demolitionsquad.co.uk))

### 2.5.2.2 Mechanical Demolition

Mechanical demolition involves both the pulling down and the knocking down of the structures using machinery such as rams, bulldozers, cranes, and excavators. On the other hand larger structures also involve wrecking balls. Wrecking balls are heavy balls attached to strong cable and swung by large cranes. Mechanical demolitions should be planned to be systematic and sequential to demolish in the reverse order to which it was constructed as shown in the figure 2.4 below.



Figure 2.4: Mechanical demolitions ([jetdemolition.co.za](http://jetdemolition.co.za))

### 2.5.2.3 Induced Collapse

As indicated in the figure 2.5 below, induced collapse is a systematic or sequential removal of key structural members and the application of a force to result in the controlled collapse of all or part of a building or structure (AS, 2013). Expert advice has been required from a competent person before this method is used. The application is only used on detached, isolated structures on reasonably level sites. There must be sufficient clear space into which the collapsing material will fall.



Figure 2.5: Induced collapse (Horea, 2009)

### 2.5.3 Demolition Techniques

There are many types of demolition techniques in the demolition sector to achieve the structural types of demolition together with demolition methods discussed under section 2.5.1 and 2.5.2. Irrespective of which demolition technique is adopted, its choice is based on minimizing the risk to personnel and the re-use or the recycling of materials arising from the demolition. In general according to Arham (2008) the demolition technique employed in the industry can be classified in to five main categories which are:

1. Demolition by hand
2. Demolition by towers and high reach cranes
3. Demolition by machines (with mechanical or hydraulic attachment)
4. Demolition by chemical agents
5. Demolition by water jetting

Figure 2.6 below shows the detail classification of the five demolition techniques and in this research some of them only discussed.

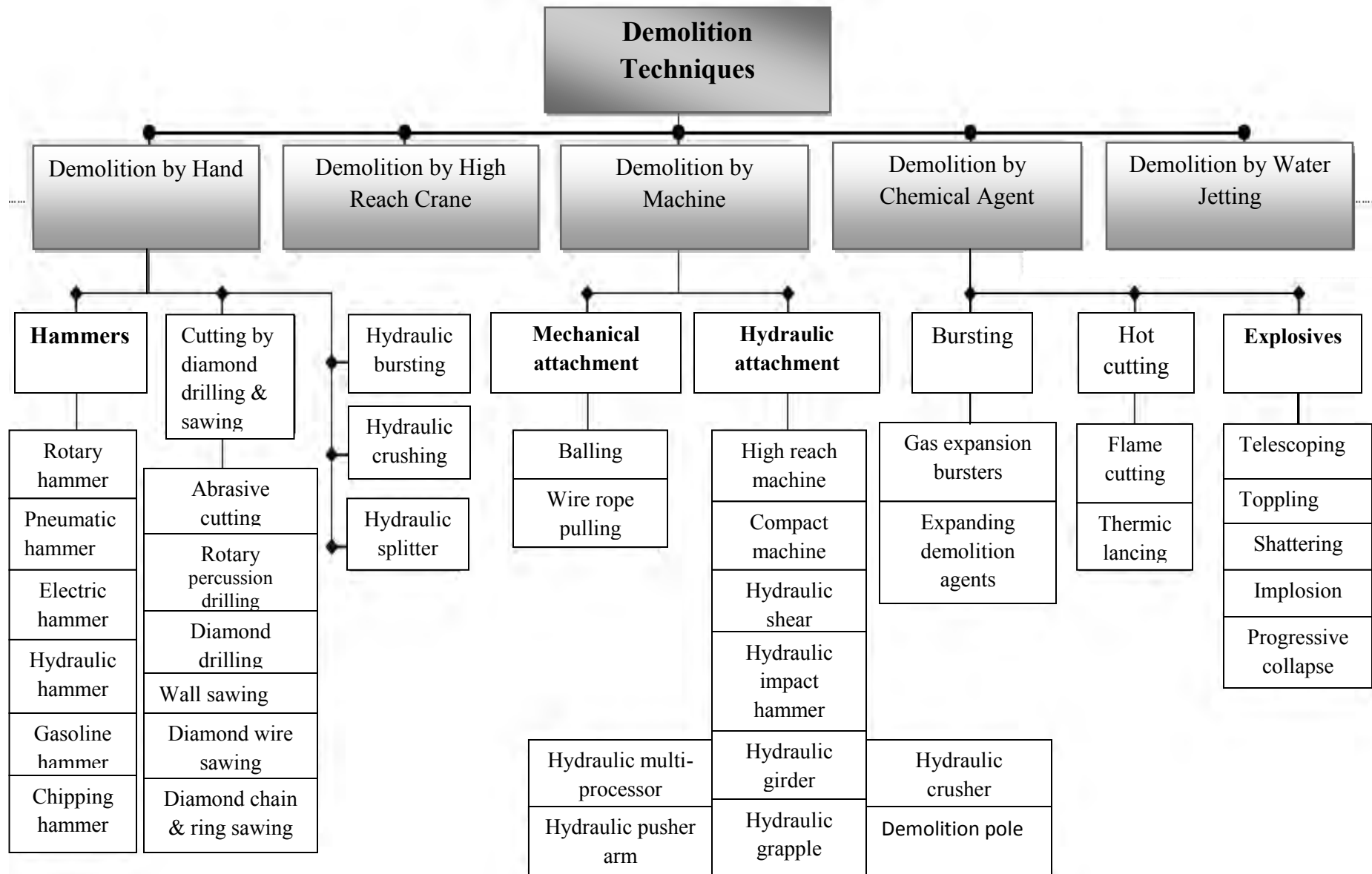


Figure 2.6: The demolition techniques (Arham, 2008)

The selection of techniques for demolish structures will be combination of few techniques which is affected by the requirement and specification of building. The content herein will elaborate to a certain extent of functions, features as well as benefits and disadvantages of each respective technique.

### 2.5.3.1 Demolition by Hand

According to the BS 6187 (2000) demolition by hand is the demolition of structure progressively by hand held tools. The advantages of this method are saving the reuse building material and reduce the air pollution. However, the efficiency of this method is low if compared to other techniques. The technique is most often used in small scaled demolition operations. In large projects, it is employed to primarily weaken the structure before heavier equipment is brought in. Strict safety precautions in terms of working conditions for example, scaffolding, and secure platforms always be considered and checked. Safety belts or harnesses must be used when working on dangerous and high elevations. If it is comparing the figure 2.7 below, figure 2.7(a) demolishers are more exposed to collapse and in (b) workers are carefully dismantled and they are safe.



Demolition by hand includes equipment's such as hand hammering and hand held tools as discussed below.

### **i. Hand hammering**

Hand hammer is a light weight hammering process and can be easily positioned to break and crack vertical and overhead concrete structures. Figure 2.8(a) shows the hand hammering equipment. There are four types of hammer which are operated by using pneumatic force, air compression, gasoline and hydraulic force. The advantage of pneumatic hammer and gasoline hammer are lighter in weight and low in vibration. However, it is more noise than the hammer that operated by hydraulic force. Thus, hydraulic hammer is widely used in urban areas (Thong, 2010).

### **Electric hammer**

The stroke energy is obtained from an electric motor via eccentric cam, which produces a reciprocating motion. It able to deliver more power full blows since it typically have about 35% more power than rotary hammer. This is due to the reduction in components as well as longer piston stroke. Although the hammer delivers fewer blows per minute, the increased strength of the tool makes it quick and more efficient in demolition concrete and masonry. Figure 2.8(b) shows the electric hammer operation system.

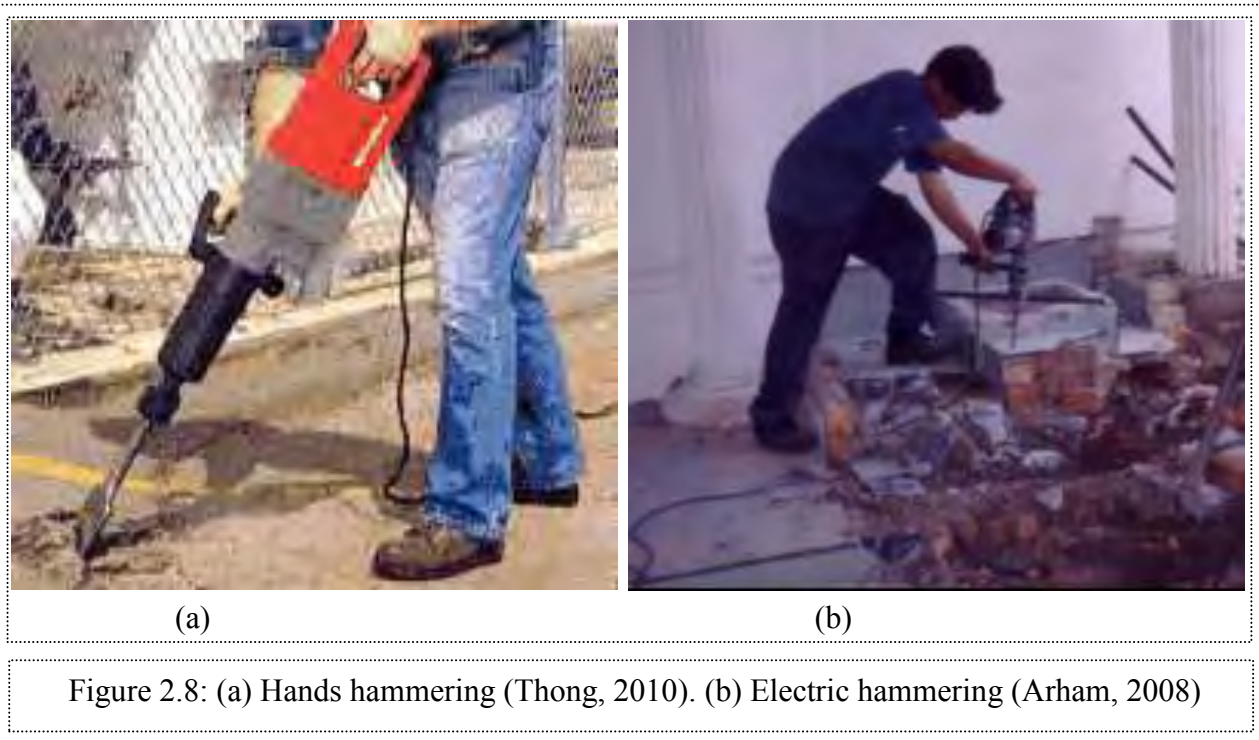


Figure 2.8: (a) Hands hammering (Thong, 2010). (b) Electric hammering (Arham, 2008)

### Rotary hammer

The versatility of the rotary hammer (see figure 2.9(a)) allows it to demolish concrete with a hammer only action or delivery rotary hammer action for boring holes. This is done in the rotary hammer mode by driving twist drills and core bits. It uses a battery ram that floats inside a cylinder and is launched and retrieved by a piston. A shock absorbing air space between the ram and the piston compresses and drives the ram forward as the piston advances, then sucks it back as the piston retracts.

### Pneumatic hammer

The impact energy of this hammer is obtained by allowing compressed air to expand in the cylinder of the hammer. Driving the piston rapidly against the anvil to transmits the released energy to the chisel. This tool works on a basic principal of movement induced by the expansion of compressed air. An air compressor is normally used to supply compressed air to the hammer. The advantage offered is that, it can be easily mounted on the light carriers, requires less accessories as well as maintenance. It does work better in confined space due to its weight-power ratio and suitable for under water usage (see figure 2.9(b)).

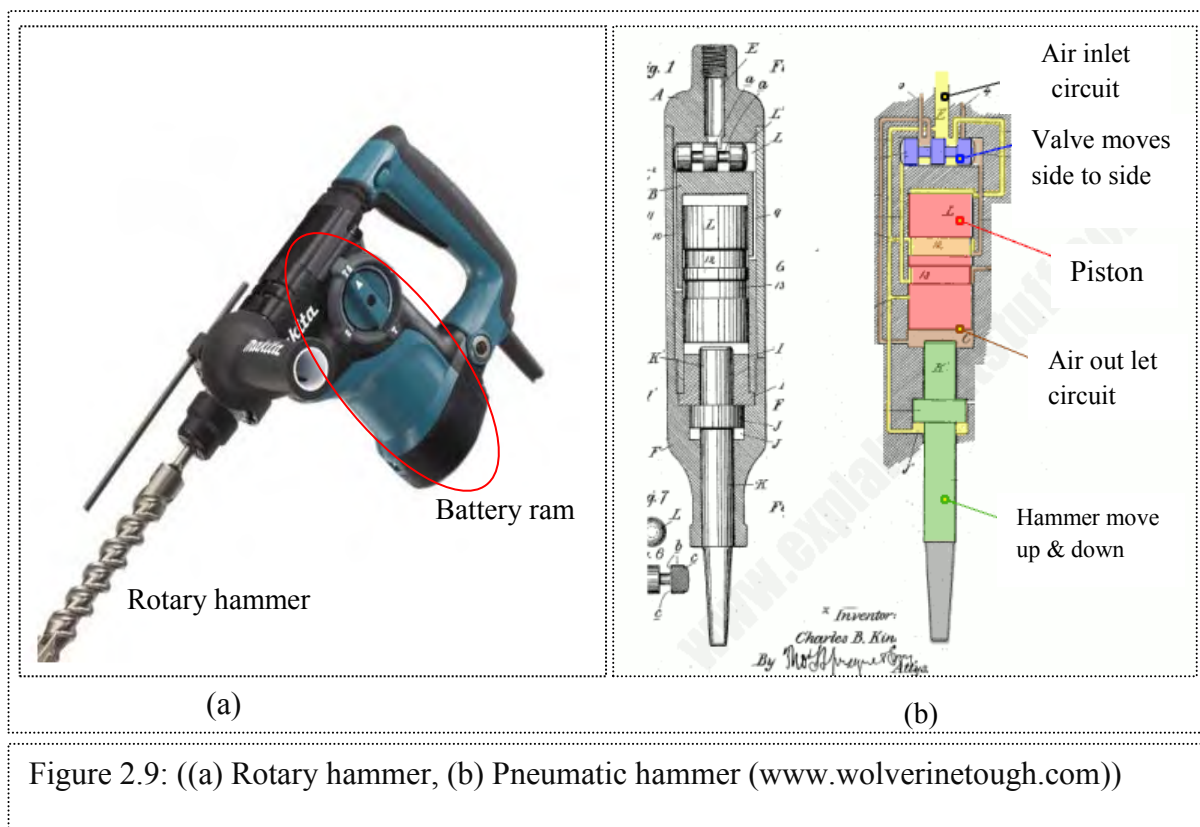


Figure 2.9: ((a) Rotary hammer, (b) Pneumatic hammer (www.wolverinetough.com))

### Hydraulic hammer

The impact energy is obtained from hydraulic oil supplied at a fairly high pressure. Since hydraulic oil is an incompressible fluid, the pressure cannot be converted in to motion without an auxiliary medium. In order to make such a motion possible, hydraulic hammers are equipped with a nitrogen bulb or chamber. The compressible nitrogen is separated from the oil by a diaphragm and provides the requisite conversion of pressure in to motion. In this way, the piston is able to thrust rapidly against the anvil. The anvil then transmits the released impact energy to the chisel. The hydraulic hammer operates with a completely enclosed hydraulic system (see figure 2.10 (a)).

### Gasoline hammer

The stroke energy is obtained from the rotation of a gasoline motor (see figure 2.1 (b)), which is converted to reciprocating motion by an eccentric cam. These hammers normally weigh from 10-40 kg. However, the gasoline hammer produces lower strokes energy in contact to the pneumatic and hydraulic type of hammers.



Figure 2.10: ((a) Hydraulic hammer, (b) Gasoline hammers (www.loink.com))

## ii. Hand held tool

There are many manually hand tools that are still applicable in present for demolition construction or building material. Although the hand-held tools are very slow in progress but those can demolish the part of building precisely. Thus, those only suitable to be used for small renovation purpose of small part of the structure. For example, a “crow bar” which is typically has pry bar and hooked pry bar that can be used in removing the nails or other fastener sand wedged into building materials.

### 2.5.3.2 Demolition by Machines

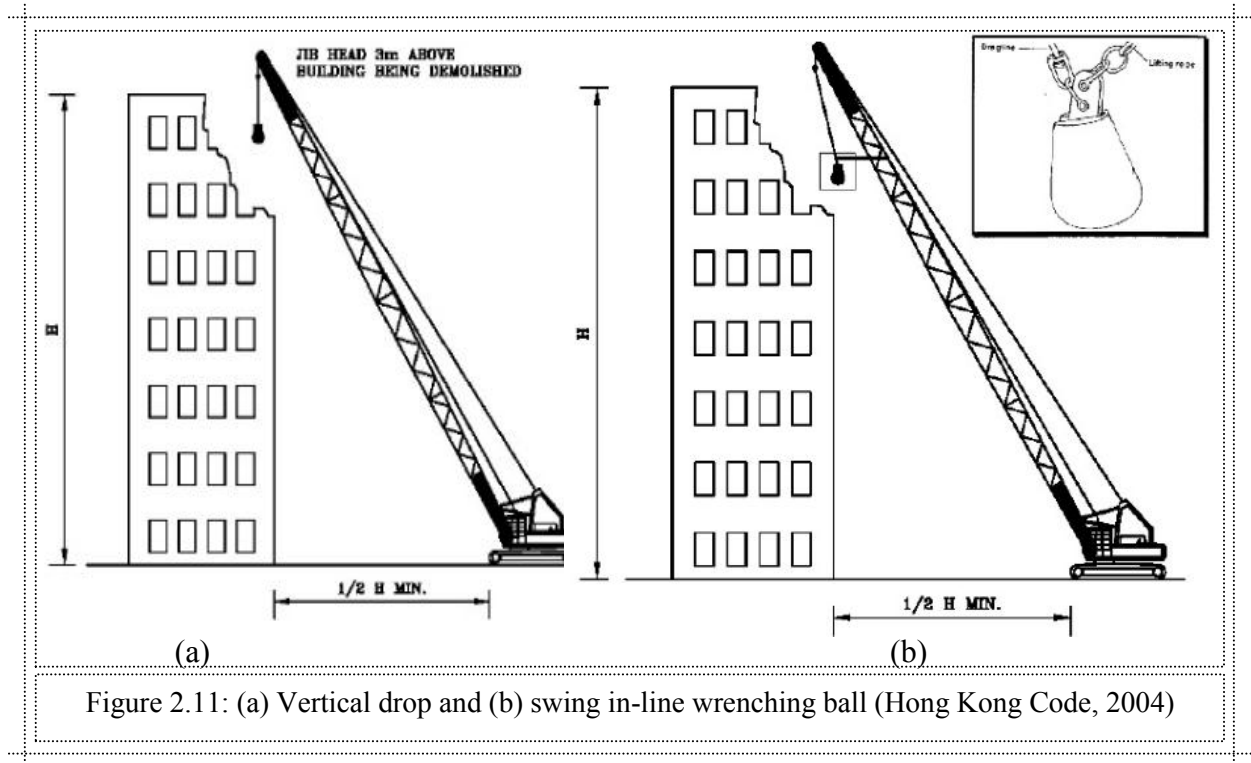
Machines are usually applied to speed up the demolition process using mechanical or hydraulic attachments instead of using manual hand tools especially for demolition of bigger parts of structures. The efficiency of this technique is higher than using hand method. The execution of demolition by engaging machines with mechanical attachments are usually performed by balling, hydraulic crusher with long boom arm and wire rope pulling (Arham, 2003; Thong, 2010).

#### Wrecking Ball

Demolition by ball involves the progressive demolition of a building by the use of weight that is suspended from a lifting appliance and then released to impact the structure, repeatedly, in the same or different locations (Hong Kong Code, 2004). During the process, the ball is either dropped onto or swung into the structure that is to be demolished. It is one of the oldest and most commonly used techniques for building demolition. The ball is weighing up to 6000kg to demolish concrete and masonry structures.

For demolition by balling, the auxiliary machine from which the ball is suspended must permit the ball to perform two types of motion: free fall and a swinging or ballistic motion. The choice of auxiliary machine depends on the object to be demolished, the direction of impact (horizontal or vertical as shown in figure 2.11), the size of ball required and the distances involved (including the height). To be safe during demolition by wrecking ball, the minimum horizontal distance of the equipment or crane for both vertical drop and swing in line should be half of the height of the structure to be demolished. Wrecking ball method is not suitable for all demolition applications. Because for ball and crane demolition projects, only highly skilled and experienced crane operators should be used. Besides, additional work in the form of cutting rebar may be

necessary since the concrete can be broken into rather small pieces. Moreover, the size of the building that can be demolished with this method is limited by crane size and working room, including proximity to power lines. Lastly, a wrecking ball method creates a great deal of dust, vibration and noise.



### Wire Rope Pulling

This technique of mechanical demolition involves attaching wire ropes to a structure, usually of steel and pulling the pre-weakened structure to the ground by winch or tracked plant (BS 6187, 2000). The technique is suitable to detach buildings when clear space is sufficient. Wire ropes at least 16 mm in diameter are normally used with a safety factor (Hong Kong Code, 2004). A safety distance of 1.5 times the height of element to be demolished shall be maintained between the machine and the building during the pulling.

The arm of the hydraulic excavator can also provide the required force on the rope. This arrangement has the advantage that the machine operates at a suitable distance from the member to be demolished. However, the wire rope pulling is often limited to buildings less than 15m in

height for safety reasons. This technique can be used for timber framed buildings, masonry and steel chimney as well as bridges. Figure 2.12 shows the operation of wire rope pulling technique.

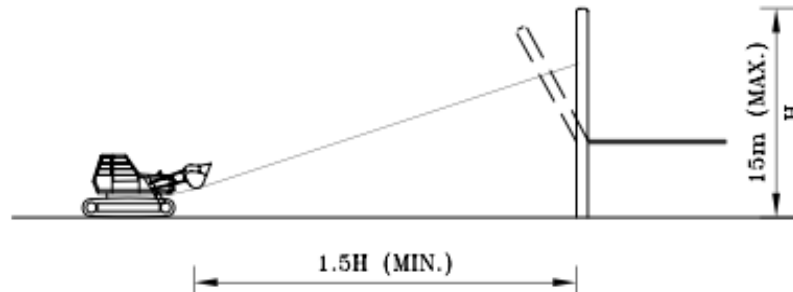


Figure 2.12: Wire rope pulling techniques (Hong Kong Code, 2004)

#### Hydraulic crusher with Long Boom arm

The crusher attachment breaks the concrete and the reinforcement by the hydraulic thrust through the long boom arm system. Normally, this is applied in the top-down method. After the upper floor is destroyed part by part, the crane will remove the debris to ground. Consideration should be made to use an appropriate machine e.g. excavator fitted with suitable booms and arms to mechanize the dismantling of high rise structures or building as shown in the figure 2.13 below.

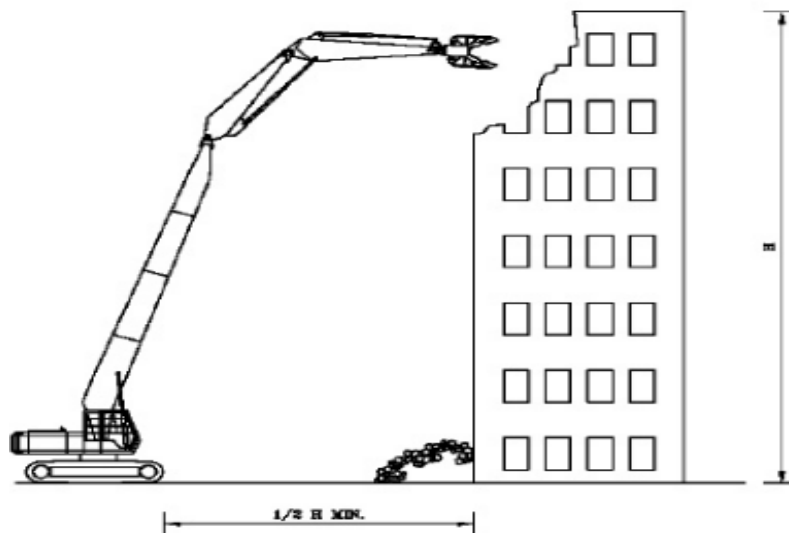
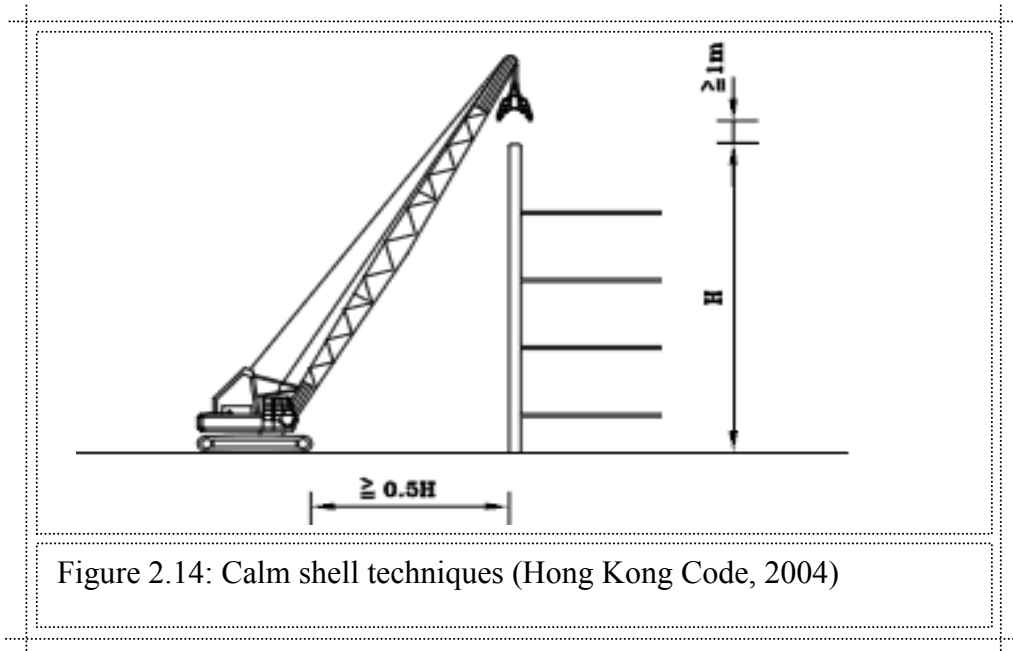


Figure 2.13: Hydraulic crusher with long Boom arm (Hong Kong Code, 2004)

### Clam shell

Demolition by clam shell typically involves the use of a crane equipped with a clam shell attachment which progressively bites away the structure. It requires a minimum safety distance of 0.5 times the height of the building element being demolished to maintain the machine and building during operation. The process of biting off the structural elements begins from the top and progress downwards and operated not less than 1 m above the structure being demolished. . Figure 2.14 shows the operation of calm shell technique.



#### 2.5.3.3 Demolition by Towers and High Reach Cranes

Demolition by towers and high reach cranes are normally used to carry out demolition works on structures that are very high. It is also used for high structures that do not provide sufficient working platforms such as towers, elevated water tanks and storage silos. BS 6187 (2000) states that the use of such cranes for demolishing high rise structures should be considered for the removal of structural elements and debris as an alternative to dropping of materials.

#### 2.5.3.4 Explosive Demolition Techniques

In order to induce the collapse, the explosion product realizes, in a controlled manner, a mechanical work within the structure. Directing the explosives' enthalpy towards the critical points of the structure represents the core of the design activities related to a controlled demolition of a particular building (Bassam,2008).

In Australia explosives do not apply to induce the collapse of any structure unless approved by the regulatory authority. All possession, storage, handling and use of explosives must be carried out in compliance with the relevant dangerous substances/goods or explosives legislation applicable in once state or territory (AS, 2013). There are two main methods for building explosive demolition:

- Vertical collapse method
- Side collapse method

### Vertical collapse method

The structural elements where to place the explosive charges are chosen in order to create locally elementary mechanisms within the structural elements. It is positioned symmetrically against the vertical-longitudinal plan of the building. The loss of equilibrium was obtained as a result of the vertical movement of the gravitational volume. In the demolition process all structural supports should be removed by explosions in order to set the structural instability. This demolition process can be done by the reducing the total number of supports to  $(n-1)$ , where  $n$  is the required number to guarantee the stability (Horea, 2009) as figure 2.15 shown below.

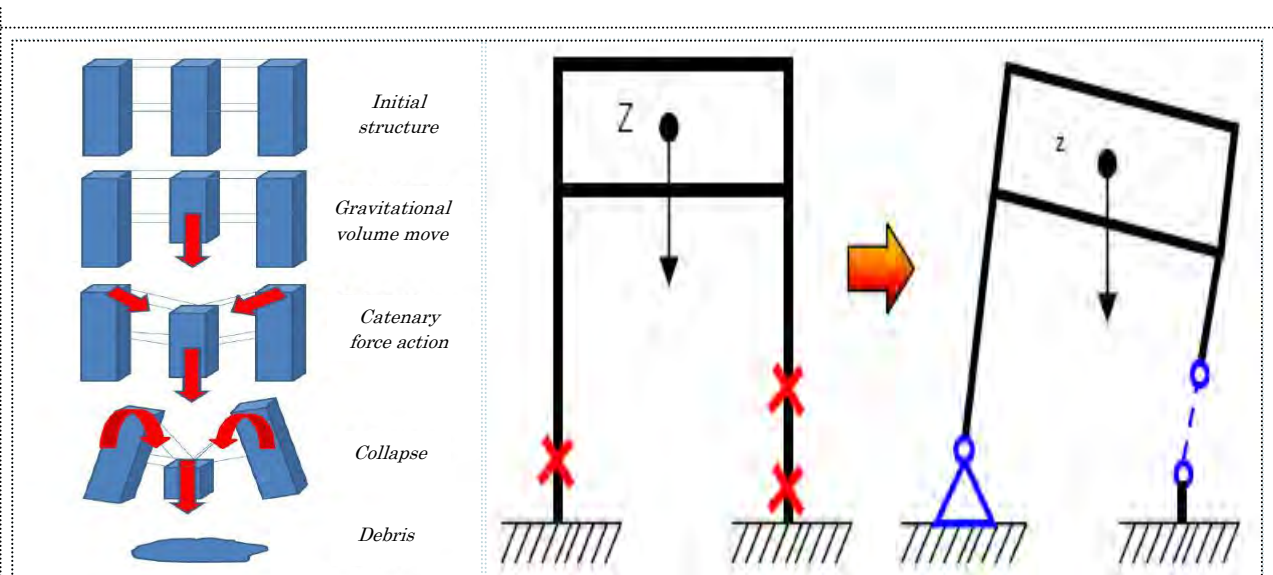
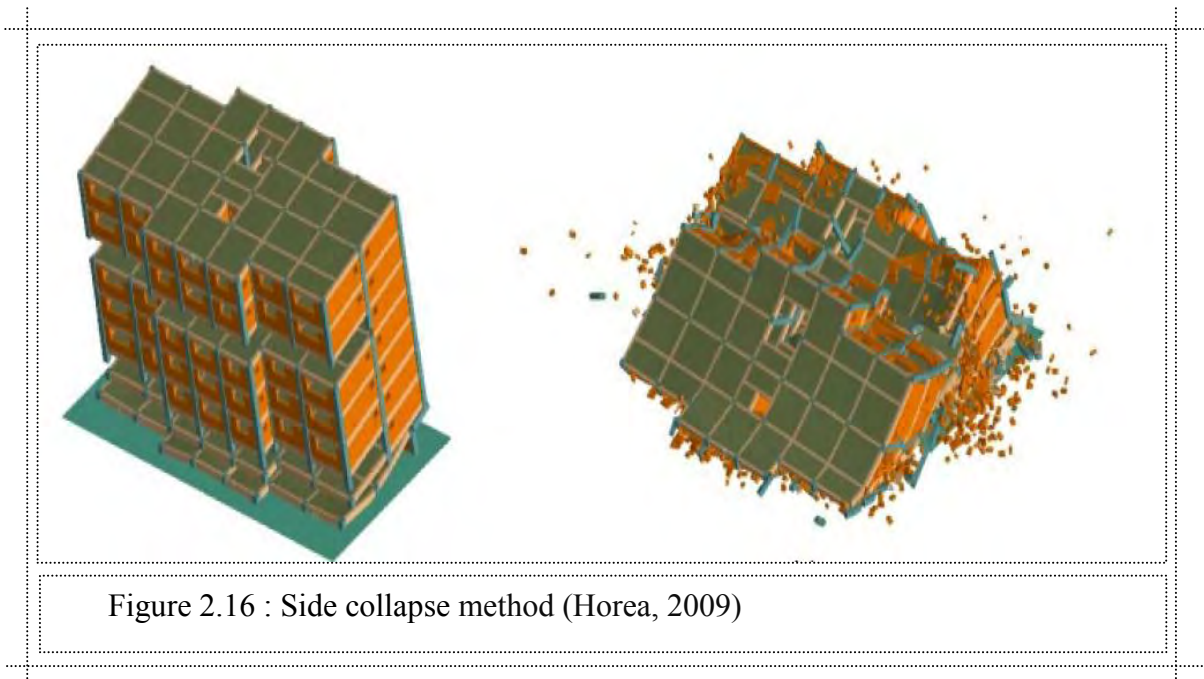


Figure 2.15: Vertical collapse method (Horea, 2009)

### Side collapse method

As indicated in the figure 2.16 below, the method gradually removes some structural elements in order to deny the dead load transfer to the basement and to force the structure to bend towards the required direction. The gravitational stage is when there are no more detonations and it is the gravity alone that accelerates the mechanism movement.



#### 2.5.3.5 Demolition by Water Jetting

BS 6187 (2000) defined high-pressure water jetting as “water jet stream pumped at high pressure to erode the cement matrix and wash out the aggregates including those using additives and abrasives where there is energy input to increase the pressure of water and for cutting of reinforcing steel”. For example, a high-pressure water jet about 250-300 MPa from a nozzle about 0.3-0.5 mm in diameter can cut through plain concrete by abrasion (Abdullah,2003). Water jetting is executed by hand held equipment’s and imposes several disadvantages such as it cannot be preset to a certain depth, difficult to work with and requires frequent pause or two operators taking turns to avoid risk of accidents” due to fatigue. It also generates a lot of water. On the other hand, the benefits of water jetting are, it reduces the production dust and fire hazards.

### **2.5.4 Combined Classification of Methods and Techniques**

This classification is according to Hurley and Hobbs (2000) the method of demolition classify in to three categories based on their modernity of the methods and techniques which are discussed under section 2.5.2 and 2.5.3 above. These are;

1. Traditional
2. Explosion and
3. Newer methods

This classification differs from the above mentioned by Australian standard code of practice for demolition, Hurley and Hobbs (2000) provides specific tools and equipment required, the type of building the method is suitable for, and the procedure that the method entails. On the other hand provides a commentary on the methods and includes the advantages and disadvantages, just as each building to be demolished has its own characteristics, and these must be considered carefully before any decision is made on the method that would be most suitable for a particular case.

The frequency of application of a demolition method is a result of the evaluation from the suitability, performance, and nuisance. In many cases it is likely that the demolition, which eventually takes place, is a combination of methods, which achieve the overall aim of the project.

#### **2.5.4.1 Traditional Methods**

##### **Demolition by hand**

Tools or Equipment required for this type of demolition are, Portable tools including: crowbars or mattocks, pneumatics drills and power saws. It is suitable for reserved mainly for high and inaccessible areas, or architectural salvage. Demolition proceed in a top-down fashion, floors in buildings are removed prior to demolition to prevent premature collapse due to weight of debris collection. This method is an oldest method, labour intensive and slow and expensive if labour costs are high, debris is easily segregated for salvage purposes, possible safety implications of working at height.

##### **Pulling**

Wire rope vehicle to provide pulling power used as equipment and for brick or masonry structures suitably applied. The procedures to apply pulling, remove all stabilizing elements example, pipework, beams and lintels detach from adjacent buildings, set rope around section of

brickwork and drag to collapse. drawbacks of this method is causes dust nuisance, time consuming if uncontrolled, collapse occurs due to destabilized for a period before demolition bad safety implications.

### **Impact**

Demolition ball between 0.5 and 2.0 ton suspended from a crawler, Crane Pusher arm (extended arm and steel pad fitted to tracked vehicle) and applied for fairly large, brick, masonry, concrete or reinforced concrete structure. The preparation or procedure used for impacts are remove floors as per hand buildings more than 30m high should be reduced by hand before using ball, then detach from adjacent, finally arm is positioned at top of wall and forward motion applied to the structures. It is widely used in European countries produces noise, vibration, dust and can be set to drop weight vertically onto floors and foundations. It is Popular in late 1970s, more controllable and versatile for demolition using ball in restricted areas in terms of height of wall to be demolished.

### **Percussion**

Tools used for percussion; hammer, hydraulic or pneumatic, hand held or vehicle mounted hydraulic breaker. This is applied for concrete, brickwork/masonry for capable of partial demolition. It involves repeated impact Jaw-like attachments break concrete by holding and crushing into sections. Pneumatic hammer is smaller and lighter, but noisier than hydraulic both produce persistent noise, produces small size materials, no need for secondary crushing before use as recycled aggregate for reasonable cost.

#### **2.5.4.2 Demolition Using Explosives**

##### **Borehole charges and lay-on charges**

Both method of demolition applied for concrete, brickwork and masonry, not suitable for narrow members. Borehole charges placed in pre-drilled holes and lay on charges placed in contact with structure and contained with sandbags or clay.

##### **Concussion charges**

Applied for enclosed structures example tanks/ reservoirs or containers, and it prepared with bulk charge placed within structure. Borehole, lay-on and concussion charges create shock waves from powerful explosives can be transmitted over great distances by some ground conditions

such as clay and by airwaves. Risk of flying debris produces medium sized materials that may require further crushing before use as recycled aggregates.

#### **2.5.4.3 Newer Methods**

There are various methods under newer method of demolition, like expansion/ bursting (static and dynamic), abrasive, heating, cryogenic and bending.

##### **Expansion/ bursting (static and dynamic)**

The equipment's or tools used for this method are buster with wedges and chemical expansive agent for dynamic bursting. Buster with wedges and chemical expansive agent applied for concrete or masonry but chemical expansive agent cannot be used for narrow structural members, reinforced concrete or prestressed concrete. Mechanical wedges forced into pre-drilled holes and expanded by hydraulic pressure and chemical expansive agents applied by Injection of un slaked lime composite mixed with water into predrilled hole, hydration of mixture causes expansion which splits surrounding material. This method of demolition is create noise and dust at drilling stage, otherwise nuisance free, slow, good for working in close proximity to other buildings.

##### **Abrasive**

Tools used for abrasive demolition; hammer drill, hand operated, or vehicle mounted applied for general application and diamond boring machine (drilling concrete), diamond disc cutter (capable of cutting R.C.), diamond wire saw(cuts around circumference of concrete sections) and high-pressure water jet(can be used to cut cement grout to release components).

Hammer drill, hand operated, or vehicle mounted tools Reduces concrete to dust using rapidly rotating and hammering bit. Vehicle mounted hammer drill used for the destruction of mass concrete. Diamond boring machine is quite slow and expensive, Diamond disc cutter and Diamond wire saw creates noisy, but produces little dust or vibration. High-pressure water jet used 250-300 Mpa water jet forced through small nozzle can cut plain concrete. Addition of particles of steel allows it to cut through reinforced concrete.

##### **Heating**

Thermic lance (metal tube, approx. 3m long containing aluminum alloy or iron alloy rods fuel oil flame used as a tool and applied for reinforced concrete. Tip of lance heated to 1000°c oxygen

fed to tip produces flame 2500<sup>o</sup>c, can melt reinforcing rods and concrete, combustion of mixture of kerosene and oxygen gas produces flame to melt concrete. The drawback of this method is cutting of some materials can cause toxic fumes.

Another tool of heating is, heating and peeling using electrical conductors which is also used for reinforced concrete. Drill holes to reveal rebar's, attach electrical conductors to induce current through the rebar's, causes heating which dries out surrounding concrete so it peels. Little noise or dust after drilling stage. This could use microwaves to dry out concrete and omits use of drilling but it is expensive.

### **Bending**

Jack-up is used to demolish reinforced concrete horizontal members. Application of point force upwards against floor slab induces bending and shearing forces into slab designed for down loading only. This method is developed in japan and rarely used.

To conclude, the first types of demolitions discussed by BS 6187 (2000) are only for structural demolitions and did not include non –structural demolitions. Next the Austrian code of practice has been classified the methods in to three including of both structural and non-structural demolitions. To achieve the execution both demolitions (structural and non-structural) in Arham (2008) research clearly indicates that, the demolition technique employed in to five main categories.

Lastly Hurley and Hobbs (2000) have been classified all the methods and techniques in to three based on their modernity as well as provide specific tools and equipment required with available area of application with their merits and demerits. Therefore this research study feeds from all overviews and finally changed in to local context at the discussion and analysis part as appropriately.

## 2.6 SELECTION OF DEMOLITION TECHNIQUES

There are various demolition techniques available to the demolition contractor from complex technique to the simplest one. Before selecting any type of demolition technique, the demolition contractor needs to consider a set of criteria and assess their relevance to the demolition work to be undertaken, in order to attain the most appropriate demolition technique (Nassir, 2014). To review of the available demolition techniques, it is important to explore a number of considerations or criteria's that need to be taken into account as follow. According to Anumba (2002), there are six main criteria and several sub-criteria that affect the choice of demolition techniques. The main criteria are:

- Structural characteristics
- Site conditions
- Demolition cost
- Past experience
- Time
- Reuse and recycling.

In addition, research done by Kasai's (1988) as cited by Abdullah (2003) listed eight criteria which affect the choice of demolition techniques

- Structural form of the building,
- Scale of construction
- Location of the building
- Permitted level of nuisance
- Scope of demolition
- Use of building
- Safety and period of demolition.

Both researchers Anumba, (2002) and Abdullah (2003) agreed on the majority of the selection criteria, except the health and safety that is excluded in Anumba's selection process. So the selection of the most appropriate demolition technique will be subject to a unique combination of all these main criteria's.

The selection of demolition techniques are also depends on a number of other factors such as client specification, presence of hazardous material, extent of demolition, financial constraints, environmental and recycling consideration etc. When buildings are demolished, large quantities of waste may be produced in a relatively short period of time, depending on the demolition technique used. The demolition project duration can vary depending on the technique used implode a structure with explosives, use a crane and wrecking ball technique, or deconstruct the structure (Fesseha et al., 2003). The report added that, there are thirteen criteria that may affect the selection of demolition techniques. However, they did not mention the scale of significance on demolition projects. The criteria listed by the researchers have been summarized and discussed as follows:

*Client specification:* The demolition contractor, before embarking on any type of demolition technique, needs to be aware of the restrictions imposed by the client such as on the type of demolition technique that should not be used in a particular project;

*Location, accessibility, shape and size of the structure:* The location, accessibility, shape and size of a structure are important factors, which can have an effect on the selection of demolition techniques on a demolition project. For example, a high-rise demolition project located at the center of a busy town center will require different demolition techniques to a demolition project located on a remote site. Hence, a high rise building has different demolition techniques compared to a single storey building;

*Stability of the Structure:* The stability of a structure is an important factor, which needs great consideration before selecting a demolition technique. For example, if a structure were highly unstable, then the demolition contractor would be expected to select a technique, which does not require site personnel operating within the structure. If the unstable structure is located on a confined site, the demolition contractor needs to stabilize the structure by providing appropriate temporary supports before selecting a particular demolition technique;

*Presence of hazardous materials:* In the presence of hazardous materials, the contractor would be expected to assess the full extent of the risk that is involved with the work. The demolition contractor then needs to select safe demolition techniques to carry out the demolition work based on the presence of hazardous materials;

*Time constraint:* A time limit is usually imposed on demolition projects just as in a construction project. However, demolition projects are generally required to be carried out as quickly as possible by the client who may want to develop the land as soon as the demolition work is complete. Where the time imposed on a demolition project is short and the client is willing to pay for a quick demolition, the contractor is expected to select demolition techniques with little regard for cost;

*Degree of confinement:* The degree of confinement of a demolition site refers to the number of existing features in close proximity of the structure. Therefore, it is essential for the demolition contractor to survey the site and assess the confinement of the structure before selecting demolition techniques. For example, city center demolition works can be so confined that the demolition contractor is left with the option of deconstructing the structure, which is a slow, expensive option but a safe and more controlled demolition technique;

*Transportation consideration:* The demolition contractor, unless he plans to use debris as infill material, should consider the transportation of the debris pile from site, before selecting a demolition technique. This criterion has to be considered because it may result in increased of costs;

*Extent of demolition:* The extent of demolition of a structure may influence the selection of demolition techniques. For example, in partial demolition, the contractor must not only worry about the demolition work but must also consider the effect of the selected demolition techniques on the rest of the structure that is to be retained. Therefore, the contractor is expected to select appropriate techniques to demolish the building while at the same time needing to retain parts of the structure unlike in total demolition of structures;

*Structural engineer approval:* Due to increasing complexity of construction techniques and structural forms, it is no longer easy for the demolition contractor to readily assess the likely collapse mechanisms of structures. Therefore, the structural engineer is actively involved in the demolition process of sophisticated structures and directly influences the contractor's choice of demolition techniques;

*Financial constraints:* The demolition contractor is expected to select a safe and financially feasible demolition technique. However, the demolition contractor should not, under any

circumstance, compromise on safety while selecting a demolition technique despite the financial constraint that may be imposed on the demolition of a structure. Therefore, it is important that the demolition contractor considers the financial implications of the demolition techniques selected for a particular demolition work;

*Recycling consideration:* Recycling of demolition materials is an important aspect of demolition projects that the contractor needs to consider when selecting demolition techniques. The more selective the demolition techniques that are used on a demolition project, the higher the value of the materials to be recycled. However, the use of more selective demolition techniques generally would mean a higher cost and more time to carry out the work. Therefore balances need to be struck between the agreed cost and time of the demolition work and the degree of selectivity of the demolition techniques that are to be used by the demolition contractor;

*Environmental considerations:* Several environmental restrictions are imposed on demolition projects by local environmental authorities and by environmentally conscious clients. Therefore, the demolition contractor is expected to work closely with the local environmental services to fully assess the environmental risks before selecting demolition techniques; and

*Health and Safety:* The site personnel and the public are key issues, which cannot be compromised by the demolition contractor when selecting a demolition technique. The responsibility for safety lies on both the contractor and the client. The demolition techniques selected by the contractor should not at any time pose any threat to the health and safety of site personnel and the general public.

Another method of selecting demolition technique is also developed by Mahdi (2002), called „Analytical Hierarchy Processes (AHP)“. This method uses a multi-level hierarchical structure of goals, criteria, sub criteria, and alternatives to demolish structures using progressive, deliberate collapse mechanism and deconstruction. A hierarchy is a tree-like structure that is used to decompose a decision problem. It has a top-down flow, moving from general categories (criteria related to structural characteristics, site conditions, cost, past experience, reuse and recycling as well as time) to more specific ones (sub-criteria’s such as stability, health and safety, manpower, availability of plant and equipment, level of reuse and recycling as well as actual demolition),

and finally to the alternatives, Figure 2.17 below shows the hierarchal structures to select the most appropriate demolition techniques.

Goal: to select the most appropriate demolition techniques

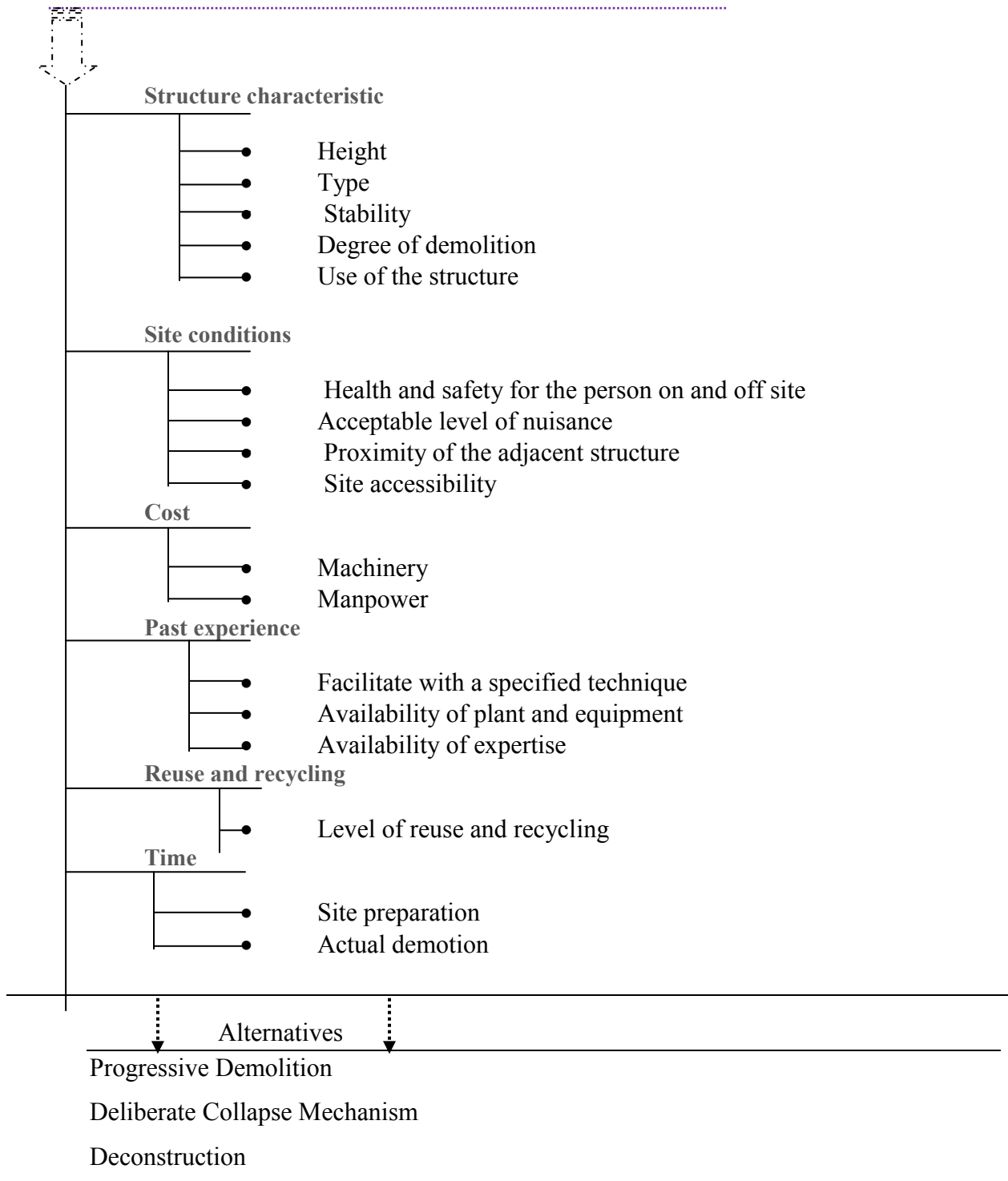


Figure 2.17: Hierarchal structures for the selection of demolition techniques (Mahdi, 2002)

## 2.7 HEALTH AND SAFETY PRECAUTIONS IN BUILDING DEMOLITION

The demolition of a building can be considered among the most dangerous activities to be undertaken on site and therefore, in need of a rigorous health and safety precautions. The improvement of safety, health and working conditions depends ultimately upon people working together, whether governments, employers or workers. Safety precaution involves the functions of planning, identifying problem areas, coordinating, controlling and directing the safety activities at the work site, all aimed at the prevention of accidents. If demolition is not planned out properly; it could result in many injuries and also lead to fatal deaths. This is why it is really important to go through the safety precautions issues when planning and executing a demolition (HSE, 2004).

The report added that, most of the health and safety risks in demolition activities are related to an unplanned Collapse of the structure; at the same time the incorrect use of a demolition tool can cause injuries as well as an unsafe site. Through the analysis of accident statistics by health and safety executive, it is noticed that a reported accident such as trapped by something collapsing or overturning can be related to the collapse of structural parts or uncontrolled discharge of debris. Demolition is carried out on structures no longer required, Often there is little or no information related to their original design. The nature of demolition work is such that people often have to work close to severe hazards including: falling from height, premature collapse of structures, temporary hazardous situations and exposure to harmful substances are the most frequent kinds of accidents encountered.

Risks related to explosions have be assessed when plants and services are still in use and therefore, a temporary suspension of gas and/or electricity supply should be also required during the execution of demolition activities. Even if the numbers of risks related to demolition activities seem to be relatively small, there are many factors that are not properly addressed may cause a serious injury or fatality. Based on Australian occupational health and safety act work cover (2000) for safe demolition work, persons who want to demolish buildings must have a builder's license that authorizes demolition work issued by the ACT Building, Electrical and Plumbing Control (BEPCON). Incompetence and lack of knowledge to conduct demolition work may lead to accident and incident occurrences or worst case, fatality.

On the other hand as Arham (2008) indicated that the most likely reason for causes of demolition injuries are; unsafe attitude followed by poor site management, unsafe procedures at the workplace, not wearing proper protective gear, lack of knowledge and experience and unsafe condition such as hazardous materials and dangerous elevations poor health and safety monitoring and enforcement, lack of cooperation between management and workers and lastly avoidable hazardous conditions at the project site.

Workers have a duty to take reasonable care for their own health and safety and that they do not adversely affect the health and safety of other persons. Workers must comply with any reasonable instruction and cooperate with any reasonable policy or procedure relating to health and safety at the workplace (AS, 2012). So every worker must use the Personal protective equipment (PPE) in the site work. In addition BS 6187 (2000) mentioned that, safety equipments are importantly protected workers, only if they are properly used. A number of hazards in demolition work require the use personal protective equipment, these equipment's are:

- Protective clothing
- Safety foot wear(safety shoes)
- Safety helmet
- Eye face protection
- Hearing protection

### **2.7.1 Demolition Health and Safety Plan**

Demolition safety plan is one of the phases involved in demolition process which covers all the steps acquire to identify asses and control hazard which might occur at the workplace during the demolition work. It has been developed in consultation with employees and health and safety representative (Rizman, 2010). It includes a description of the demolition workplace which contains all the information about the site such as the overall height of the structure above ground level and minimum distance between the structures that need to be demolished with each site of the boundary. It is also embraced all the details about the location of the services such as drainage, sewerage, electricity, gas, water, telecommunication and all other cases such as underground basement and hazardous material that can be found in the workplace.

As indicated by Kassim (2008), the safety plan covers all the steps involve in identifying, asses and control hazard, which might occur in the workplace. It should contain all the available information to make sure that, demolition contractors aware of the hazards that will arise during the demolition work and the result that may cause by the hazard. Besides that, information about how to minimize the level of risk instructions to report additional hazard must be included. This information is very important to ensure the effectiveness of safe and healthy environment during demolition work. It is also clarifying all the details about the proposed demolition methods that might be applying to the project including the types of equipment used, the steps involve, methods of handling and disposing hazards material and any other description on the work process.

Induction and Training of employers enable all the employees to perform their work in manner that is safe and without risk to health. Therefore, demolition safety plan should include all the details about the training involve for the workers and record on the activities. It is also highlight the information for first aid requirement and prompt medical attention in case of serious injury. So, locations of the nearest medical facility have to be stated as well as contact numbers and person in charge in the situation (Rizman, 2010).

### **2.7.1.1 Hazard Identification**

A hazard is anything with the potential to harm life, health or property. Hazards are the main cause of occupational health and safety problems at workplace. Therefore, finding ways of eliminating hazards or controlling the associated risks are the best way to minimize workplace injury and illness. So Hazard identification is the process of identifying all hazards in the workplace. It involves the systematic approach or investigation of all potential hazard sources and the recording of hazards identified. In other words, it means identifying all of the possible ways in which people may be harmed caused by the activities. Furthermore, systematic approaches are applied in identifying hazards at the workplace to ensure the effectiveness of the process (OSHA, 2000).

In demolition work the methods of identifying hazards includes, inspections of the demolition site and structure, plant and equipment, and direct observation of work processes. It is also involves consultation with workers, who are usually aware of what is going wrong and why, based on their experience with a job. Not only that but also consultation with specialist

practitioners and representatives of industry associations, unions and government bodies regarding advices and information on health and safety matters relevant to demolition work. Analysis of workplace injury and incident records on demolition sites, to identify where and how injuries have previously occurred are also embraced under the identification. It is important to notice that hazards can arise in many different ways and can take various forms which may result unnecessary costs and human suffering. Hence, hazard identification process must be properly done to achieve zero injuries.

### 2.7.1.2 Risk Assessment

Risk is the potential outcome of hazards or possibility of injury, illness and damage that may arise in the workplace. Risk assessment means the process of assessing all of the risks associated with each of the hazards identified during the hazard identification process. When hazards have been identified, the next step is to assess in terms of their potential to cause injury or illness to anyone at or near the workplace. Risk assessment has to be carried out to identify hazards associated with the demolition process, assess such hazards and take reasonably practicable steps to eliminate or control the risks arising from those hazards (WSH, 2012). According to OSHA (2000), the steps in the risk management process are:

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1. Identify the hazards associated with the proposed demolition work
  2. Assess the potential risks to workers and other persons affected by the work
  3. Determine control measures to eliminate or reduce the risks
  4. Monitor and review the implementation and effectiveness of the control measures
  5. This process safety work method statement (SWMS) should be documented as part of the demolition safety plan.
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When assessing risks associated with execution of demolition work, AS (2012) considers; the structure to be demolished and its structural integrity, method of demolition including its sequencing, scheduling of the work, layout of the workplace including whether there are hazards both for people and objects, plant and equipment that will be used, skill and experience required by the people who will use it safely, number of people involved as well as local weather conditions.

### 2.7.1.3 Risk Control

A risk assessment must be completed by a technically competent person who has experience in demolition work. The report of AS 2601 (2012) is mentioned the following risk control measures that are considered for public safety:

- Street closures and vehicle / pedestrian detours.
- Hoardings and security fences.
- Scaffolding.
- Overhead protective structures.
- Adequate lighting.
- Warning signage

Effective hazard management requires consultation, input and communication with employees and others relevant to the work being conducted. As mentioned in Occupational Health and Safety as well as Australian standard code of practice (OHS, 2011; AS, 2014), risk control measures have to be considered for site safety, adjoining or adjacent buildings and the surrounding environment as listed in the table 2.1 below:

Table 2.1: Risk control measures (OHS, 2011; AS, 2014)

Site safety	Adjoining buildings	The surrounding environment
<ul style="list-style-type: none"> <li>▪ Safe means of access / egress</li> <li>▪ Personnel are not to work underneath or within the structure being demolished</li> <li>▪ Adequate PPE</li> <li>▪ Electrical safety rules</li> <li>▪ Overhead protective structures and scaffolding</li> </ul>	<ul style="list-style-type: none"> <li>▪ Vibration minimization</li> <li>▪ Shoring underpinning adjoining structures</li> <li>▪ Weather proofing and</li> <li>▪ Protective screens / structures.</li> </ul>	<ul style="list-style-type: none"> <li>▪ Dust control measures including vacuuming and hosing down</li> <li>▪ Fire hazard reduction</li> <li>▪ Noise minimization techniques.</li> <li>▪ Local flora and fauna protection.</li> </ul>

### 2.7.2 Health and Safety Key Factors

According to Health and Safety Executive (2004), health and safety has a great influence in the design and management of demolition projects. Furthermore, it is also stated as the most influential factors in selecting demolition methods to avoid structural instability and prevent structural collapses. Structural collapses have to be identified as events with predictable and unpredictable causes. Unpredictable causes are generally related to natural and catastrophic events such as earthquakes, landslide, floods, etc. On the contrary predictable causes can be determined, controlled, reduced or removed. Causes of collapse associated with demolition activities can be identified through the different phases of the building design, construction and use.

Here, it is noted that a design phase needs to be developed and an execution phase needs to be planned. Therefore, demolition phases have been considered as a sub-project where design, planning and execution phases must be carefully studied and assessed. When developing a study of these phases, it is possible to determine possible causes for structural instability and therefore, provide in such phases different methods and tools to prevent collapses.

Demolition work is one of the most dangerous operations and cause injury to human workers basically because of difficulty of accessing into or working inside a building which is under demolition. Falling of smaller objects or debris from demolishing of buildings, falling of partially demolished structure, collapse of unstable structure seeing that original structure being disturbed, employing inappropriate methods to demolish, collapse of heavy demolition equipment because of inadequate support of the partially demolished structure, collapse of the partially demolished structure due to the accommodation of large amount of un cleared debris, congested environment that is easily caused damages to workers, third parties and their properties that situated nearby the demolition site are some of the predictable causes (Arham,2008).

In order to investigate the predictable causes of structural collapses, the demolition process is considered as an independent project with design, planning and execution phases (HSE, 2004). Such division of the demolition process facilitated the identification of key health and safety factors as depicted in Table 2.2.

Table 2.2: Identification of key health and safety factors during demolition process phases (HSE, 2004)

Demolition Phases	Key factors
<b>Design</b>	<ul style="list-style-type: none"> <li>▪ Structural knowledge of the structure</li> <li>▪ Structural knowledge of any adjacent construction</li> <li>▪ Demolition equipment and methods selection</li> </ul>
<b>Planning</b>	<ul style="list-style-type: none"> <li>▪ Site knowledge</li> <li>▪ Health and Safety risk assessment</li> <li>▪ Development of safe sequences of demolition activities</li> <li>▪ Limitation of the level of subcontracting</li> <li>▪ Pre-qualification and selection of specialist contractors</li> </ul>
<b>Execution</b>	<ul style="list-style-type: none"> <li>▪ Workforce supervision</li> <li>▪ Control of method statements implement at</li> <li>▪ Communication of unplanned discoveries</li> <li>▪ Safety information and training selection</li> </ul>

As depicted in (BS 6187, 2000; HSE ,2004) the purpose of demolition design is to determine the condition of the framing, floors and walls as well as weak structural elements so that measures can be taken to prevent the premature collapse of any portion of the structure. The interruption of a load path, the effect of gravity and inability of the remaining structure to support any force redistribution may cause structural instability and therefore lead to unplanned collapse. Any adjacent structures or improvements have to be similarly checked. When all the information about the structure is available, demolition techniques can be assessed and schedules developed accordingly. When designing demolition activities, it has to be recognized that collapses may be caused by activity induced during the execution of demolition works and not only by the removal of key structural elements. Therefore appropriate plant and equipment have to be selected to avoid excessive loads on the remaining parts of the construction.

Demolition planning is also important to prevent unplanned collapses and unsafe sequence of demolition activities. According to BS 6187(2000) demolition planning gives clear instructions or information about the knowledge of the site. The information can be obtained either form a

desk study or from a site survey. A desk study provides information about site conditions that may affect structural integrity during demolition activities such as:

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- Ground conditions (water table, ground type, sink holes, etc.)
  - location and type of services, above and below ground
  - traffic condition and site access
  - Extent of buried features or above ground structures.
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Investigations on site help to extend the knowledge gained during the desk study and provide a more accurate understanding of the existing conditions of the construction compared to what is identified in drawings and documents. Site investigation plays an important role in the development of a structural design survey, as well as in the planning of all demolition activities.

Diven and Taylor (2006) further explained as, demolition planning is crucial for projects in which the removal of materials causes risks to the safety of people or adjacent property. For instance, the following situations may require a higher level of planning rigor and analysis:

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- A structure to be demolished is close to others
  - A contaminated structure requires special demolition techniques and material handling to avoid exacerbating dangerous conditions
  - A structure to be demolished has historic significance
  - A building with special construction features requires special demolition techniques (e.g. post-tensioned concrete structures, buildings with significant structural damage, etc.)
  - Portions of an existing facility must be kept in operation while demolition work is carried out in adjacent portions.
  - Assets of high value are to be salvaged for sale or for reuse.
- 
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For these project situations among others, demolition contractors ultimately determine which demolition methods and techniques are used. After the selection of methods and plant for demolition, a work schedule has to be developed taking into account site-specific conditions.

In HSE (2004) demolition executions provided all the structural and site surveys have been properly developed, the demolition methods have to be correctly implemented. To control demolition, method of execution and supervisions need to be properly managed. Prior to setting up a supervision activity through inspectors and safety professionals, the client is selected

contractors and subcontractors for demolition activities. On the other hand, contractors have to respect demolition methods assessment and the site-specific demolition health and safety plan procedures. A continual workforce control activity must be carried out by contractors' demolition supervisor to stop workers executing unplanned activities. At the same time workers have to be informed of the risk arising non-compliance with safety instructions through training courses.

## **2.8 DEMOLITION WASTE MANAGEMENT AND ENVIRONMENTAL ISSUES**

### **2.8.1 Waste Management**

Demolition is often considered to be a waste generating activity and results from demolishing of built structures like buildings, roads and bridges for renovation, removal or renewal. Most demolition wastes are classified as solid wastes. They are usually categorized according to their composition, potential to harm the environment and their disposal procedures. So Solid Waste Management (SWM) is associated with the management of generation, storage, collection, transportation, processing and disposal of solid waste using the best principle and practices of public health, economics, engineering, conservation, aesthetics and other environmental conditions (Maiké, 2007; Nassar, 2014).

Most developing countries do not have the technical and financial resources to manage demolition wastes safely. This means that storage at the point of waste debris generation is often inadequate and collection services are inefficient and insufficient (Abdelhamid, 2014). With the sharp development of construction and increase of people's awareness concerning to environmental protection, demolition waste debris control and management becomes one of the great challenges of modern society for the mission of sustainable development (Alfaqawi, 2012).

Demolition debris is excess material produced during demolition of buildings and structures. This debris is made up of materials such as asphalt, brick, concrete, masonry, lumber, shingles, roofing materials, glass, plastics, aluminum, steel, architectural elements, drywall, insulation, wiring, plumbing and electrical fixtures, vinyl and aluminum siding, corrugated cardboard, soil, rocks, tree stumps and other landscaping (Leigh and Patterson, 2004). Demolition waste including of demolished concrete, bricks, and masonry, limestone, ceramic and other materials are the major constituent portions of a total solid waste or debris.

Table 2.3: Typical components of demolition debris material (Arham, 2008)

Components Content	Examples
Wood	Forming and framing lumber, stumps, plywood, laminates, scraps
Metals	Pipes, rebar, flashing, steel, aluminum, copper, brass, stainless steel
Plastics	Vinyl siding, doors, windows, floor tile, pipes
Roofing	Asphalt and wood shingles, slate, tile, roofing felt
Rubble	Asphalt, concrete, cinder blocks, rock, earth
Brick	Bricks and decorative blocks
Glass	Windows, mirrors, lights
Miscellaneous	Carpeting, fixtures, insulation, ceramic tile

Demolition waste can be reused, recycled or returned to nature as compost materials. The underlying goal of demolition waste management is to minimize or eliminate the discharge of such rubble or debris into storm drain systems or water-courses as it increases alkalinity levels in both land and water bodies. Demolition rubble can be cored and ground into fine material, which can be used in the building industry, whilst slurry can be disposed of in accordance with the Solid Waste Management Standards and Specifications (Mehta, 2004).

Brick and concrete wastes can be used for on-site or offsite construction projects as well as Wood waste can be used as covering in composting operations, landfill covers and as an industrial fuel source. However, in developing countries as demonstrated by Operation Restore Order in Zimbabwe, demolition waste disposal options are often limited by structural, economic and logistical constraints (Madebwe, 2006). It is not given special attention, unsystematic reuse and recycling is predominant. It is not recycled with a high efficiency even though significant amount of demolition wastes than construction wastes.

Usually it is very difficult to gain data on the amount of generated demolition wastes in developing countries. However, as tried by GTZ, for example in Thailand particularly Bangkok in 2005, the average generation rates of demolition waste were 984.66 kg/m<sup>2</sup> (residential

demolition) and 1,803.94 kg/m<sup>2</sup> (non-residential demolition) which is much more relevant than waste from construction (56.23 kg/m<sup>2</sup> residential and 30.47 kg/m<sup>2</sup> non-residential) (Maïke, 2007). The report is also added about the main causes for the demolition waste management problems in developing countries in general as listed in the table below:

Table 2.4: Demolition waste management problems in developing countries (Maïke, 2007)

Major problems of demolition waste management
Lack of awareness about the problems associated with the uncontrolled disposal
Lack of acceptance that wastes are valuable resources
Ease of disposing waste legally or illegally
Lack of clear demolition waste management policy
Lack of technology, know- how and standards
Lack of infrastructure
Lack of national waste information systems
Lack of information on good practices
Lack of funds
Unstable political situations

In developed countries like Germany, Netherlands, Britain, United States of America and Australia stakeholders are familiarized with the importance of proper segregation of materials to keep disposal costs at a minimum, partly because of the fact that the most potentially harmful materials attract the highest disposal costs. If materials are mixed, the whole consignment should deal with respect to the most harmful material and may be treated as special wastes (Maïke, 2007; Arham, 2008). Such countries especially in Europe is applied the waste management licensing system implemented under the waste management licensing regulation with conditions imposed by the Environmental Protection Act. As the Environmental Protection Act (EPA, 2000) states, it is illegal to treat, keep or dispose of controlled waste without a waste management license. Those who produce, import, carry, keep, treat or dispose of demolition wastes must take all reasonable measures to ensure that is managed properly and recovered or disposed of safely. This clearly stresses that waste management must take its duties and responsibilities seriously. The point is particularly relevant at the demolition site since the nature of the waste may be difficult to

identify. Therefore to control the practice figure 2.18 illustrates the overall process of demolition waste management framework.

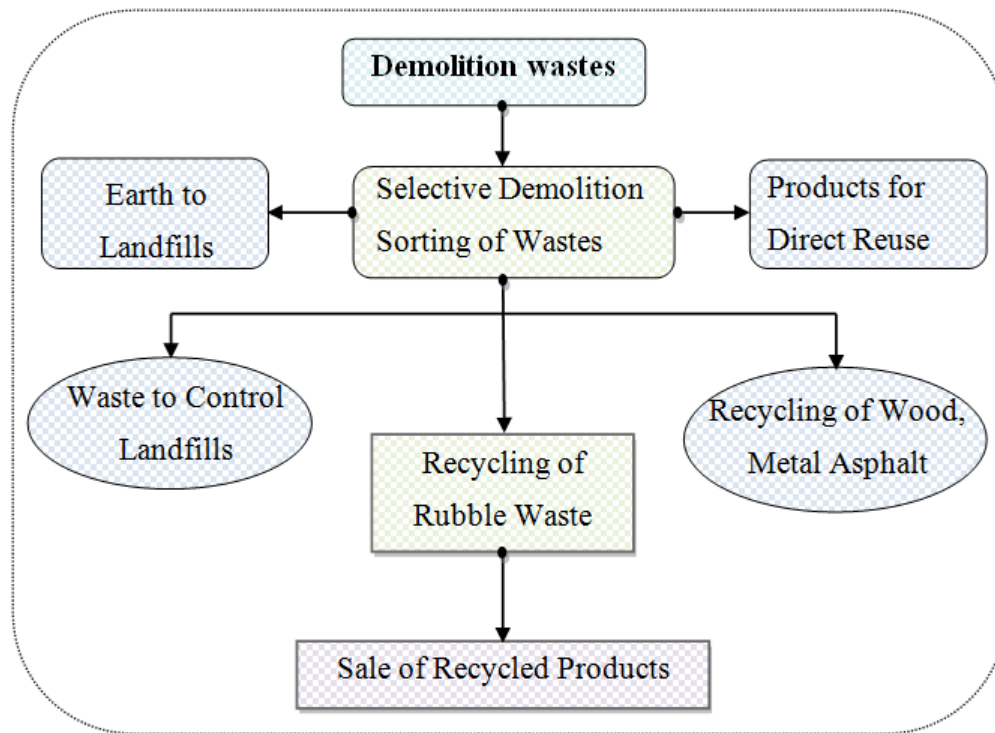


Figure 2.18: Demolition waste management framework (Nassar, 2014)

In implementing a sound waste management practice, there are several key areas which can be actively addressed to ensure legislation compliance and to promote good environmental practice. These areas are appointment and auditing of waste carriers and disposal contractors, traffic management, storage and sorting of wastes, salvaging and recycling as well as dealing with asbestos and other known hazardous materials. After successful demolition Operations, considerations must be given to undertake a post-demolition survey to establish the actual levels and areas of any residual contamination, to act as a basis for future action and development and to ensure there has been no unintentional cross-contamination of otherwise clean ground. Many environmental agencies appreciate the common problems faced by the demolition industry with regard to waste management and effortlessly endeavor to assist demolition organizations by providing information and guidance. However, persons or companies that are ignorant and show disregard inadequately managing wastes are normally prosecuted. This is partly due to the ever

expanding and stringent policies outlined to counter and control wastes as well as pollution. To support and implement the waste management, both reuse and recycling are essential parts of the process. Reuse the main components of residential and commercial structures appear to be making continuous progress. The benefits of reusing of waste streams from building demolition reduced depletion of natural resources. This clearly signifies reclaiming or recovering materials on demolition projects and using these products in the construction of new buildings have less environmental impact than using recycled materials, as the energy used to manufacture. However, due to the tight timescale given to the demolition contractors to demolish a building, there is limited time to recover items that do not have high value. Moreover, the health and safety requirements placed on demolition contractors hinder them in recovering lower value items for reuse. As the demolition process is highly mechanized and difficult to remove partly by workforce, it results risk of injuries, such as falls and cuts. So demolition contractors do not invest time into cleaning up demolition materials and components as this would result in workers being put in closer proximity to the demolition work areas (Zakar, 2009).

As a second option next to reuse by the same researcher added that, recycling from demolition projects can result in considerable saving, since it saves the costs of transporting to the land fill and eliminate the cost for disposal. Land fill costs for demolition and land clearing debris continue to rise and become more heavily regulated, it makes more economic sense to seek alternative means of disposal from these operations. Recycling gets strong support from contractor and subcontractor work crews. This means that they give extra effort to make recycling work, and enhances the overall tone on the work site, which makes the work go smoother and quicker. It also creates employment and economic activity that help sustain local economies. It produces usable materials at much less environmental cost from primary sources and conserves energy, water, as well as reduces the production of greenhouse emissions and other pollutants. On and off job site, recycling is one of the most significant commitments that can be made to sustainable building demolition.

Arham (2008) further explained that, since the mid-1990s, the word recycling with in the industry has been more of fashion word in the sense that there has been a lot spoken about it, but very little has been done. However, there are a number of countries particularly in Europe such as Netherlands, Germany, Australia and Denmark which are great examples that illustrate how

the recycling of demolition materials has been both profitable and important to the environment. These European countries understand and take the matter of recycling demolition debris or wastes seriously. Despite the abundance of natural resource, they continue to use recycled bricks, concrete, asphalt and other similar materials in new construction projects. This because the government, environmental organizations and manufacturers of recycling plant have a developed a successful cooperation which benefits both the environment as well as professional recycling contractors.

It also added that a well-functioning recycling sector increase the potential for developing even more effective recycling technology. In general, the increased environmental focus and recognition of the cost effective of recycling has seen it become a major considerations and a big business. Recycling can also form parts of a certain company's long term diversification strategy in the sense that apart from demolition being one of its core activities. Its source of income can be supplemented from recycling. Developments for the future of recycling will most probably focus on the machinery used in terms of incorporating new technology to improve efficiency, reduce noise emissions, at the time increasingly focusing on environmental considerations.

### **2.8.2 Demolition and Environment Issues**

Demolition operations are often at the highest concerns of environmental issues. These issues are usually associated with water, dust, noise pollutions as well as vibration. It also involves the demolition wastes generated from the demolition of buildings and structures. From an environmental perspective, it would be useful to quantify the reduction in environmental impact from diverting wastes from action sites and landfills. However, section 2.8.1 has already discussed the demolition waste effects and its management with respect to environment. This section therefore, focuses on the remaining environmental matters such as noise, dust, vibration and the contribution of deconstruction on minimizing negative effects on the surrounding environment.

The main emphasis here is tackling environmental problems by proper monitoring and controlling work procedures of the above subject matters and must compliant each other, otherwise the total effort will be pointless. Controlling the considered nuisance factors associated with almost all demolition is an important aspect of building demolition (AIA, 2006; Port-Louis,

2012,). The demolitions of buildings have the potential impact on the residents and the local environment in terms of the following factors:

### 2.8.2.1 Dust

Dust is one of the most frequent problems caused by any demolition project. New technology has made it possible for equipment to control dust more effectively, preventing it from becoming a nuisance to neighbors and workers. Dust emissions can also be reduced by modifying demolition methods. The site of works shall be fenced and screened to protect site from strong winds and winds contain dust (Port-Louis, 2012). Large volumes of dust which in windy, busy or densely populated areas can dangerous to vehicular traffic and a nuisance as well as health hazard to the general public. The most common form of dust formation is attributed by the usage of equipment such as hydraulic breakers and processors as well as other demolition techniques, such as balling and wire rope pulling.

Arham (2008) added that, the movement of heavy vehicles such as excavators and dump trucks within the site also contributes to a large percentage production of dust. Dust from such sources are normally controlled by conducting continuous dust suppression spray along the vehicles' routes on affected structural elements and on debris heaps during the demolition works as well as providing dust screens attached to scaffolding.

### 2.8.2.2 Noise

Noise pollution from the demolition works arises due the use of powered mechanical equipment such as pneumatic breakers, excavators and generators, loading and transportation of debris, etc. affects the workers, and the sensitive receivers in the vicinity of the demolition site. Noise levels on any demolition project can be mitigated by using properly equipped sound suppression devices on heavy equipment or silent type equipment and by scheduling noisy work activities to avoid, or at least reduce, noise levels during evening hours or special events. Demolition activity shall not be performed within the restricted hours established and the average level of exposure allowed during eight hours per day is 60 decibel (DB) (AIA, 2006; OSHA, 2012). On the other hand, noises can control through constructing noise barriers such as wall or piles between noisy activities and noisy sensitive receivers and constructing walled enclosures around noisy activities, or clusters of noisy equipment. Avoid night time activities because sensitivity to noise

increases during the night time hours especially in residential neighborhoods (Hanson et al., 2006).

### 2.8.2.3 Vibration

Vibration from demolition activities can be annoying to neighboring buildings or structures to various extents, depending on the method of demolition. Vibration and vibration related problems should be controlled by suitable monitoring through work methods and scheduling. Vibration is most seriously caused by implosion or collapse. Similar to noise control approach, Hanson et al. (2006) states the mitigation of vibration from demolition requires design consideration, projects layout, sequence of operations as well as alternative demolition methods.

Considering the route of heavily loaded trucks away from residential streets, if possible and operate earthmoving demolition equipment's on the demolition lots as far away from vibration-sensitive sites as much as possible. On the other hand demolition by explosives caused a huge vibration due to the energy released that is totally hazardous to public and other structures nearby. Therefore, special design considerations must be given when conducting demolition by explosives for below ground structures such as foundations or totally excluded from the alternative demolition methods.

Sequence of operations is also important to consider during the demolition phases to execute the work in order. For example earthmoving and ground-impacting operations should not occur in the same time and avoid nighttime activities. Compare and contrast alternative demolition methods for Select demolition techniques to mitigate vibrations. For example, sawing building structural columns into sections that can be loaded onto trucks results in lower vibration levels than impact demolition by pavement breakers.

Generally the effect of demolition dusts, noises and vibrations can cause undesirable consequences up on the air quality, water quality as well as human environment. Therefore demolition parties or stakeholders should concern with these significance issues or consequences and make sure to mitigate each other through the whole demolition process. However, this is not to mean that, they are totally different with above factors but to support for further accomplishment.

#### **2.8.2.4 Air Quality**

Demolition activities could create adverse effect on the local air quality of the site and its surroundings. A whole range of demolition and site clearance activities may generate dust which may constitute a nuisance for local people as discussed in section 2.8.2.1. Concrete breaking, handling of debris and hauling process from haul trucks, heavy demolition machinery are main sources of dust to the surrounding environment. Dust mitigation measures, such as water spray, shall be adopted to minimize dust emissions. Burning of waste shall not be allowed. Diesel fumes generated by mechanical plant or equipment shall be controlled (Martin, 1985).

#### **2.8.2.5 Water Quality**

Surface water hydrology can be affected during demolition through the generation of fine materials eroded as a result of clearing surfaces and exposing soils to rainwater and drainage water. Demolition activities may have significant impacts on groundwater hydrology and quality. The most likely hazard is from underground storage tanks and pipelines which contain toxic or hazardous materials. Invariably, residual or even very large quantities of these materials may remain when a site is abandoned. Groundwater contamination often occurs when such storage tanks are punctured or when pipelines are damaged during demolition and ground clearance activities (EIA, 2001). Therefore to mitigate the discharge of waste water from demolition sites shall be controlled by a license. Effluent or waste sewerage shall be treated to the standards as stipulated in the licenses before discharge. The Demolition Contractor shall maintain proper control of temporary water supply and an effective temporary drainage system.

#### **2.8.2.6 Human Environment**

The potential impacts of operations on the human environment may take a variety of forms. They are divided here into sections covering socioeconomic and health issues; amenity, visual impact, nuisance issues, culture, heritage and archaeology. The potential for socio-economic and perceived health impacts arising from demolition works will be site specific. Health impacts are likely to arise when hazardous materials on site are released into the environment, generally as dust. The site itself may have constituted a hazard, especially to children, as a result of dangerous structures or features on site. Nuisance and hazard may be associated with the heavy trucks removing recovered materials and demolition waste off-site.

To conclude for all the above factors, according to environmental impact assessment for demolition projects (2001), demolition activities have the potential to affect the environment in many ways. They can differ widely in terms of their mode of operation and location, and key issues are likely to vary from site to site. Therefore, it is recommended that expert advice on detailed technical issues should be obtained. The chief result amongst these factors that need an expert advice is potential hazard to workers or local residents and the environment directly and indirectly.

### 2.8.3 Deconstruction and Environment

Deconstruction is the process of systematically dismantling a structure in an environmentally, economically and socially responsible manner, aiming to maximize the recovery of materials for reuse and recycling (Deconstruction and Reuse guide, 2011). The process is also sometimes referred to as „soft demolition“ which refers to the manual method used to recover materials, as opposed to „regular demolition“ which involves mechanically bulldozing a structure, often using heavy machinery (EPA, 2000).

Environmentally, deconstruction reduces demolition waste, reduces air pollution, reduces carbon dioxide emissions, decreases the need for new landfills and incinerators, preserves resources and saves energy by decreasing the extraction and processing of raw materials, and supports sustainable building practices (Nassar, 2014). While selective demolition and deconstruction are often undertaken to increase the quantity of materials available for resale, the ability of these procedures to reduce landfilled demolition waste is beginning to be appreciated.

The economic competitiveness of selective demolition or full deconstruction in comparison to traditional demolition is dependent on local labour costs, waste disposal costs and the productivity of the labour force employed (Dantata et al., 2005). Higher waste disposal costs for example, or increased worker efficiency can play a large role in the profitability of deconstruction. The local value of used building materials will also impact the cost effectiveness of deconstruction activities. Therefore, to evaluate the cost-benefit analysis, developed countries like United States and United Kingdom use best practice to implement building demolition and resource recovery which is compatible with the environment. This is according to Institute of Civil Engineers protocol (ICE, 2008); demolition takes through pre-demolition audit, demolition site layout plan and evidence of material recovery.

Activities that executed in the pre-demolition audit are desk study for examining building plans, drawings, and investigation year of construction valuable to determine potential contamination, quality assessment of materials by experienced contractor who knows market values and finally completion of bill of quantities (BOQ). Under the demolition site layout plan, assessment has been done to make sure space requirements for segregated demolition materials and use of reprocessed demolition material onsite. Finally, it is required to establish recovery target and material transfer notes for the evidence of material recovery from the overall demolition structure.

In general the demolition protocol emphasizes for the potential of recovering materials from the building in terms of cost benefit associated with land fill, reclamation and recycling of materials. It is also preferred to material separation and resulted in assessment of sites to manage segregated materials as well as it strives to maximize the potential of material for reuse priority and secondly for recycling which is similar to section 2.8.1 discussed under waste management.

## **2.9 DEMOLITION PROJECT STAKEHOLDERS**

Stakeholders are individuals, groups or organizations, institutions and others that are actively involved in a project and whose interests may be positively or negatively affected by the project execution. They may also exert influence over the project and its results (Kasim, 2008). To ensure and accomplish the demolition practice safely, knowledge, skill and experiences are very important for the existence of awareness among the various stakeholders. This awareness of stakeholders includes considerations to environment, public, workers safety and others such as cost, time, and client goals. The involvement of stakeholders in the demolition process comprises close collaboration and interaction between clients, contractors, engineers" regulatory agencies and subcontractors.

Most of these demolition parties are acquired their knowledge and skill from job training in the demolition sector either as owners of the demolition firm or as construction field superintendents. Some others also acquired from experience, as a construction engineers and from university however in working to add specialization in demolition. On the other hand contracting firms like national demolition contractors association and independent consultants

provide assistance for the proper demolition planning and specifications (Diven and Taylor, 2006).

### 2.9.1 Clients

The client, as in the construction industry, is the single most important person on a demolition project and defines the extent of work through ensuring the principal contractor has all available descriptions of the building or structure to be demolished. This includes drawings, site surveys, plans of services and information on the nature and location of hazardous materials, the nature of building materials and the building or structure's relationship to surrounding properties (OHSA, 1989).

It also informs the location and condition of all underground tanks, wells, voids and structures to the contractor. Because, the client select contractors that agree with the objectives, specified constraints, risk assessment, plant the work, communicate and monitor the plan (Abdullah, 2003). On the other hand clients impose restrictions on the selection of demolition technique that has to be used in the demolition projects. This means the contractor embarking on any type of demolition technique needs to be aware of the restrictions imposed by the client (Fesseha et al., 2003).

According to HSE (2004) also, Clients play a key role in setting the most appropriate health and safety management strategies. When the Client is involved in the health and safety management of the work he/she is procuring, and when high health and safety standards are demanded, the site is safely managed. In addition the engagement of client is crucial in setting and achieving high standards of health and safety management strategies through: an overall supervision of contracts setting, Set up time and budgets for demolition projects, Set up time to allow preliminary structural investigations to be carried out and pre-qualify and select designers, contractors and specialist demolition subcontractors.

Beyond, the selection of contractors, role in setting health and safety management, clients have the highest influence in requiring the demolition contractor to implement the highest level of material segregation on site. The clients' requirement on resource efficiency can be written in the tender documentation in the form of sub-contractor clauses for fully aware of the importance of the demolition stage of a project. Materials for reuse and separate materials for higher value

recycling serves as a performance target against which the demolition contractor can be assessed. Therefore, pre-demolition audit is a useful means for the client to understand the value of the demolition materials and set targets on the demolition contractor. From an environmental perspective, it would be useful to quantify the reduction in environmental impact from diverting this waste from landfills. This could be included within pre-demolition audit and Site Waste Management Plans (Zakar, 2009).

### **2.9.2 Planning Supervisor**

As HSE (2004) states a planning supervisor develops the client's health and safety plan or pre-tender demolition safety plan that indicates health and safety requirements to be satisfied by contractors while working on site. He /she ensures co-operation between designers in order to verify the inclusion of health and safety considerations in design development. Give adequate advices to Client and contractors in order to make them comply with health and safety legislation, such as methods used for risk assessment, identification of safety measures and personal protection equipment as well as work activity schedules to ensure safety on site.

### **2.9.3 Designers**

As indicated in AS (2013), designers should ensure that the Client understands the need for an accurate survey and investigative of the demolition work. Clients therefore, appoint professionals who will conduct and undertake such surveys, within a reasonable time before the actual works commences. Before undertaking any design activity a designer has to take reasonable steps to ensure that the Client for that project is aware of the duties to which the Client is subjected. Furthermore, designers have to develop design activities to achieve adequate health and safety considerations through avoiding predictable risks, combat risks at source, priority given measures that will protect any person at work or any person who may be affected by site works.

Adequate information prior to work commences about any aspect of the project demolition, structure or materials that may affect the health and safety of any person carrying out works on site or of any person who may be affected by site works have to ensure by designers. To do all this responsibilities, designers co-operate with the planning supervisor or any other designer who is preparing any other relevant design in connection with the same project or structure to enable

them to comply with the requirements and prohibitions placed on, in relation to the project by or under the relevant statutory provisions.

#### **2.9.4 Structural Engineers**

Structural engineers are actively involved in the demolition process of sophisticated structures and directly influence the demolition contractor's choice of demolition technique to be implemented on such demolition projects. Generally, the structural engineer will take on board the demolition contractor's working method and then identify those aspects of any temporary works design that are sensitive to the proposed demolition technique or sequence so that the necessary temporary supports can be evaluated and designed (Fesseha et al., 2003). The structural engineer also assesses the behavior of a structure during collapse, which is essential to the demolition contractor especially when making decisions on measures to protect adjacent properties. The structural engineer is expected to know the requirements and methods available to the demolition engineer so that together they can ensure the safe and efficient demolition of the structure. Moreover, they are also in charge of the supervision and control of demolition activities on site and required to update design documents if any differences from project information should show up on site.

#### **2.9.5 Principal Contractor**

„Principal contractor“ means the person who is responsible for the management and control of the site where demolition work is being carried out. The principal contractor may also be the demolition contractor (OHSA, 1989). Principal contractor ensures, the demolition contractor has all available descriptions of the building or structure to be demolished, including drawings, site surveys, plans of services and information on the nature and location of hazardous materials, the nature of building materials and the building or structure's relationship to surrounding properties. He/she approves all relevant authorities and utility service providers are notified before work commences. Notify the owners of adjoining properties of the proposed demolition work where appropriate, ensure buildings are inspected and any existing defects recorded. It is also verify that the location and condition of all utility services and underground tanks to ensure that any chemicals, volatile fuels and gases contained in them are completely removed and the workplace is secured.

Principal contractors also have an influence on ensuring that demolition contractors improve resource efficiency on site by ensuring that the waste targets set by the client are met by the demolition contractors and demolition information is inputted into the site waste management plan( SWMP). The SWMP is essential for contractors to monitor by principal contractors through type and amount of waste being generated, Waste management routes as well as diversion from landfill target (Diven and Taylor, 2006).

### 2.9.6 Demolition Contractors

„Demolition contractor“ means, in relation to any demolition work, the person who directly carries out that work and who is licensed to carry out such specialist building work under the Building Act’s 1972 (stated in OSHA,1989). The demolition contractor is required to be a competent contractor or sub-contractor who is in charge of the execution of demolition works. He/she has to provide selected and qualified workforce and equipment after assessing the quality of the structures to be demolished and the surrounding environment. The principal contractor provides for the demolition contractor, all the information available from the Client organization including structural design documents and results from site surveys and inspections. Then, the demolition contractor is strongly suggested to carry out further investigations on the demolition that may have been omitted or left aside. Any unexpected finding needs to be reported to the Client and to the design team to allow relevant modifications to be brought to the project before demolition works start. The demolition contractor produces a specific risk assessment for the demolition activities and develops method statements to be handed to the principal contractor. The principal contractor will revise them, in co-operation with the Planning Supervisor, and include them in the health and safety plan. The approved method statements have to be communicated to the workers including health and safety instructions and procedures (HSE 2004).

The responsibility for safety lies both on the contractor and the client, but the contractor is responsible for managing the health and safety risks on site. In general, the demolition technique selected should not at any time pose any threat to the health and safety of site personnel and members of the public (Abdullah, 2003). Therefore, before selecting any type of demolition technique, the demolition contractor needs to consider a set of criteria and assess their relevance to the demolition work to be undertaken, in order to succeed at the most appropriate demolition

technique (Anumba, 2002). Contractors ensure workers are consulted and provided with all the information, instructions, training and supervision they need to perform their work safely based on the chosen technique as well as with providing appropriate amenities for workers.

On the other hand contractors also concerned with reuse and recycling of building waste wherever possible and the disposal of all other refuse and debris which is compatible with the environment. Traditionally, much of the demolition contractors' income was from the sale of salvaged and recycled materials. Today income is mostly generated from the contract fee demolishing as quickly and as safely as possible. Nevertheless, substantial amounts of materials and components are recovered or reclaimed but not used to its fullest potential (Hurley and Hobbs, 2000).

Finally, in qualify contractors to take all the above mentioned responsibilities, both private and public clients frequently use a prequalification process to select a contractor for demolition work. If the demolition consultant is part of the project team, it may assist in this process by reviewing information provided by prospective contractor. The typical process in qualifying the contractor includes but not limited to; company's experience on similar projects, experience of personnel designated for the project, safety record, financial strength, insurance coverage and statement of approach. In reviewing the qualifying criteria's and subsequent submittals, the architect and the client have the opportunity to understand the contractor's approach for performing the work safely and effectively. Carrying out this review before demolition starts makes it possible to identify misunderstandings and potential problems when they can still be corrected or otherwise addressed (Diven and Taylor, 2006).

### **2.9.7 Temporary Works Coordinator**

In demolition activities the temporary works coordinator supervises the design activity developed by structural engineers appointed by the principal contractor or by the demolition contractor. He/she will has to supervise the construction of temporary works on site and control constantly any modification or instability that may occur during demolition phases. When unexpected finding has been occurred such as modify the knowledge of the structure to be demolished, the temporary works coordinator has to be supervising the changes to the temporary works design and assess their compliance with the new structural behavior of the structure itself (HSE.2004).

### 2.9.8 Workers

Workers have a duty to take reasonable care for their own health and safety and that they do not adversely affect the health and safety of other persons. Workers must comply with any reasonable instruction and co-operate with any reasonable policy or procedure relating to health and safety at the workplace. They carry out their work in accordance with the demolition safety plan and using equipment in accordance with the instruction and training provided (AS,2014).

### 2.9.9 Consulting Bodies

Prior to carrying out the works, and at relevant stages throughout the works, the following should be contacted, as appropriate, in order to discuss the effects of the proposed demolition works or its progress and also the working spaces or exclusion zones where they are planned to extend beyond the site boundary, including:

- 
- 
- Local authorities, including housing, environment and building control departments
  - Statutory undertakers
  - Highways and roads authorities
  - Local residents and housing bodies
  - Interested or affected parties, for example, schools, hospitals and neighboring businesses.
- 
- 

The overall demolition practice therefore, must account for local regulations regarding required permits, disposal sites, recycling requirements, and so on. Whenever possible, a demolition site is isolated from public access. Especially in downtown areas, public protection is frequently afforded by covered pedestrian walkways and fabric-covered scaffolding. For the accomplishment of this, Considerations are also given to contacting other organizations, as appropriate, such as the regulatory policies, Environment Agency as well as the Health and Safety Executives (BS 6187, 2000).

Contractors, managers and supervisors consult with workers and consulting bodies regarding the methods, how to manage wastes as well as health and safety representatives working on the demolition project. The principal contractor is responsible for ensuring for the existence adequate consultation between all parties at the workplace. The regulations and procedures adopted should allow adequate time for workers and their representatives to consider the

implications of the information provided and discuss issues with the demolition contractor before decisions are made on matters affecting the whole practice (OSHA, 1989).

Furthermore, it could be added important considerations before winding up this section to assess some experiences of countries on the demolition practice relating to the responsibility of various stakeholders and their contribution to the methods selection, ensuring health and safety as well as environments as provided below. However, this emphasizes on demolition contractors most importantly participated.

In Malaysia, demolition projects are primarily executed based on the consultants' advice as well as contractors' proposal. This shows that both parties are equally important, where by the consultants technical input and contractors know how are very much essential in ensuring the proper planning and executions (Arham, 2008). Contractors maintain and ensure a safe working environment by keeping the site neat and tidy and free from all hazards and debris as well as materials stocked up safely. The consulting engineer also conducts a detailed building survey to determine the structural framing of the building. Tests conducted through cores on the concrete structures to determine its strength (kassim, 2008).

On the other hand in Gaza Palestine, demolition decisions are usually made primarily with consultants' advice followed by the contractors as well as based on the owners' desire. However, the overall demolition practice is performed through professionals like contractors, sub-contractors, site engineers /supervisors, project engineers and upper managements. Their emphasis are on reducing demolition risks and achieving the health and safety, then as a second option to recover materials and waste management to keep the environment safe (Nassar, 2014).

Unlikely of developed countries like united kingdom and Australia, in Malaysia and Gaza demolition workers are highly exposed to risks because of unsafe attitudes, not wearing proper protective gear, and lack of experiences. Therefore, their effort on the selection of methods and techniques are the need to improve the awareness of workers in demolition sites and trained before work begins. Safety meetings held continuously and the need for the safety engineer permanently in the site to make sure that all workers commitment, the safety procedures at the work site, and conduct continuous monitoring and enforcement in health and safety implementation. This is done to create a good relationship between all the levels in the project

that can minimize accidents and the need for increasing cooperation between the workers and upper management.

In United Kingdom, Contractors and other engineers are mostly focused on the selection of most appropriate demolition technique for a specified project based on their experience. The engineers' experience is very important to decide the demolition technique and plan. In order to ensure the demolition works follow the plan and precautions, monitoring and supervision are needed. During the selection of demolition techniques, engineers need to consider factors like discussed in section 2.6 in order to minimize the side effects of structures in nearby and around its base (Anumba, 2002; Thong, 2010). However, the main emphases of stakeholders here in selecting the demolition methods and techniques are for resource recovery through reclaim and recycling system. Because of in such a country injuries and accidents are less occurred, especially as compared to developing countries in Asia and Africa.

In Egypt, like other countries in Far East, waste generating from demolition site is one of the most irritating problems. Contractors emphasize on waste management and particularly site supervision and environment. Contractors are collecting, segregating, sorting and then dumping the non-recyclable waste in the nearest legal dumpsite. However, they are faced with problems related to absence or inaccuracy of data such as quantities, cost and environmental impact (Abdelhamid, 2014). On the other hand countries like Zimbabwe and Ivory Coast, demolitions were a part of a plan to clear cities of unsafe buildings. Demolitions had been sub contracted to private construction firms due to absence of professional demolition contractors. As a result many accidents took place when workers demolition that had been condemned as unsafe collapse.

In general, this section implies the role of demolition parties or stakeholders on the execution of building demolition and affects the sector whether negatively or positively. It depends based on level of awareness, experience and knowledge. Much effort was still needed with respect to; selection of suitable techniques, safety precautions and waste management. It was also sad to note that the industry had little regard toward sustainable growth especially in the developing countries.

## 2.10 SUMMARY AND IDENTIFIED GAPS

The various sections of this chapter have been written to give a clear and detailed description on the aspects as well as relevant issues that are normally associated with overall demolition practice. The whole chapter includes key term definitions, demolition history, demolition process, demolition types, methods, techniques and the selection criteria, health and safety precautions, demolition waste management and related issues as well as demolition project stakeholders. After reviewing numerous previously conducted researches and code of practices; proper understanding of the activities and operations are crucial to ensure the work procedures to encounter the expected specifications and regulations.

So, from the reviewed experience of developed and some developing countries, various methods and techniques of demolition are commonly employed and selected according to the health and safety of stakeholders and impacts to environment. The selections are executed based on experienced professionals. Demolition contractors, consultants and other stakeholders are devoted on the importance of safety precaution requirements, demolition waste management, recycling and environmental issues. These matters are equally important and should be given adequate consideration in the practice to prevent environmental pollution as well as impacts to human lives.

However, in Addis Ababa there are no demolition professionals to execute the demolition planning, lacks technical and financial resources to manage demolition wastes, and unsafe and dangerous demolition to human life and property. The practice in general is so primitive, substandard and it has not equally seen as the construction work. As a result, many accidents are occurred to demolition workers and peoples nearby. Therefore, the concentration of information provided in this chapter is hoped to have achieved its goal in identifying the gaps through an in-depth and comprehensive overview of the demolition practice from both developed and developing countries and finally the researcher is intended to address the problems in the research study.

## **CHAPTER 3: RESEARCH METHODOLOGY**

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### **3.1 INTRODUCTION**

The preceding chapters presented a background to the study, defined the research topic and discuss relevant literatures related to the building demolition practices, health, safety precautions, and contribution of waste management to the environment for the economic benefit as well as stakeholders' involvement to implement the practice. Consequently, this chapter discussed the research procedures and the methods used to achieve the whole research through research design, method of data collection and analysis for capturing knowledge, better understanding and clear vision to establish a general perspective about the demolition practices are considered.

The methods and procedures should describe what was done to answer the research objectives, describe how it was done and explain how the results were analyzed as explained by (Kallet, 2004). Therefore, this chapter provides the information about the research design, research population and sample size, methods of data collection and statistical data analysis. The statistical data analysis was done from gathered data with various methods of data collection and results of the data analysis are presented using tables, figures and charts for better clarification.

### **3.2 RESEARCH DESIGN**

Even though different research designs have different attributes, design is the structure of any scientific work. It gives direction and systematizes the research. The methods once chosen will affect the results and conclusion of the findings. Most scientists are interested in getting reliable observations that can help the understanding of a phenomenon. So the term „research design“ refers to the plan or organization of scientific investigation, designing of a research study involves the development of a plan or strategy that will guide the collection and analyses of data (Abiy et al., 2009).

It is also defined according to Bums and Grove (1997) the term „design“ as some consider „research design“ to be the entire strategy for the study, by identifying the problem to find the plans for data collection. Therefore in this research the overall approach, as described in chapter 1 of this research followed a six stage processes. Having established the basis of the research,

literatures were reviewed, and then necessary data were collected followed with discussions. Furthermore, to strengthen the discussion of survey result, case studies were done. Finally, conclusions and recommendations were made based on the discussion. The methods of data collections employed for the research were quantitative questionnaire, desk study, physical observation and interviews. Interviews, physical observations and desk study were analyzed in relation to theoretical propositions, and the responses obtained from the questionnaires were also analyzed using descriptive statistics method.

### **3.3 METHODS OF DATA COLLECTION**

The data collection approach adopted for conducting this research includes both primary and secondary sources. Questionnaire, interview and desk study provide the primary data for this research, while the secondary resources have been utilized in collecting data, these includes books, code of practices from different countries, research papers, journals and internet web pages. Information was gathered through extensive reading and understanding, making notes as well as keeping record of reference list for an easy identification. These different methods of data collection have been used, in order to obtain data or information from informants. This can be supplemented by others for the fact that, the collected data will give multiple evidences.

#### **3.3.1 Questionnaire**

Questionnaire provides firsthand information for the subject matter of a research as it is focused on issues which further serves as a survey to understand the main concerns and attitudes of respondents towards the problems (Abiy et al., 2009). In this research study, questionnaire was distributed to conveniently selected employees, micro and small enterprises, and individuals who took the contract of building demolitions. The questionnaires comprised of close ended questions and were distributed to concerned stakeholders. According to the literatures related to the research topic that include a survey of previous studies in the field, to achieve the objectives of the study were reviewed, and then after testing, and reviewing, questionnaires were developed. The questionnaires consist of five parts:

**Part one:** consists of general information related to the extent of demolition, demolition stakeholders' profile, types of building to be demolished as well as process and reasons for demolition projects.

**Part two:** focuses on demolition method and techniques; this section discusses issues such as the demolition methods, techniques and the factors affecting the selection of the demolition techniques.

**Part three:** this part consist of questions related to stakeholders' level of awareness such as contract participation to demolition work, responsibility for safety activities and work procedures.

**Part four:** it is designed to understand the causes of demolition accidents and injuries at site and corrective measures to enhance the health and safety at the work place that can contribute in minimizing the accidents that may occur.

**Part five:** this section was mainly designed to assess demolition waste management, discuss issues such as deconstruction, reused or recycled materials; the barriers that affect demolition recycling, pollution and environmental issues were incorporated for strict considerations.

### 3.3.2 Interview

Interview is one of the primary data collection methods, which is flexible and adaptive way of investigating underlying motives of a subject in a way that self-administered questionnaires cannot (Abiy et al., 2009). The interview undertaken for this research was based on formal and informal style. This type of interview has a generalized form of the questionnaire with a flexible order depending on what the interviewer perceives the subject matter by looking at the respondent capability and exposure or experience. The interview for this research study was made with officials from municipalities, sub cities, woreda officials and micro and small enterprise (MSE) institutions that are directly and indirectly concerned with the demolition issues.

Interviewed professionals were taken; (a) two from Addis Ababa administration urban renewal office, (b) three from Addis Ketema, Yeka and Arada urban renewal offices, (c) four from woreda city development and constructions (Kirkos, Addis Ketema, Lideta and Arada) and another three were from Addis Ababa city institute of information and planning with situations of building demolition for preparing local development plans, expansion of roads and light railway transits. These stakeholders were selected as they hold particular characteristics, which the researcher is believed and necessary to the topic on target. The formal interviews of these focused groups were extremely important to prove reliability of data gathered by questionnaire

and used as appropriate in the analysis. Furthermore, informal interviews were done with demolishers and recovered material sellers on site.

### **3.3.3 Desk Study**

Desk study was chosen as one of the instruments to assess the practices from relevant studies, reports and documents related on building demolition practices to supplement responses found by questionnaire and interview through the analysis of the selected site projects. The cases considered in this research include order of areas to demolish, compensation payments, letters for utility lines to cross check and formation of micro and small enterprise with their contractual issues.

### **3.3.4 Physical Site Observation**

Physical site observations Conducted on selected sites of the inner city to make an observation, recording events of the site situation and investigation on the demolition are considered more importantly. This technique is particularly useful for discovering how individuals or groups of people act to demolish.

In this research non-participant of physical observation was used to simply observing the activities without taking part in the concerned stakeholders, whilst this has the advantage of preventing the researcher from unduly influencing or becoming involved in activities they may not wish to take part in.

### **3.3.5 Case Study**

It was intended at apprehending and illustrating the actual practice of a particular demolition projects carried out by micro and small enterprise as well as individuals in the inner city of Addis Ababa. “American Gbi and Gojam berenda” in Addis ketema subcity, “Africa Union (02)” in kirkos sub city around Bulgaria embassy and demolition along the main road from “Mexico Square to Hayahulet” are selected for this section to get in-depth information for the demolition practice.

## **3.4 RESEARCH POPULATION AND SAMPLE SIZE**

The population of the study was limited to government employees who administered the demolition, micro and small enterprise and individuals who took the contract of demolition. This is mainly due to the fact that these stakeholders, most of the time involve in the urban renewal

projects as well as in the right way of expansion, which demands integrated management system for the implementation. To determine the sample size for each population, the guide of Wood and Haber (2014) defined sampling as the process of selecting representative units of a population for the study in research investigation. A sample is a small proportion of a population selected for observation and analysis. According to Abiy et al. (2009) also defined Sampling for quantitative studies is the process of selecting a number of study units from a defined study population.

Typically there are two broad types of sampling plans used in research (Seale, 2004). One is based on probability samples where the probability of the selection of each respondent is known. On the other hand, if it is not possible to specify the probability of each member of the population, the sampling falls under the non-probability sampling. Probability samples consist of simple random, systematic sampling, stratified random sampling, cluster sampling and multi-stage sampling; and non-probability sampling include quota sampling, dimensional sampling, convenience sampling, and purposive sampling (Robson, 1993) as shown in the table 3.1 below.

Table 3.1: Probability and non-probability sampling types

Sampling types	Explanations
Simple random sampling	Sample selection is random from a list of the population. All units of the population have an equal opportunity to be selected. It requires a full list of the population.
Systematic sampling	It randomly selects a starting point in the sampling frame, then selects the specific N <sup>th</sup> persons or items at each circle in every around.
Cluster sampling	Dividing the population in to a number of units or clusters, and each of which contains individuals having a range of characteristics.
Convenience sampling	It involves the nearest and most convenient persons as a respondent. The process continues until the required sample size has been reached.
Purposive sampling	From the researchers judgment as typically or interest, sample built up which enables the researchers to satisfy specific needs in a project.
Dimensional sampling	Considering the various dimensions importance in the research that is incorporated in to the sampling procedure in such a way that at least one representative of every possible combination of those factors and dimensions is included.
Quota sampling	It involves selecting the sample in stages from samples.

Based on the scope of this research, the study is focused in the inner city of Addis Ababa and covers five sections of the sub cities which are selected **purpose fully**. Because according to the report of Hailegiorgis and Alemayhu (2014) cost- benefit analysis on urban renewal, most of the building demolition executions are found in the inner five sub cities, for both urban renewal and light railway construction. Therefore, the researcher was interested to take population samples from the five sub cities which enable the researchers to satisfy specific needs from the demolition projects. Accordingly, as shown in the table 3.2 below, there are **156** numbers of micro and small enterprises and **10** individuals who participated in the contract of demolition; totally **166** have been involving in the selected sites of building demolitions from 2013 until to 2015.

Table 3.2: Number of micro and small enterprises and individual demolishers

Sub city	Number of micro and small enterprise
Addis ketema	21
Lideta	50
Kirkos	51
Arada	34
Yeka	10 individuals
<b>Total</b>	<b>166</b>

Even though, there are a total of **166** numbers of demolishers registered in the respective five sub cities for the building demolition practice, to take these population sizes in to statically sample, some of them had already been demolished and left the site. Hence, the researcher could not find their address, due to their files are dead. Some of them have not yet started to demolish and others were failed their enterprise to demolish. As a result the numbers of demolition population reduced to 79 micro and small enterprises as well as individual temporary demolition contractors.

On the other hand there are also **24** employees of local authorities added to **79** population size based on their nearest back ground involvement to the building demolition. These employees of local authorities were selected from urban renewal agency, planning and information institute, sub city and woreda houses and construction development office as well as micro and small

enterprise institutions. Therefore, the total population size of the above three groups would reach to **103**.

Consequently, according to research advisors (2006), an equation is provided to determine sample size for categorical or quantitative data as depicted in equation 3.1 below is used to determine the sample size for limited population. The formula requires knowledge of variance or proportion in the population and determination to the maximum desirable error, as well as the acceptable error risk for example confidence level.

$$n = \frac{(X^2 * N * P * (1 - P))}{(ME^2 * (N - 1) + (X^2 * P * (1 - P)))} \dots\dots\dots [3.1]$$

[Source; the Research Advisors (2006)]

Where;

n=sample size

X<sup>2</sup>= chi- square for the specified confidence level (95% confidence level)

N= population size

P= population proportion (percentage picking a choice, expressed as a decimal (50% used for sample size needed).

ME= desired margin of error which is (5%) expressed as a proportion

Based on the formula equation 3.1 the sample sizes of the total population 103 are calculated as follow;

$$\frac{0.95^2 * 103 * 0.5 * (1 - 0.5)}{0.95^2 * (103 - 1) + 0.95^2 * 0.5 * (1 - 0.5)} = 81$$

From the total number of **103** population size, **81** sample sizes were selected. Therefore, the survey sample method used in this research was based on **Convenience sampling method**, where the respondents who are willing and available are selected until the required sample size which is **81** has been reached. The targeted respondents were contacted on site during the execution of demolition, while others by telephone to make sure of their willingness; because some of them were no longer interested to respond and participate in the research before the questionnaires were distributed. Finally, **81** respondents were agreed to participate in the research.

Table 3.3: Total distributed questionnaire survey and response rates

Respondent category	Questionnaire		Percentage of returned	Valid response	Percentage of valid response
	Distributed	Returned			
Employees	19	17	89.5%	16	84%
Micro & small enterprises	54	47	87%	42	74.1%
Individuals	8	6	75%	6	75%
<b>Total</b>	<b>81</b>	<b>70</b>	<b>86.4%</b>	<b>64</b>	<b>79%</b>

70 questionnaires were returned from 81 questionnaires delivered (see table 3.4). Out of these the 81 distributed and 70 returned responses, 64 were valid and usable, representing a response rate of 79%. There is one questionnaire from local authority employees, five questionnaires from micro and small enterprises were rejected for the case of incompleteness and validly approved by interviews and observation before starting the analysis of the returned questionnaires for their reliability

### 3.5 METHOD OF RESULT ANALYSIS AND MEASUREMENT

In this research a descriptive statistical method has been used for the analysis of the data which provides general overviews and details in order that some kind of interpretations and discussions can be made on the results. Moreover, reviewed literature was also used as one of the main backbone for the analysis of the findings. The collected data were primarily analyzed in terms of percentage and ranking of computations as well as tables and charts has been used for the analysis output. Micro soft Excel 2010 version used to indicate the level of agreement and responses in charts among the pairs of respondent groups for further clarification and understanding.

In order to be able to select the appropriate method of analysis, the level of measurement must be understood. In these regard, participants were asked to indicate the importance level of influence factors or research variables by ranking them as 1, 2, 3, 4....in ascending order. The numbers assigned to the important (1, 2, 3, 4, 5) do not indicate that the interval between scales are equal, nor do they indicate absolute quantities. They are merely numerical marks for ranking choices of response.

## CHAPTER 4: RESEARCH FINDINGS AND DISCUSSIONS

### 4.2 EXTENT OF DEMOLITION IN THE INNER CITY OF ADDIS ABABA

In Addis Ababa, buildings were demolished and ongoing demolition since 2008/2009. This is because of government policies and utilization approaches in urban renewal projects, like slum clearance that is demolition of dilapidated dwellings located in a slum, redevelopments through demolition of existing buildings and replacement by new buildings as well as development of infrastructures. Currently, according to the data gathered from the Addis Ababa city land development and urban renewal agency, 13625 buildings that cover 254 ha of land were demolished and ongoing demolitions excluding of demolitions for road and rail constructions.

Demolitions are executed for land redevelopment in areas of so condensed and inconvenient for living. It involves relocation of new businesses, demolition of structures, relocation of people and the use of eminent domain such as government purchase of property for public purpose as a legal instrument to take private property for city-initiated development projects and for expansion purposes. In addition, 2625 buildings were demolished because of right of way road expansion as well as light railway construction which signify the extent of demolition (see table 4.1 and 4.2).

Table 4.1: Demolition due to urban renewal and expansion (Source; A.A city land development and urban renewal agency (data documentation case team))

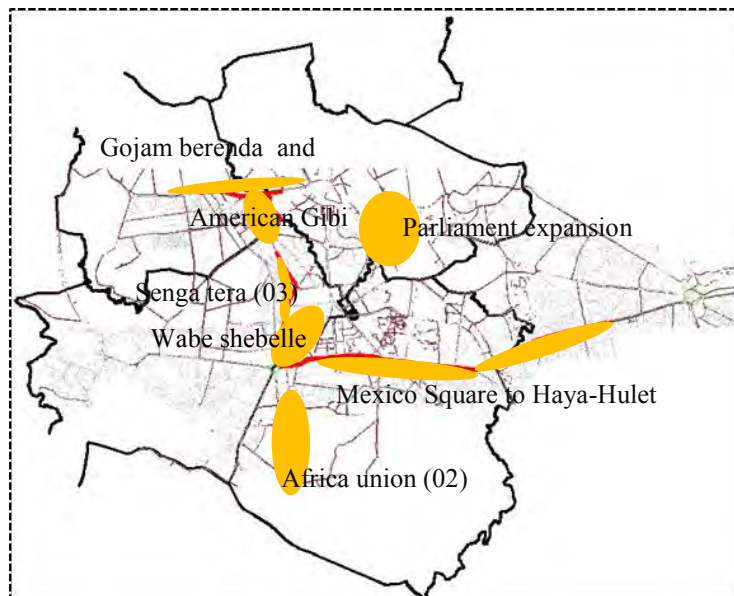
Sub city	Demolished sites	Currently on demolishing	Number of buildings demolished	Area (Hectare)
Lideta	Senga tera(01) Senga tera(02)	Senga tera(03) Wabe shebelle	2509	61
Kirkos	Sheraton expansion Meskel entrance Wollo sefer	Africa union(01) Africa union(02) Kassanchis(02)	3329	76
Arada	Sherato expansion Basha Wolde(01) Basha Wolde(02)	Parliament expansion Aaroge kera Deja- wube	6069	101
Addis ketema	Gojam berenda	American gibi	1718	16
<b>Total</b>			<b>13625</b>	<b>254</b>

Figure 4.1 shows map of the inner city and selected demolition project sites. The inner city includes portions of Arada, kirkos, Lideta and Addis ketema.

- **Ak** =Addis Ketema
- **L** = Lideta
- **K** = kirkos
- **Ar** =Arada



Demolition sites are selected from the four inner city parts and small portions of Yeka sub city right way of expansion that is demolished due to light rail way transit construction.



The selected demolition project sites in the inner city of each sub cities are; American Gibi and Gojam berenda, Parliament expansion, Senga tera (03), Wabe shebelle, Africa union (02) as well as Mexico Square to Haya-Hulet.

Figure 4.1: Map of Addis Ababa inner city and selected demolition sites

Table 4.2: Demolition due to right of way expansion and LRT (Source; A.A city land development and urban renewal agency (data documentation case team))

Type	Buildings demolished due to infrastructure development					
	kirkos	Lideta	Addis ketema	Yeka	Arada	Total
Right of way expansion	2004	128	94	156	-	2382
Light railway construction	60	95	47	41	-	243
Total	2064	223	141	197	-	2625

The survey indicated that, from the total buildings that were demolished in the inner city as described in tables (4.1 and 4.2), 67.2% were kebele owned houses, used as a residential or commercial, 11.2% rental buildings functioned as the same to kebelles" and owned by the rental housing agency and 21.6% were private buildings (see Figure 4. 2). These enumerated data shows that, even though the building demolition in Addis Ababa is at infant stage, however the trend now is very common and urgently needed to improve. This is because of increasing land values for various businesses, investments and infrastructural development without adequate emphasis is given.

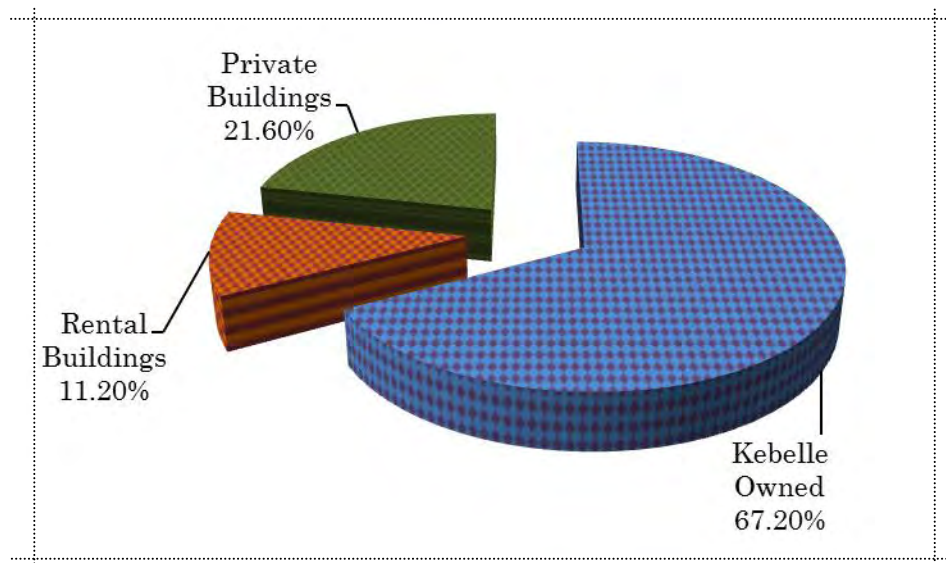


Figure 4.2: In the last seven years the types of buildings demolished in the inner city

As the need for building demolition increases, there are also problems that hinder the development resulted from the improper handling of demolition. This research study therefore focuses on demolition practices, basically on the selected inner city sites which are mentioned in the above projects started since 2013. These projects are ; (a) Africa union (02) in kirkos , (b) Wabe shebelle in Lideta, (c) Teklehaymanot or Senga tera (03) in Lideta, (d) Parliament expansion in Arada, (e) American Gibi and Gojam berenda in Addis Ketema finally (f) Mexico Square to Haya-Hulet in Kirkos and Yeka inner city site projects. Therefore, the research is intended to discuss on the results that have been deduced from a field survey of 64 questionnaires which were distributed to the selected sites, and supported with interviews, observation and desk study. The questionnaires were targeted to local authority employees, small and micro enterprises as well as individuals who involved in the execution of demolition works in the inner city projects of Addis Ababa.

#### 4.2.1 Questionnaire Response Rate

The survey indicated that there are three groups of respondents based on their position in the demolition practice (see table 4.3).The biggest group was the „micro and small enterprise“ category, which represents 65.6%, followed by „employees from local authorities“ with 25%, while 9.4% represented other individual temporary demolition contractors. From the respondents“ proportion, it can be seen that the high percentage of micro and small enterprise and individual temporary contractors 75% took the contract of building demolition for owing “seed money” as a transition to other medium and sustainable enterprise. It is also indicated that, the execution lack specialists such as professional contractors, consultants in the selected demolition project sites.

Table 4.3: Percentage proportions of demolition participants

Respondent category	Questionnaire issue	Valid responses	Percent of valid response
Employees /local authority	19	16	25%
Micro and small enterprise	54	42	65.6%
Individual as contractor	8	6	9.4%
<b>Total</b>	<b>81</b>	<b>64</b>	<b>100%</b>

### 4.2.2 Building Demolition Decision Making Process

Figure 4.3 shows that 53.1 % of the respondents mentioned that decisions of demolitions were done based on micro and small enterprise, 9.4 % mentioned they were based on previous experience of individuals who took the contract, 14.1 % mentioned they were based on owner desire decision and 23.4% of the respondent said the demolition decisions were made based on employees decision. When buildings were taken by micro and small enterprise for demolish, all the decisions were decided by their members. This is done for recovering more materials to increase their profit. However, this decision is performed after the micro and small enterprises pay the estimated monetary value at the beginning and then their profit is from the salvaged materials they sold.

On the other hand when the contracts were taken by the temporary individual contractors, they made decision how to demolish and how to be safe for their life based on their past experience. This is because of demolitions due to right of way expansions need more cautions than other non-structural buildings. These individuals won the contract because of past experience and urgent need of the building to demolish.

Private buildings were demolished based on decisions made by owner's desire, whether by hiring skilled or non- skilled laborers for the need of materials' salvage value. Unless and otherwise they were recommended to concerned kebele /woreda to be demolished by government. On the other hand government was compensated private building owners based on the estimated cost and outsource to daily laborers or small and micro enterprises through short training and finally materials are sold by government.

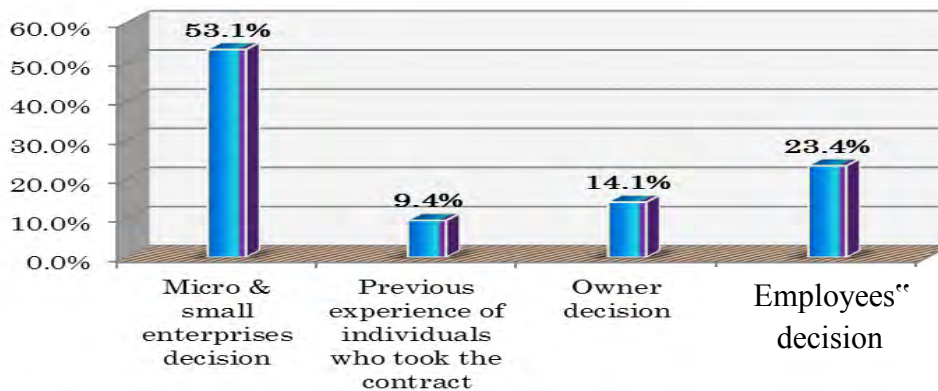


Figure 4.3: Response distribution of demolition decisions

Before decisions on demolition of buildings were done by the demolishing parties, the following procedures indicated by table 4.4 below are accomplished by the respective offices such as Addis Ababa city administration urban renewal agency, sub city and woreda construction and housing development offices. These governmental administrations work their task individually or together where it's necessary.

Table 4.4: Administrative process of building demolition

Step-1	Identify areas to be demolished by the central agency.
Step-2	Aware to the residents living in the areas to be demolished. In this case, the concerned kefle ketema/woreda tell to the residents to pay and clear the electric bills, water bills and other services consumed by each house owner. Then, they pay all the bills to the respective social service institutions, and finally report to the respective woreda.
Step-3	The agency at the city level prepares places for the relocation of people to other kebele houses or condominium houses if the peoples were living in kebele houses.
Step-4	Prepare the land for private house owners and compensation for their buildings value.
Step-5	Budget allocation for compensation (private buildings) and mobilization purpose (11,000 ETB for both kebele and private owners) by the concerned office. But it is not enough.
Step-6	Estimate the salvage value of existing buildings and houses which are the worth of the building after it will be demolished and sold by small and micro enterprises.
Step-7	The estimated salvage value of existing building and houses is cheaper relatively to the total sale value of each component of the building and houses after demolition. This is deliberately to support small and micro enterprises for generation of incomes as seed money.
Step-8	Providing 3-6 days of training and orientation for small and micro enterprises, on how buildings are demolished. This is done in Lideta and Addis Ketema sub cities. However, in Yeka, Arada and Kirkos sub cities were not incorporated.
Step-9	Certificate for small and micro enterprises given by TVET centers to ensure that they can participate for the demolition work and finally taking it to demolish.

### 4.2.3 Types of Building Demolished

The survey result regarding the demolition with respect to types of buildings demolished in the selected sites revealed that kebele house were demolished significantly with 35.7% followed by private buildings 27.8%, commercial 25.2% and rental buildings 11.3%. This result is equivalently compatible with figure 4.2 (type of buildings demolished in the last seven years).

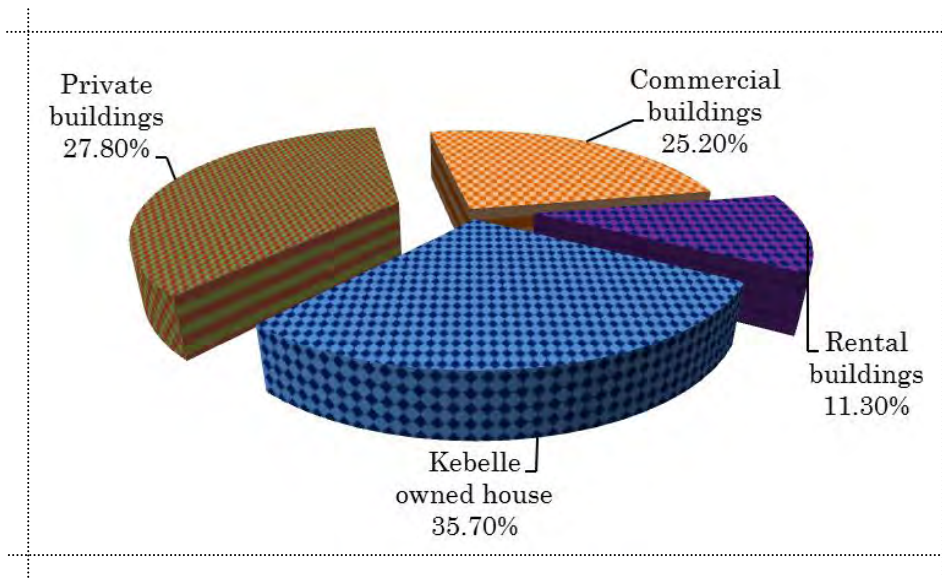


Figure 4.4: The types of buildings demolished in the selected project sites

### 4.2.4 Reasons of Building Demolition

As in table 4.5, below shows, the respondents were asked to rate the reasons for demolition works in the inner city of Addis Ababa based on their experience and the following results were obtained.

„Area redevelopment, i.e. increasing land values and economic prospects“ were the most common reasons for demolition with 40.9% of the respondents. The second reason was „building's physical condition, i.e. dilapidated, deteriorated“ with 33.9%, and followed by „infrastructure development, i.e. right of way expansion due to light railway transit“ 19.1%. The fourth reason was „lack of the desired height regulation with the structural plan“ 6.1%. This result is supported by the data obtained from Addis Ababa city development urban renewal development agency. As indicated by the report of the agency, most of the demolition works were done for urban renewal projects that are clearance of slums and infrastructural developments.

Table 4.5: Causes/reasons of building demolition

No.	Causes/reasons to demolish	Response distribution		Rank
		Frequency	Percentage	
1	Lack of the desired height regulation with the structural plan	4	6.1%	4 <sup>th</sup>
2	Building's physical condition, i.e. dilapidated, deteriorated	22	33.9%	2 <sup>nd</sup>
3	Area redevelopment, i.e. Increasing land values and economic prospects,	26	40.9%	1 <sup>st</sup>
4	Infrastructure development, i.e. right of way expansion due to light railway transit (LRT.)	12	19.1%	3 <sup>rd</sup>

The top three reasons for the execution of building demolition range from simple ground floor buildings to intermediate up to ground plus three storeys buildings for the demand of development, modernization and replaced with new ones even before they could exceed their optimal design lives. The lower ranking reason indicated that low percentage of demolition works made for lack of the desired height regulation with the structural plan or local development plan. When buildings exist at sites selected for demolition, not dilapidated and deteriorated, but did not comply with the desired height regulation by the local development plan intended to demolish.

#### 4.3 DEMOLITION METHOD AND TECHNIQUES

This section was mainly designed to discuss the methods, techniques and the factors affecting the selection of the demolition techniques. The merely demolition method and technique employed in Addis Ababa is the “classic method” through manual procedures which is demolition by hand using various traditional tools such as hammers, woods and hand held metals like bucket lift.

The respondents were agreed the execution of building demolition in Addis Ababa is totally (100%) demolished by hand. The main reason the respondents indicated the condition for using demolition by hand is because of; cost, manpower and availability of machinery as well as for reuse reasons (see figure 4.5). Furthermore, there is no selection process based on knowledge and experience of stakeholders”. The whole process is typically performed in unstructured intuitive manner without unified systematic management.

### 4.3.1 Factors Influence the Selection of Demolition Techniques

Figure 4.5 shows the following results;

„Material reuse“ requirement has first rank with 64% that the respondents were agreed to this statement to select hand demolition technique. Because demolishers were taken the contract for sorting and reusing of building materials after demolishing for the need of doors, windows, bricks and stones. Secondly proximity of the adjacent structure with 14.1% followed reuse. Addis Ababa is a high populated and buildings are close to each other, so the „proximity of the adjacent structure“ is an important issue to study when taking the demolition decision and select appropriate techniques.

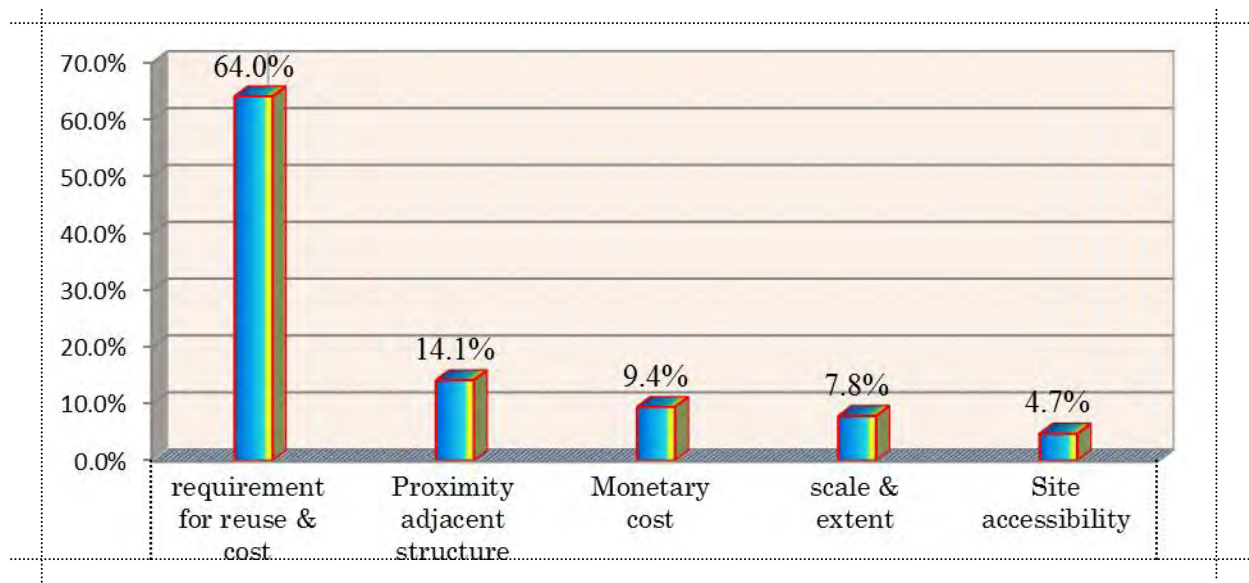


Figure 4.5: Factors influence selection of demolition techniques

Monetary cost of availability plants and equipment“s with 9.4% affects the technique next to proximity of the adjacent structure. Demolition is done totally by hand as respondents“ response and did not use modern equipment since the buildings are small and the prices of labor are less. To demolish structural building the price of a machine is also very high as compared to the cost of the building estimated to be demolished. In addition of the price, as the machine parts may broke incurring additional cost that is very difficult to cover by the demolishing parties. To some extent, scale of demolition also affects the technique with respondents“ frequency of 7.8%. Most of the buildings that demolished were very small, simple to dismantle and easily recoverable.

The last factor which affects the selection techniques is the site accessibility with 4.7% respondents' response. In the inner city buildings are very congested and difficult to access them, improper pedestrians are oriented too. Therefore demolishers could not think over using machines to demolish rather preferred manually. During demolition respondents were not familiarized with health, safety considerations, environmental considerations, time constraint, past experience on a particular project, the management and transportation of the generated wastes and debris as a factor to influence the selection. It appears that there is no regulations or by-laws in Addis Ababa to govern and regulate measures and procedures in demolish activities, and to take into account the environmental impact of those activities. Accordingly, it is needed to increase awareness, encouragement stakeholders, and develop more environmental friendly demolition work techniques.

#### **4.4 STAKEHOLDERS LEVEL OF AWARENESS TO DEMOLISH**

This section was mainly designed to discuss the stakeholders back ground information, who were involved in the building demolition process, contact type, demolition plans and procedures to demolish.

##### **4.4.1 Participants of Building Demolition**

With respect to direct involvement in the building demolition process in Addis Ababa, 81.3% of demolition contractors were small and micro enterprises organized by the woreda MSE development Bureau as well as woreda housing and construction development office. Besides quite few with 18.7% of individuals were participating as a temporary contractor in the case of right of way expansion as it needs urgent demolition. These two parties have direct involvements in the demolition project sites. Hence, there are also many stake holders from governmental local authorities who participated in the demolition indirectly as a management. These local authorities are Addis Ababa city urban renewal agency, sub city and woreda housing and construction development, TIVET institutions, Micro finance, Social service institutions as well as trade industry. However, the researcher was scoped to employees of city urban renewal agency, sub city and woreda housing and construction development to study the level of awareness.

#### 4.4.2 Educational Level

As depicted in (table and figure 4.6), it shows that 36% of the respondents hold „primary certification“, 34% „Secondary certification“, 16% „Diploma“, 9% „Degree“ and 5% of the sample holds „masters“. This result combined with the result shown by (table 4.7 of section 4.3.3) below supports that the trend of demolition were executed with non-qualified and inexperienced stakeholders.

Table 4.6: Educational levels of respondents in demolition

Educational level	Employees		Micro and small enterprises		Individual temporary demolishing contractors		Total (%)
	Frequency	Percent	Frequency	Percent	Frequency	percent	
Primary	-	-	23	36%	0	0%	36%
Secondary	-	-	18	28%	4	6%	34%
Diploma	7	11%	1	2%	2	3%	16%
Degree	6	9%	-	-	-	-	9%
Master's degree	3	5%	-	-	-	-	5%

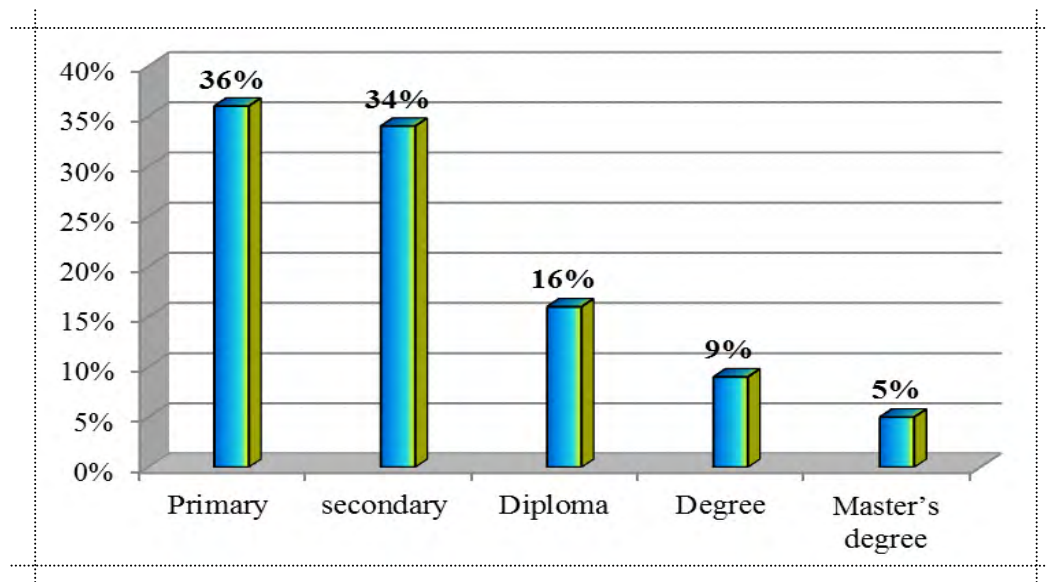


Figure 4.6: Educational certification of the stakeholders based on the total percentage

### 4.4.3 Working Experience

The respondents who had „less than 5“ years of experience were the largest group constituting 95.3% of the total respondents (see table 4.7). 5.2% had experience „5 and less than 10 years“, and no one has seven and above years of experience on building demolition. As the result shows most of the respondents had less than five year means, it is a good indicator for the absence of experienced and specialized personnel in the demolition sector. Even though few of respondents had more than five years“ experience, nevertheless they had no direct involvement to the demolition as a professional demolition contractor. They were decision makers for areas to demolish how to make compensations to the resident as well as make cost estimation before demolition starts.

Table 4.7: Distribution of respondents by years of experience

Years of working experience	Employees		Micro and small enterprises		Individual temporary demolishing contractor		Total (%)
	Frequency	percent	Frequency	Percent	Frequency	percent	
0 - 5	13	20.3%	42	66%	6	9%	<b>95.3%</b>
5-10	3	4.7%	-	-	-	-	<b>4.7%</b>
10-15	-	-	-	-	-	-	-
15-20	-	-	-	-	-	-	-

Out of the 95.3% of the respondents, 90.4% were beginners with zero experience and 9.6% had more than one year work experience on the execution of „urban renewal projects as well as infrastructural development i.e. right of way expansion“. However, the chance for getting buildings to demolish is very rare unless the project is urgently needed. Because the main criteria demolishers participated on demolition projects are; be unemployed and lack of „seed money“ for establishing another micro or medium enterprises. Therefore, it is indicated that, irrespective of the importance given to the experienced stakeholders, the demolition contract made offers for those of unemployed.

#### 4.4.4 Demolition Contract Type and Planning

Based on the respondents' response, there are no standard contract guidelines and formal contractual agreement between the property owner and small and micro enterprises that demolish the buildings. In the case of micro and small enterprise contractors, the concerned woreda gave by direct entrusting for joining it and for a particular building, "lottery" is the main means. Then the contract originates from estimated salvage value of buildings and houses when it is paid by the enterprises to the concerned kefle ketema trade and industry bureau; at that time the contract will bind it at woreda level. On the other hand for those of individual temporary contractors who are involved in the demolition, they owned the chance through tendering. The criteria to win the contract unlike that of micro and small enterprise is based on the past experience of the individual, educational background and the finance capacity to pay it for the estimated value.

The stakeholders who were directly involved in the execution of demolition approximately 89.6% of respondents were not aware of the methodology concerning planning, design and the execution of demolition. This is because of they did not have special personnel or licensed demolition contractor. All the disconnections or isolations of public utilities like water, electricity and telephone cables did not ensure before demolition commences. They were not aware of the demolition plan method of statement developed by demolishers to incorporate a step by step on how the execution intends to safely demolish the building. Besides, few respondent demolishers with 10.4% tried to reflect their awareness on the execution because of their past experience.

On the other hand when respondents were asked on how often is done an instructing, work protection and safety? They responded as simply oriented at hiring without any criteria except age and unemployment. This is done only for those of micro and small enterprises but never instructing for those of individual contractors at all. No personal protective equipment and guidelines are stated at any stage. There is no demolition guidelines prepared either by urban renewal agency or sub city construction and housing offices as well as no waste management plan for demolished houses.

#### 4.4.5 Demolition Work Procedures

With the Woreda announcement to job vacancy for demolition job seekers, unemployed youths organized by MSE bureau at their concerned woreda level. Then their unemployment condition is examined starting from their “ketena” by “ketena committee”. Thus all the woreda micro and small enterprises collected by their sub city for training purpose. This training is experienced only Lideta and Addis Ketema sub cities and one morning oral orientation is experienced by Arada and Kirkos sub cities. After a small technical and business management training, TVET institutions send them back with their certificate. Next they are requesting to have trade license and recognition of their share. Based on their share, woreda housing and construction development activate the “lottery” on the buildings to be demolished with the estimated salvage value.

Finally micro and small enterprises pay the money by their share name if they agreed with the cost and taking all the dismantling, deconstruction and demolition process for their reuse and to gain the seed money which helps to transfer to medium enterprise. If the micro enterprises have no sufficient fund to pay, they will encourage getting a loan from kefle ketema or woreda micro finance institutions. Compliance is possible by the MSE for the estimated cost, if demolition has not yet started and can request to re-estimate the salvage value of buildings. However, they could not get back the paid amount of money once they agreed to demolish the buildings with pre-determined value. Once the small and micro enterprises win, they are responsible for anything which will happen during demolition but the enterprises did not have any insurance coverage for this.

Regarding the time to complete their contract, there is no specified days, weeks, months or years to complete within. Simply they are only told to finish early and they are not forced to clear the place immediately after demolition is completed. Because of this reason, they will not leave the project site until the dismantled building parts are sold. Conversely, if the execution of demolition work is urgently in needed, in the beginning owner or employers might give to experienced individuals or experienced small and micro demolition enterprise to shorten the completion time.

The main purpose to do all this procedures is organizing individual job seekers in small and micro building demolition enterprises to create job opportunities and to generate income from demolished buildings after parts of the buildings components are sold. Most of the buildings are demolishing using manual methods which create a job for the unemployed job seekers who are interested in demolition works. Figure 4.7 shows the work procedures which are related to administrative process and do not reveal the procedures related to technical demolition executions.

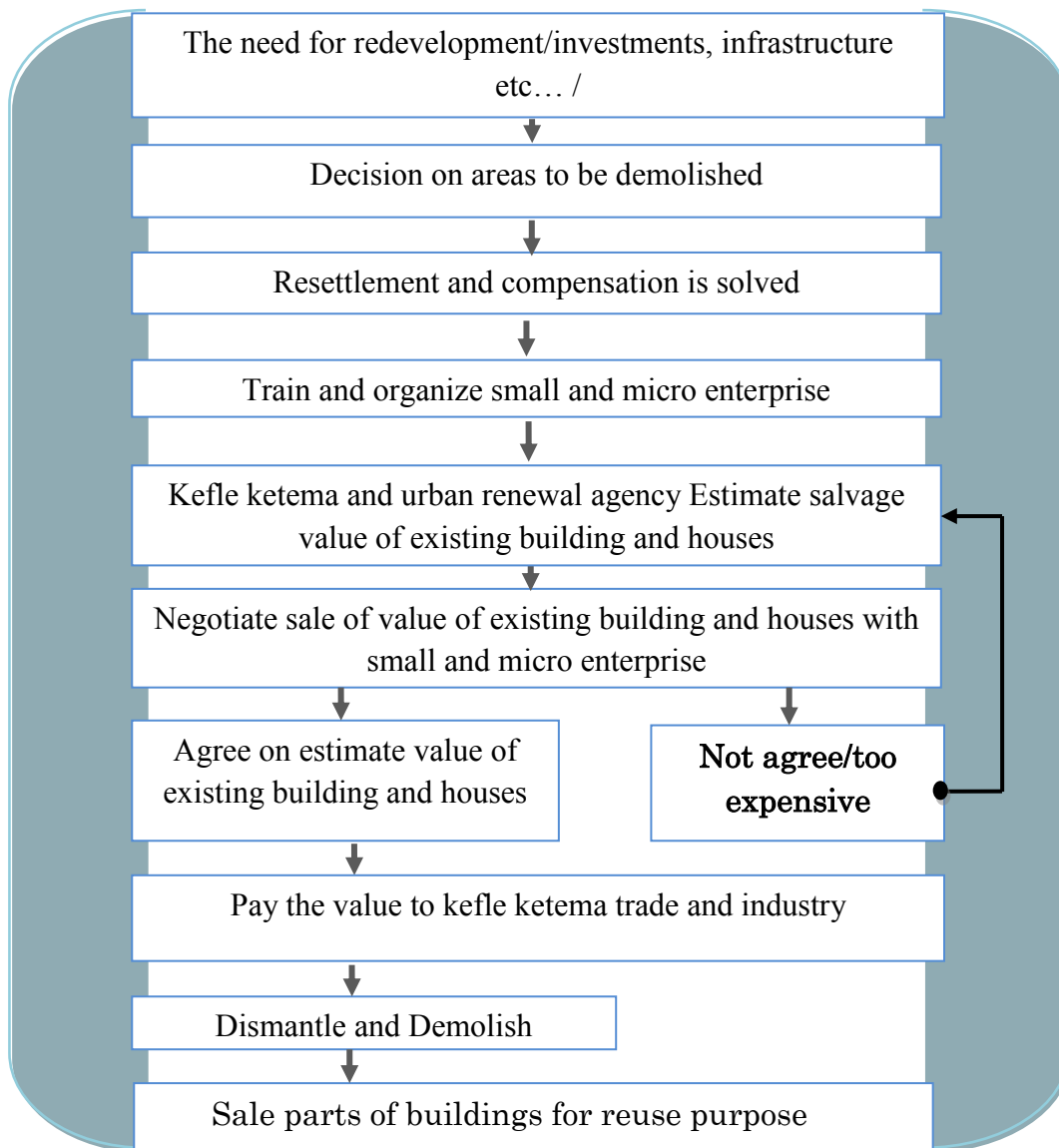


Figure 4.7: Summary of the demolition works procedures

## **4.5 DEMOLITION HEALTH AND SAFETY**

This section was mainly designed to understand the existence and causes of demolition accidents and injuries at site. It is important to notice that hazards can arise in many different ways and can take various forms which may result unnecessary costs and human suffering (HSE, 2004). It is also revealed that health and safety considerations in demolition sites can improve through reviewing some procedures that can contribute in minimizing accidents that may occur.

### **4.5.1 The Existence of Accidents and Injuries**

Accidents and injuries are the potential outcomes of hazards that may arise in the work place. Accidents are risks because of the possibility of injury, illness, damage or loss occurring (kassim, 2008). In this research, employees from local authorities, micro and small enterprise as well as individuals“ with 59.4% were agreed with the existence of the accidents and injuries in demolition. Besides, further they were witnessed that deaths and injury in Gojam –Berenda on people nearby, death in Lideta up on a demolisher, physical injury of demolisher in Mendida around Teklehaymanot as well as ease physical injury around Leghare on a pedestrians user. The rest of the respondents with 40.6% had no any information regarding the issue. However, they explained the degree of sensitivity workers to expose.

To strengthen the existence of accidents and injuries, one member of the kirkos wereda (06) Houses and Construction Development Office said,” we are chance full as the trend of our demolition is very severe, and the exposure to risk is very wide; but due to God“s will as compared to limited occurrences”. He added that look at the electric cables; demolition is executed without termination or disconnection properly. Otherwise any service retained during demolition work should be adequately protected as required by the relevant authority like protection of overhead electric lines.

### **4.5.2 Causes Accidents and Injuries**

The survey result as shown in table 4.8 indicates that, „lack of proper protective personal equipment and umbrellas to protect pedestrians or others nearby“, „unsafe attitude, i.e. negligence“, „lack of knowledge and experience“ were the most factors for causing accidents and injuries with response of 32.8%, 26.6% and 20.3% respectively. In addition to the above results, change of the causes at all the levels in the project can minimize the accidents, so the need for

site management, increasing cooperation between the workers and upper management is important.

Table 4.8 Causes of accidents and injuries

No.	Causes	Response distribution		Rank
		Frequency	Percentage	
1	Lack of proper protective personal equipment, and umbrellas to protect pedestrians or others near by	21	32.8%	1 <sup>st</sup>
2	Unsafe attitude, i.e. negligence	17	26.6%	2 <sup>nd</sup>
3	Poor site management	9	14%	4 <sup>th</sup>
4	Lack knowledge and experience	13	20.3%	3 <sup>rd</sup>
5	Lack of cooperation between workers and management	4	6.3%	5 <sup>th</sup>

### 4.5.3 Corrective Measures to Ensure Health and Safety

All of the 59.4% respondents who agreed with the existence of accidents and injuries explained that, corrective measures were not taken to ensure health and safety of demolishers and peoples nearby, through reducing the accidents and injuries at demolition work project sites. Moreover, respondents agreed with the absence of documentation with respect to risks for future remedial measures. However, somebody heard the risks from residents nearby and co-workers.

On the other hand electric lines were not disconnected before the work commences, which is an indicator for the degree of demolition workers expose to risks. Of course, owners of the buildings supposed to demolish, and ordered to cutoff services like electricity, water and telecommunication by the concerned woreda houses and construction development office before demolition takes place. Though, this is not to ensure health and safety, rather the matter of return back of services. Respondents further explained that, there is no a survey to ensure the building to determine the outline and the state of the building floors, walls and the possibility of a sudden collapse of any part of the building or potential risks. No examination of adjacent buildings that workers and employees that can ensure the risks rather it consequences additional conflict with neighbors.

## **4.6 DEMOLITION WASTE MANAGEMENT AND ENVIRONMENT**

This section is mainly premeditated to assess the demolition waste management, discuss deconstruction, reused/recycled materials, and the obstacles that affect demolition recycling. Finally, issues related to effects of improper demolitions on the environment were incorporated.

### **4.6.1 Deconstruction**

When referred to deconstruction of this study 95.8% the respondents said that, they selected deconstruction techniques using handheld tools, and obvious in many projects of Addis Ababa. Woods, bricks, stones, steel bars, doors, windows and light fixtures are the majority of materials recovered from deconstruction. 4.2% of the respondents said that, they could not select deconstruction techniques. This is because of when the execution is urgently needed and the cost is covered by the owner, rapid execution of demolition is expected from demolishes rather than salvage value benefits. For both the two cases, the process of deconstruction was performed in the absence of prior planning, knowledgeable and experienced contractors. Even though, demolishers had great importance on the deconstruction to gain building material for reuse purpose, however they were executed without proper demolition work schedules and cost analysis.

### **4.6.2 Demolished Materials on Site Separation**

Building making materials were conducted to select on site during deconstruction or demolition process. Approximately 97.9% of the respondents were agreed on the presence of site separation. However, there is no land fill to transports or removes wastes and demolishers have the responsibility to demolish or deconstruct according to their contract, but not to remove wastes from the existing site. Consequently, available materials were collected and separated on site for salvage purpose. Steels, masonry stones, bricks, hollow concrete blocks and walls were separated for reuse. While 2.1% of the respondent partially disagreed and said “sometimes”, because if materials are available in the demolished debris which may have salvage value, then they separate it. Unless the whole debris is considered as waste without materials for reuse they did not separate.

### 4.6.3 Reused and Recycling of Materials

In the practice of deconstructions and demolitions in Addis Ababa, building materials were reused not recycled. In the figure 4.8 shows, the responding stakeholders would mainly reuse doors and windows with 34.8%, masonry (brick, stone, HCB) 24.3%, roofs 17.4%, steel bars 14.8%, timber/wood 6.1%, plastics (ceramics tiles) 1.7% and light fixtures and cabinets with 0.9%.

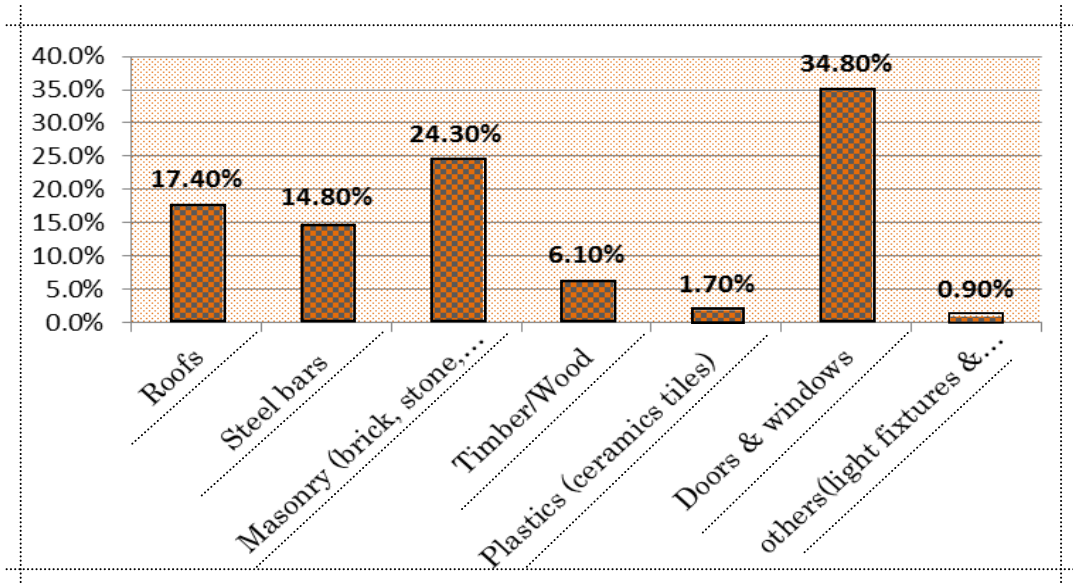


Figure 4.8: A bar chart showing the percentage different kinds of materials which reused

Doors and windows were recovered during dismantling process of the building, and most of the stakeholders or demolishers get more advantage of selling windows and doors like French doors to customers for reuse purpose. Masonry materials were also isolated or separated from the building debris during deconstruction and demolition. From these materials the demolition parties collected their salvage value secondly to doors and windows. Steel bars found in structural elements such as columns, slabs, beams, and footings were collected after demolished. Then these recovered steel bars are sold to customers according to their length and diameter of the bar. The implication of this survey leads to that construction materials or demolition debris are reused not recycled and there is no disposed of at landfills. So this may results negative environmental effects due to lack of proper handling and disposing the remains of wastes from reusing.

To make stronger the condition of reuse building materials, demolishers were used to select deconstruction technique for the purpose of recovering materials like woods, bricks, stones, doors, windows, iron sheets and steel bars for salvage value (see figure 4.8). In the table 4.9 below also shows the average market or monetary salvage value of building materials and components that can be recovered from the execution of demolitions. To bear in mind these materials were reused not recycled.

Table 4.9: Salvage values of materials gained from demolition

No.	Material type		Average Salvage unit prices
1	Stones		5 birr, 6 birr, 8 birr and depends on size
2	Bricks		1.50 birr, 2.50birr, 3.25 birr
3	Steel bars	∅ 8mm in pieces	12 birr
		∅14 >>	20 birr
		∅16 >>	30 birr
		∅18 >>	35 birr
4	Doors	Normal door(wood and metal)	50-700birr
		French doors	2000-3000 birr
5	Windows (wood and metal)		25-180 birr
6	Woods (unit price per a house)		100-300 birr
7	Roof iron sheet (old and new)		14-45birr

#### 4.6.4 Environmental Effects of Demolition

As shown in the figure 4.9, the respondents agreed with the dirt pollution from dusts of the demolition rated by 14% of employees, 32.7% of micro and small enterprise and 3.1% of individual temporary demolition contractors. Totally with 49.8% respondents' response implies dust from demolition is rated as a first rank to cause an impact to the environment. These results were based on the community complaints to employees during their visit to the demolition sites and in rare case in their office as well as micro & small enterprises and individual temporary demolishers during their demolition execution. This reflects the extent of how people annoyed

from this dusts and it was not considered the potential environmental impacts directly or indirectly in connection with the demolition works. Precautions would not include such as use of water spraying for control of dust, or no any method to reduce the potential of wastes release in to the air.

Noise from demolition came to the second rank with a rate of 9.3% of employees, 29.6% of micro and small enterprise and 1.6% of individual temporary demolition contractors because direct impact of noisy to the community especially when buildings were demolished along main roads. As a result, complaints typically arise from the execution interference with peoples' activities, mainly when the community has no clear understanding of the extent or duration of the demolition.

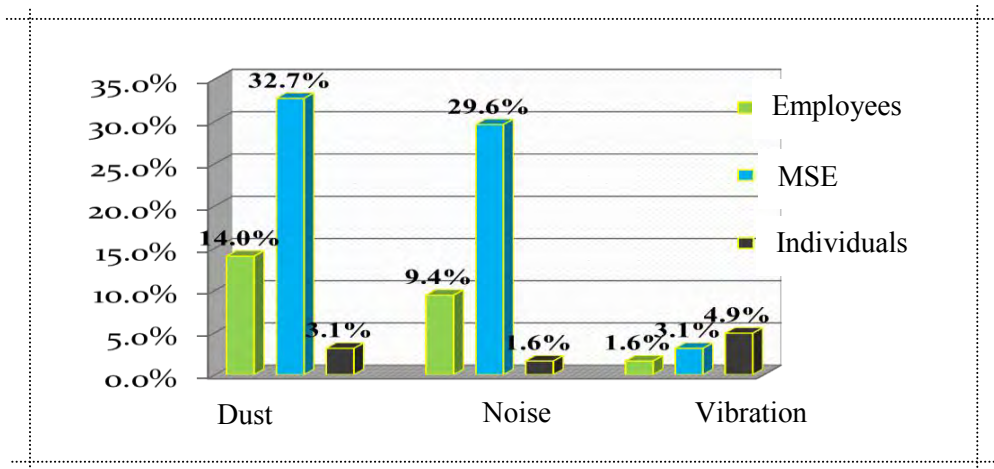


Figure 4.9: A bar chart showing the respondents response on impacts to the environment

In relation to the impact of vibration few employees with 1.6%, micro and small enterprises 3.1% and 4.9% of individual temporary demolition contractors were believed, in a rare case during demolition of structural buildings, vibration would cause to the adjacent buildings and areas near too, but it is insignificant. On the other hand when respondents were asked to comment others, some impacts were indicated such as water pollution and soil contaminations have long term effects to the environment. Water would result in minimal direct and indirect impacts to water resources associated with the surface water, groundwater, and flood surface of utility lines and the surrounding area. Especially during rainy season, flood erodes the waste of demolition and collects to the rivers and ditches which are found by near and causes bad smells as well as pollutes the water.

Consequently, an assessment was done to reveal the causes of the environmental impacts (dust, noise and vibration) as the respondents requested to rate the issues. The majority of 51.6% respondent groups with 31.3%, 64.3% and 16.3% of employees, micro & small enterprise and individual temporary demolition contractors respectively rated „lack of environmental education and awareness“. Secondly, the total 20.3% of respondent groups with 37.5%, 9.5% and 50% of employees, micro & small enterprise and individual temporary demolition contractors respectively rated the“ lack of initiative and commitment of demolition parties“. Thirdly out of 18.7%; 12.5% employees, 21.4% micro & small enterprise and 16.7% individual temporary demolition contractors agreed with the „Nature of demolition itself“.

Finally, from the total 9.4% of response distribution, 18.7% employees, 4.8% micro & small enterprise and 16.6% individual temporary demolition contractors were agreed with the „inadequate contract provisions and specifications on environmental management“. The finding of this results reflects that employees from local authorities and individual temporary demolition contractors were more interested on the“ lack of initiative and commitment of demolition parties“ as a main cause for the environment issues. On the other hand micro and small enterprises were more believed on „lack of environmental education and awareness“ is a first rank to cause the impacts. The table and figure 4.10 below indicates rate of respondents“ response in total distribution and respondents“ response in group for the causes of environmental setbacks respectively.

Table 4.10: Agreement ranking causes to environmental impact from total response

No.	Causes of environmental setbacks	Response distribution		Rank
		Frequency	Percentage	
1	Lack of environmental education and awareness	33	51.6%	1 <sup>st</sup>
2	Nature of demolition itself	12	18.7%	3 <sup>rd</sup>
3	Lack of initiative and commitment of demolition parties	13	20.3%	2 <sup>nd</sup>
4	Inadequate contract provisions and specifications on environmental management	6	9.4%	4 <sup>th</sup>

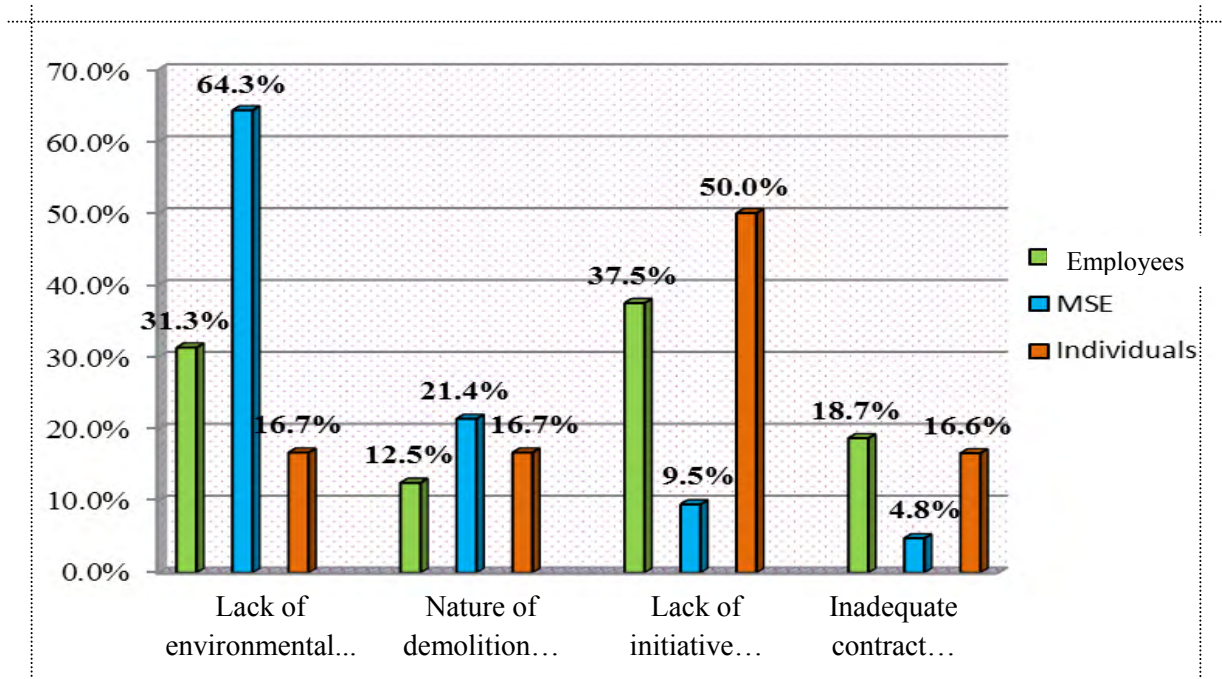


Figure 4.10: A bar chart showing group agreement ranking of causes to environmental impacts

#### 4.7 POTENTIAL IMPROVEMENTS TO DEMOLITION PRACTICE

As stated in section 4.1 of this research, local building demolitions were practiced for the last seven years, without any revisions or amendments of the process of demolition. Thus, the survey result including with semi-structured interviews and open ended questionnaires were conducted for this section and respondents were requested suggestions towards improvement of demolition.

So, from the total 42 number of micro and small enterprises, 61.9% of respondents were answered with “government should decrease the cost estimation of buildings to demolish”, 26.2% of them dealt with “transportation mechanism to transport recovered materials to customers” and 11.9% of them dealt with “better hand held tools for better dismantling should provide by government”. On the other hand to the same issues all the six respondents of individual temporary demolishers were dealt with “contract of demolition should left to experienced personals”.

These results were more or less reflected to fulfill their personal benefits from the deconstruction process and did not concern with the technical problems that cause impacts on safety and environments. Demolishers more dealt with, what concerned local government authority should

do for them; nevertheless they were not focused on personal co-operations contributions to improve the execution.

However, as per employees from local authorities requested their believe with “what can be done to improve the existing demolition and to comment the overall work execution” through both questionnaires and interviews; they were saying a lot, but the researcher organized and summarized the suggestions in the following points.

- ☞ Demolition has to perform through experienced and well trained personnel’s and to achieve this, trainings, awareness creations and discussions should be done through workshops for the betterment of the practice.
- ☞ Share information or experiences between experienced and beginners of demolishing parties involved in the process
- ☞ Keep far more comprehensive records or documentation, so that other demolishing stakeholders can learn from experiences of previous projects
- ☞ Formulate instructions and implement better planning and site management
- ☞ Comprehensively, collecting of detailed information on the neighborhood or building being demolished from various surveys
- ☞ Conduct researches on new demolition techniques and process re-engineering and management
- ☞ Training and education on health and safety executions needs to educate demolishers about their responsibilities with regard to direct execution of the demolition
- ☞ Finally, Raise awareness on environmental considerations: recycling and reusing demolition debris, waste management as well as considerations of code of practices for the overall demolition process in an attempt to unify the process management system is clearly necessary.

## 4.8 DISCUSSIONS OF THE FINDINGS

The research questions on the problems of building demolition and safety in the inner city were raised and investigated through questionnaire survey supported by interview and desk study and studied appropriately. From the result obtained and researcher's perception on the overall local practice, this section will proceed to discuss the survey findings as outlined in the previous sections.

### 4.8.1 The Extent of Demolition

To assess the physical extent of demolition in the inner city of Addis Ababa, 13625 buildings that covers 254 ha of land and 2625 buildings with unknown or non-documented hectare of land were demolished since 2013. The prevailing scenario of the extent and the data that were quantified indicated that, the trend now is very common and urgently need to be reviewed. Building demolitions are in needed, because of increasing land values for various businesses, investments and infrastructural development without adequate emphasis is given to the practice. If it continues the trend for instance, as per the need of building demolition increases, there are also draw backs that hinders the development that comes from the improper handling of demolition. Therefore, the extent of demolition was not the cause for little emphasis is given.

On the other hand, the importance studies of buildings types were, to identify both structural and non-structural components of the building. The highest proportions of kebele houses were totally non-structural and government strategies intended totally 100% to demolish as they are located at the renewal site or right of way expansion. Commercial and private type of buildings contains both structural and non-structural components. Extra care should be taken to dismantle the structural elements carefully since it has considerable sale value as compared to non-structural houses.

With regard to decision making process, the survey highlighted that demolition projects in the inner city were primarily executed based on the decision of micro and small enterprise, previous experience of individuals, owners' desire and employees' decision. However, it can be seen that demolition decisions should primarily be executed based on professionals such as consultants' advice as well as contractors' proposal. This emanates to show that both parties are equally important in ensuring the proper work planning and execution. Therefore, the result obtained

from the survey was endowed with a lack of knowledge and it is value oriented from building materials, it has not been concerned with the work execution at site, safety provisions as well as the environment. Demolition stakeholders or workers did not have a clear overview of the ongoing demolition process; consequently difficulties arise when implementing the process on site.

On issues concerning the reasons for building demolition, most projects of this fall in to the context of „area redevelopment“ that is when the buildings do not fit the requirements in terms of facilities and working environment. The overall reasons for building demolition were ranked as follows;

▪ Area redevelopment i.e. Increasing land values and economic prospect	<i>Ranked 1<sup>st</sup></i>
▪ Building's physical condition, i.e. dilapidated, deteriorated	<i>Ranked 2<sup>nd</sup></i>
▪ Infrastructure development, i.e. right of way expansion	<i>Ranked 3<sup>rd</sup></i>
▪ Lack of the desired height regulation with the structural plan	<i>Ranked 4<sup>th</sup></i>

The survey result strengthens for the government policies and approaches on utilized urban renewal sites for redevelopment that is demolition of existing buildings and their replacement by new buildings and infrastructure. As a second approach slum clearance that is demolition of dilapidated buildings located in a slum. On the other hand one possible reason and very true that, the recently has been started demolition of buildings for the construction of light railway transit construction. Lastly, the lower ranking reason indicates that only a small percentage of buildings were actually demolished due to „lack of the desired height regulation with the structural plan“ compatibility. From this, it can be deduced that many buildings never really live their potential life spans.

Good observations were made by the researcher with this regard, and totally agreed with respondents“ respond. This is indeed true that, the majority of the buildings demolished were because of these reasons. Therefore, as the decisions on demolition were done with non-professionals without knowledge of the work execution; the extent reflects, efforts need to make for higher improvements.

### 4.8.2 Method and Techniques of Demolition

The demolition method and technique studied in this research falls under “manual demolition which is by hand” using traditional hand held tools. Respondents totally 100% agree with demolition by hand, as far as demolitions by machines were totally arguing for the work execution.

It is evident that from Nassar (2014) report, in Gaza Strip „demolition by hand“ is the most techniques used for building demolition followed by; demolition by „towers and high reach cranes“, demolition by „machines with hydraulic attachments“, demolition by „machines with mechanical attachments“ and demolition by „chemical agents“ as necessary based on knowledge and experience of stakeholders. However, in Addis Ababa building demolitions were executed merely by hand. Besides, it has been typically performed in unstructured intuitive manner without unified systematic supervision. Furthermore, the main reason the respondents justified condition for using demolition by hand is because of cost, manpower and availability of machinery as well as for reuse purpose.

On the other hand it agreed with (AS 2013), the method particularly suitable to apply in smaller site with congested space where larger machine cannot be employed and workers could not cover the cost of machinery comparatively with the salvage value as the study depicted. In this case, human operatives were used in the demolition process using simple tools such as, chiseling metal, hammers, or hand driven metallic bucket lifts etc., to carry out the accomplishment of demolition.

This assessment was crucial to gain better insight pertaining to the respondents“ ability in carrying out the execution of demolition. A clear link can also be established in terms of the respondents“ potential and frequency of the technique whereby, techniques marked highest means respondent capabilities were the ones most often employed. However, to choose the most suitable techniques for the demolition projects are crucial to be based on professionals like demolition contractors, consultants to offer guidance on selecting appropriate demolition techniques. Conversely, in Addis Ababa unprofessional micro and small enterprises as well as individual temporary demolishers were chosen hand demolition using various traditional tools, such as hammers, woods and hand held metals like bucket lift.

Finally in the researcher perception from observation, even though it is quite common to observe walls and floors being demolished by chiseling, it disagrees with totally 100% responded demolition by hand. as a result in a rare case excavators were also involved in the demolition of walls and floors of structural buildings. Then this was proved by the demolition of a building by excavator along the main road around Haya-Hulet supported as evidence in the figure 4.11 below.



Figure 4.11: Building demolition using machine (Excavator) around 22

As the researcher was interviewed some residents nearby and responded, this did happen when owners of the building requested to demolish themselves or outsourcing to micro and small enterprise, though as they did neither of both; concerned sub city and city administration together ordered to demolish by other third parties using an excavator as it was an obstacle for the new development. However, this also did not have any relation with the concern of selection and material recovery from the building. It is only needed for the urgent need of demolition and to minimize delay in the new construction.

To conclude with all the procedures, demolishing parties were demolishing the buildings that are jobless and concerned administration has been trying to create job opportunity. Otherwise, it has nothing to do with technique and methods of demolishing. Demolishers had not given enough

training and orientation about how to execute in compliance with the safety majors and environment conditions.

With reference the factors that influence for the execution of demolition using by hand, the significant criteria's noted in the survey were;

▪ The requirement for reuse and low cost to demolish	<i>Ranked 1<sup>st</sup></i>
▪ Proximity of the adjacent structure	<i>Ranked 2<sup>nd</sup></i>
▪ Monetary cost Availability of plants and equipment's	<i>Ranked 3<sup>rd</sup></i>
▪ Degree of demolition (scale and extent)	<i>Ranked 4<sup>th</sup></i>
▪ Site accessibility	<i>Ranked 5<sup>th</sup></i>

Respondents rated these factors based on their personal interest on demolition and based on claims from owners of adjacent buildings and neighbors. Thus, the result of the survey is partially agreed with what mention in (Anumba, 2002; Abdullah, 2003) researches, suggested that from the eight criteria's: the requirement for reuse and cost to demolish, structural form of the building, location of the building, site condition or accessibility and scale of construction. On the other hand this study result reveals demolishers did not concern with the rest of selection criteria's like characteristics of building, safety and environmental issues under their execution.

As stated in Environmental guideline for demolition of buildings Port-Louis (2012), hazards and environmental impacts are associated with demolition works mainly a function and location of demolition work, type of building being demolished, method of demolition, scale of the project and duration of demolition work. Selections are also based on various alternative and suitable machineries to execute demolitions. Conversely, demolition practice in the inner city of Addis Ababa considers neither the environment nor health and safety of workers. So, the overall of this section implies that, prior to main demolition work, options of selections to methods and techniques will necessary and sequence of demolition for various types of buildings should it be different.

### 4.8.3 Stakeholders Awareness

The demolition practice in Addis Ababa is at its infant stage and practiced with micro enterprises and individual temporary demolishers. Employees from local authorities“ train and provide buildings to demolish without skill, experience and knowledge of the practice. However, all workers on demolition site should require possessing skill and experience with respect to nature of the work to be executed. In this research all most nearly 70% of demolishers had primary and secondary certification back ground and approximately 90.4% of them were beginners with zero experience. In addition, the trends of demolition were done with non-qualified and inexperienced stakeholders.

The result of this research totally differs with (OHSA, 1989; HSE, 2004; Arham, 2008; Nassar 2014) as demolition is done through professional contractors, consultants, planning supervisors, structural engineers as well as consulting bodies as necessary. However, Addis Ababa did not have any professional licensed contractor or other supervisors to execute, simply orient and organize micro enterprise and individual demolishers without any criteria except age and unemployment.

On the other hand, the demolition practice in Addis Abba is characterized by; lack of standard contract guidelines, formal contractual agreement between the property owner and demolishers, as well as lack of understanding about the building demolition process such as knowledge of site or site survey, risk assessment and environmental monitoring reflects for the lower level of awareness and leads to inadequate knowledge of demolition. As a result, 89.6% of the demolition parties were not aware of the methodology concerning planning, design and the execution of demolition.

However, the lower awareness does not only reflect for demolition parties who directly involved, but also the concerned local authorities“. Because, they did not instruct demolishers aimed at using personal protective equipment like safety boots, helmets and goggles before work execution commences. In addition planning was not checked by, where to locate drains, electricity, water, telephone and protection for any pipe connected to fail sewer to be sealed off. Demolition guidelines has not been prepared either by urban renewal agency or sub city construction and housing offices concerning waste management plan for demolished building

debris. Finally this implied that demolition should left to professionals who have awareness or knowledge on the methodology, safety precautions to human as well as working environment.

#### 4.8.4 Demolition Safety Precautions

Based on the aspect of demolition health and safety (59.4%) of the respondents were agreed with the existence of accidents and injuries. Besides, the reasons allied with accidents and injuries at site were:

▪ Lack of proper protective personal equipment, and umbrellas to protect pedestrians or others nearby	<i>Ranked 1<sup>st</sup></i>
▪ Unsafe attitude, i.e. negligence	<i>Ranked 2<sup>nd</sup></i>
▪ Lack knowledge and experience	<i>Ranked 3<sup>rd</sup></i>
▪ Poor site management	<i>Ranked 4<sup>th</sup></i>

The top four reasons ranked above proved that demolition in the inner city is unsafe and dangerous to human life and property. Demolition workers have not been procedural to execute and not planned properly as well as proper protection for pedestrians and traffic were not provided. Workers were not clothing personal protective equipment's such as helmets, goggles, and safety shoes during work as discussed under awareness of parties. As a result, loss of human life, physical injury and property loss were happen on workers and peoples nearby during the execution.

Therefore, efforts should be needed to improve the behavior of workers in demolition sites and workers must be trained before work begin, safety meetings should be held continuously, professional or engineer permanently need in the site to make sure that all workers committed to safety procedures at work site and conduct continuous monitoring that will lead to minimize or mitigate the reasons to cause and have less injury and accident.

Likewise, the result reveals, the importance of taking a comprehensive program of work for the health and safety considerations (site work, workers, visitors, surrounding areas) as well as get the notice of demolition permit from all services (electricity, water, etc.) before demolition work commences in order to identify hazards in the work and make the first step to risk assessment

process. With respect of taking corrective measures to ensure health and safety in this study, nothing was done at any level and by any stakeholder. Thus based on the researcher's insight and judging the ranking result, much effort is needed to improve and enhance health and safety awareness. Among a few measures are;

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- all parties and levels of the project must to be made aware of the importance of health and safety
  - increase cooperation between management and workers to secure freedom from accidents
  - there must be a definite and known healthy and safety policy in the workplace
  - make health and safety an important in the planning process of the project
  - conduct continuous monitoring and enforcement in healthy and safety implementation
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#### **4.8.5 Demolition Waste Management and Environment**

This section survey discussion beheld with the aspect of demolition waste management and impacts to environment. With regard to the question of whether deconstruction was carried out to salvage materials prior to demolition, a majority of respondents with 95.8% were agreed. Secondly, with regard to the question of on-site separations, large numbers of respondents nearly 97.9% also agreed and were practiced. The overwhelming response to both questions provides initial indication for the contribution of waste management and is evident to a certain extent.

In the inner city demolition project sites, deconstruction process has started as an advantage of reusing for construction materials. However, the study reflected the importance of further motivation through multiple goals like salvage high quality materials for reuse and re-manufacturing, provide long term high quality employments, and provide reusing and recycling for numerous environmental, economic and social benefits. These benefits includes generate revenue by selling the salvaged materials as well as unskilled and low-skilled workers can receive on the job training in use of basic tools and techniques for deconstruction, materials recovery, as well as to develop critical thinking, problem solving, good work habits, and team work.

With respect to on-site separation the implication of this research study marked as a good practice, materials were sorted and recovered to reuse. Nevertheless, the responding stakeholders

did not have a formal plan which is designed for demolition waste management in their sites and absence of legislation to mandate the demolition parties to have plans before the commencement of the work. Indeed, such planning is critical to success of waste management. It specifies the goal of the waste management and strategies and procedures in dealing with the executed demolition waste materials. Then all demolition parties could have a comprehensive guideline to follow.

The next survey looked in to the characteristics of reused and recycling of materials conditions at site or off site. The survey result denotes, buildings making materials or demolition debris were reused not recycled and wastes were not disposed of at landfills. Thus, this may result in negative environmental effects due to lack of proper handling and disposing the remains of wastes from reusing. This truth verifies that there is no a governmental provisions/specification in the city until now and any mechanism how to control disposing and recycling. Therefore, the need of such provisions and direct efforts towards reused or recycled demolition debris are necessary, to encourage the markets and people to deal with it. Direct regulations require or encourage waste diversion by the generators. Disposal controls, material recycling requirements, green building requirements, recycling goals, and salvage requirements are important to involve in the regulations.

On the other hand this survey entails, the awareness of respondents towards demolition waste, why recycling is not yet begun? Demolishing parties were not cooperated and participated in recycling because of; insufficient recycling facilities, lack of recycling education and awareness, inadequate cost-benefit data, no contract provisions and specifications on recycling since demolition stakeholders fear of its complicatedness and too cost as compare to cost of reusing.

That's way the responding stakeholders would mainly reuse doors and windows with 34.8%, masonry (brick, stone, HCB) 24.3%, roofs 17.4%, steel bars 14.8%, timber/wood 6.1%, plastics (ceramics tiles) 1.7% as well as light fixtures and cabinets with 0.9% respectively to gain salvage value.

Another issue finally to rise is, with reference to the subject of environmental management, and according to the respondents the most frequent types of environmental impacts encountered during demolition operations were dust with 49.8%, noise 40.6% and vibration 9.6%

disturbances. Environmental issues should arise throughout a demolition project process. People or concerned stakeholders working in demolition have to be aware of their environmental obligation and benefits that good practice will bring at every stage from the beginning plan to actual work on site. As the environmental issues differ at each stage the approach to resolving the problem may also differs accordingly. People should know While buildings and development provide countless benefits to society, they also have a significant environmental and health impacts.

On establishing the problems faced when tackling environmental issues, the top ranking impacts as reported in the survey were:

▪ Lack of environmental education and awareness	<i>Ranked 1<sup>st</sup></i>
▪ Lack of initiative and commitment of demolition parties	<i>Ranked 2<sup>nd</sup></i>
▪ The nature of demolition it self	<i>Ranked 3<sup>rd</sup></i>
▪ Inadequate contract provisions and specifications on environmental management	<i>Ranked 4<sup>th</sup></i>

As indicated by the survey „lack of environmental education and awareness“ ranked first with 51.6%. This did reflect the lower level of awareness of demolishers how to select the methods and techniques to minimize dusts, noises during their execution, people and environment annoyed from such impacts. Besides, the lower in education and awareness in demolition did articulate as discussed in (section 4.7.3).

Demolition stakeholders were initiated on the commitment of recovering materials from dismantling for personal benefits and slightly didn’t care about the nearby communities” expense of the execution. As a result respondents with 20.3% strengthen the complaints arisen from neighbors especially from business area such as cafeterias“. On the other hand impacts from demolition could reduce through using various mechanisms, but difficult to prevent from creation. Likewise, 18.7% of the survey result agrees with impacts due to its natural conditions. To end with, the fourth ranked 9.4% did reflect, the absence of environmental protection or standard to enforce.

#### 4.8.6 Suggestions for Improvement

The result from section 4.6 suggestions for improvement result reveals that, demolishers biased for their personal benefits except the individual demolishers who said „demolition should perform based on experience“. However, based on the researcher’s point of view, the idea of individuals were also the same to micro and small enterprises since they were saying that because of they won the contract as they own more than one year’s of demolition experience.

Therefore, the whole idea of these demolition parties did reflect and totally agreed with lower level of awareness on demolition as discussed in (section 4.7.3). To conclude with this, it is easy to understand that the views of demolishers never reflect with the procedures of the execution such as planning, clothing personal protective equipment’s, why accidents occur, as well as how to combat the impacts of demolition to environment as they did mention in (section 4.5) in the survey result.

Conversely, the response of employees from concerned local authorities reflects that; they had good point of view towards the local demolition practice, on how it could be and how could develop for future (see section 4.6). Whereas, as the researcher asked „so how could it be the existing demolition condition is much lower than your awareness? And their responses were, as somebody seat on such administrative positions you will be politically committed rather than personally committed (relied on once personal knowledge and experience). As a result, that’s way as initially demolition would leave to experienced stakeholders and professionals; then again it is common that the demolition is mostly executed by micro and small enterprises for the job opportunity and to decrease unemployment. On the other hand demolishers were priory selected from owners of the proposed neighborhoods or buildings to demolish. This is because of to settle conflicts between residents and demolishers. In view of that, the execution of demolition on the ground is much differs than the logic or science behind.

However, the researcher never believes the fears that mentioned above, but it interpreted as an indication of still much efforts needs on the awareness and peoples’ point of view as compared to existing expenses. Therefore the researcher would use the suggestions of employees for improving the execution of demolition as a base line for the recommendations of this research.

## CHAPTER 5: CASE STUDY

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### 5.1 INTRODUCTION

To test the result of this research, a field surveys were conducted to study three demolition cases at selected project sites in the inner city of Addis Ababa. The first case study is building demolition of “American Gbi and Gojam Berenda” In Addis Ketema subcity for urban renewal and LRT right of way expansion. Second case study demolition of “Africa Union (02)” in Kirkos sub city around Bulgaria embassy for urban renewal and third case study is demolition along the main road from “Mexico Square to Haya--Hulet” for LRT right of way expansion. All these cases were done in order to get in-depth information about the actual demolition operation influences in a real case and identifying risks related to the executions of demolition works.

### 5.2 CASE STUDY (01)

#### 5.1.1 Description of Project

“American Gibi” is a project site ongoing building demolition for urban renewal purpose and it covers 16000 ha of land. Hence, Gojam Berenda already demolished for right of way expansion.

#### 5.1.2 Method of Demolition

All parts of the building components were demolished using hand held tools like hammer, woods and hand held metals like bucket lift. Demolished materials were collected at site for customers for selling at salvage value.



Figure 5.1: Hand held tools used for building dismantling and demolition

### 5.1.3 Health and Safety

Before embarking on the work specialists from government employees or other professionals who have demolition experience were not sent to inspect the building and make sure that, it is free of hazardous materials, toxic substances and makes a primary survey for the whole building except for the cost estimation for salvage value. Demolishers, who were trained within a short period, demolish the site. But their training did not cover how to deal with any suspicious objects, how to avoid falling off debris, how to deal with hazardous materials. From the traffic point of view during demolition, sites were open to traffic like cars, pedestrians, and street side vendors.

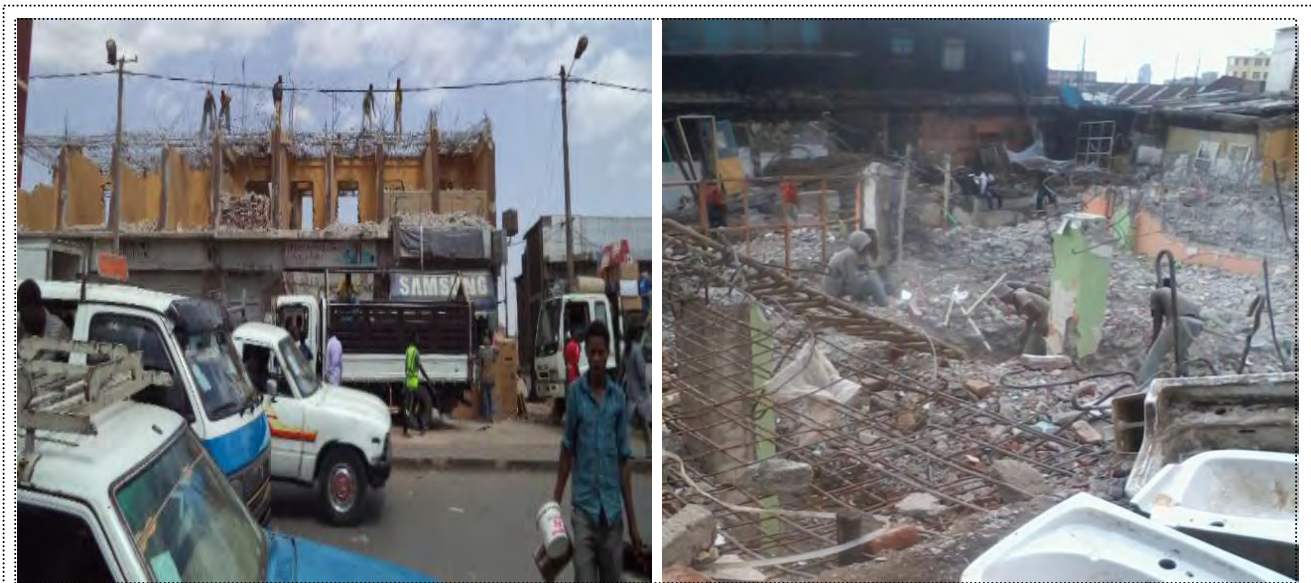


Figure 5.2: Unsafe demolition and traffic movement (*American Gibi*)

Micro and small enterprises dealt with how to demolish using hand held tools for the purpose of better gaining construction materials for better reuse. Otherwise health and safety plan was not prepared and demolishers were dedicated to the whole demolition process without insurance coverage. Those workers who are over the legal age (18 years old) were allowed to work without personal protective clothing (e.g. helmet, safety shoes, and gloves hands). To eliminate risks that threatening the public, demolition site was not fenced by strips to protect the pedestrians and workers. Besides, signs were not erected to prevent people from inward the site before demolition was finished.



Figure 5.3: Demolition workers without personal protective equipment (*American Gibi*)

Workers were not protected from falling while working, on upper floors, ground floors or even unstable floors. While demolition was executing, street vendors selling adjacently, chat chewers were chewing by nearby and beneath the building which is under demolishing at lunch time. As a result in Gojam Berenda while a building was demolished, due to suddenly collapse, people were died. Among them were a heavily pregnant woman, children, a taxi assistant and an elderly female street-vendor. However, this risk has not been recoded and documented for future remedial actions and to get better understandings of injuries and deaths during demolition work.



Figure 5.4: Street vendors sitting adjacent to building under demolition (*American Gibi*)

In order to minimize impacts to environment, demolishers were not forced to use environmental protective mechanism like spraying water during the demolition process; this was meant to reduce dust generated upon demolition. Working in the daytime was not limited to overwhelming operations. No one demolishes at night, or they did not select free time for their demolition with few movements of people and traffic vehicles. Assessment of risk associated with execution of demolition works and control measures were not taken in to considerations such as street closure, warning signs, PPE for workers, dust control measures and noise minimization techniques.

#### 5.1.4 Materials Recovered for Reuse

The advantage of hand demolition is that carefully dismantled materials can be removed to sell as a salvage value. Most of the materials from the demolished building like doors, windows, bricks, HCB, steel with various diameters, corrugated iron sheet and dressed stone were reused.



Figure 5.5: Carefully dismantled doors and hollow concrete blocks (*American Gibi*)



Figure 5.6: Carefully dismantled bricks and dressed stones (*American Gibi*)



Figure 5.7: Steel bars after demolition of building components (*American Gibi*)

### 5.1.5 Utility Services

Demolition plan or any other control mechanism were not ensured the existing utility lines in the vicinity of demolition site affected by the work process, unless owners of the building cut off before commencing. The picture below indicates, water flash on due to lack of commitment especially owners of commercial buildings and rental buildings leave public utilities without report to disconnect. This strengthens demolishers should get notice of demolition permit from all services (electricity, water, etc.) before demolition work commence as discussed in (section 4.7.4).



Figure 5.8: Demolition before water line service disconnected off (*American Gibi*)

### 5.1.6 Waste Related Issues

Large amounts of wastes were generated after dismantling and deconstruction processes of materials for reuse. Alternative mechanisms were not incorporated to collect wastes and recycling after the execution.

Majority of the waste were in the form of debris and as masonry rubbles. All these materials are classified as solid waste substances. Demolition stakeholders or demolishers have nothing responsibility to remove and clean wastes from on-site. Thus, improper handling of hazardous materials resulted in environmental effects; as demolishers did not recycled debris that remains from reuse.



Figure 5.9: On site deposited materials debris (*American Gibi*)

### 5.3 CASE STUDY (02)

#### 5.2.1 Description of Project

The project is “African Union expansion (02)” which is found around Bulgaria Embassy. The project site were partially demolished for urban renewal purpose to expand the African union and supposed to demolish 554 numbers of buildings.

#### 5.2.2 Method of Demolition

Houses were built with soil mud, straw, and a bundle of woods set in line to reduce space opening as far as possible tied together with grass string ropes. In this type of houses, removal (dismantling) was carried out by using simple tools such as pick axe, spade, light hammer and saw. These tools are used in such ways that execution is carried out from the top to bottom, at first removing carefully all items saleable, such as corrugated iron sheets, doors and windows together with frames, etc.

Next to this, removing of wall plaster called soil mud using pick axe and crew bar is carried out. After removing all the plastered mud, dismantling of the wood bundle using hammer and saw will continue till all the house parts are removed from the site. Meanwhile, this removed bundle wood will set aside as items to be sold with carefully removed saleable items. The other debris, which is dust soil changed from plastered mud, will be gathered to spoil area or for sell with cheaper cost.



Figure 5.10: Demolition of non-structural buildings near to AU

### 5.2.3 Health and Safety Practices

Health and safety issue was given little attention in connection with demolition work. Workers were not used personal protection equipment. Safety precautions to protect the public and neighboring property were not concerned. Demolishers have no insurance coverage for the workers as well as property damage in case of accidents. Demolishers or workers were not specially trained for demolition works and were not acquainted with the safety issues and risks associated with demolition even after 3 to 6 days of training which is done in Lideta and addis ketema sub city. Demolitions were executed without disconnections of electric lines as shown in (figure 5.11) below.

This finding strengthens the results obtained from respondents in table 4.8, that reveal "the reasons for demolition accidents and injuries at demolition sites"; the respondents said that the accidents related directly to the workers, not wearing proper protective gear, unsafe attitudes and lake of experience, hereafter the need for safety measures are necessary in demolition work.



Figure 5.11: Demolition without electric cable disconnections around Bulgaria embassy

### 5.2.4 Public Utility Services

Public utility services connected to building like case (01) were not disconnected prior to demolition commencing as indicated in the pictures below.



Figure 5.12: Improper disconnections of water, telecommunication and electric cables

### 5.2.5 Materials for Reuse

Sorting of materials such as timber woods, bricks, French doors, windows, hollow concrete blocks, floor tiles and steels for resale as salvage is a common practice and countered as a good practice (see figure 5.13 below).



Figure 5.13: Dismantled doors, windows, bricks, HCB'S, and woods on site

### 5.2.6 Waste and Environmental Issues

Debris created by demolition is usually allowed to drop freely from the buildings for disposal without using chutes or shafts. There is no trend of treating harmful materials for example contaminated waste from the demolition. Measurements related to waste management and environmental impacts were not taken in the demolition practice to control. There are no regulations and demolition code practices to govern dusts, noises and planning were not engaged in relation to overall debris disposal, adequate traffic routing for debris handling and vehicular access as well as land fill for disposal during and after demolition by the micro enterprises.



Figure 5.14: Improper handling of debris on site without disposal in front of AU

## 5.4 CASE STUDY (03)

### 5.4.1 Description of Project

In the recent time, the main cause of buildings demolition along main road in Addis Ababa is for the provision of right-of-way for construction of light railway transit construction. So the third selected case study site was specified along the main road from “Mexico Square to Haya-Hulet”.

### 5.4.2 Demolition Contract Conditions

Demolition was done by three different cases. The first case was by owners of the buildings if it is private, by hiring daily laborers or individual persons who had past experience. Secondly, by demolition parties like temporary individual contractors who full fills the criteria for the contract of demolition which is prepared by the woreda finance and contract administration for those of kebele houses, and if private owners outsourcing to woreda for demolishing. These two cases are familiar for buildings demolished along the main road which are found in Yeka sub city. The third case of demolition was demolition by micro and small enterprise which are established or organized by the woreda housing and construction development together with micro enterprise development bureau. This case of demolition was for the buildings along the main road which were found in the kirkos sub city.



Figure 5.15: Demolitions for right of way expansion around Urael

### 5.4.3 Method of Demolition

Even though the demolition included structural buildings, but Modern demolishing methods were not practiced. Demolition is done by traditional way using hand tools, mostly done by chiseling, and by hammering and it was time taking and delayed the reconstruction. The groups who are demolishing the buildings were jobless and the administration is trying to create job opportunity, it has nothing to do with technique and methods of demolishing. They were not given any training or orientation about, how to do the work or what kind of safety majors they are going to use. They just used traditional tools to do the work and safety is in jeopardy (see figure5.16) below.



Figure 5.16: Hand demolition using hand held tools around Mexico square

#### 5.4.4 Health and Safety

Safety requirements were not well considered for both the workers and the public

- Safety for neighboring structures and for the residents around the site were not considered as an issue.
- Use of safety equipment for personal protection like goggles, safety shoes, and helmet was not practiced on all sites. Dusts were not managed correctly, example by water sprinkling.
- Electric lines are very near to the working site and workers are highly exposed.
- Fencing demolition sites were not practiced in the demolition project.



Figure 5.17: Demolition workers without wearing personal safety equipment in Axum Hotel and around Mexico square

### 5.4.5 Public Utility Lines

As code of demolition practice (2004) mentioned, prior to actual demolition it should keep record of available utilities and has to be terminated according to the demolition plan. However, in this study during the course of demolition existing utility lines were affected in the vicinity by the execution of demolitions.



### 5.4.6 Materials for Reuse

Materials from the demolished building like doors, windows and dressed stone



Figure 5.19: Dressed stone, windows and doors dismantled around legare and 22

### 5.4.7 Environmental Impact

As depicted in the figure 5.20 below, hazardous materials were not handled properly from the debris of the dismantled and demolished buildings. When hazardous materials for example contaminated containing materials are present, they could not remove and disposed of. Because there is no statutory requirement administered by environmental protection and did not examine the site for what purpose previously has been used.



Figure 5.20: Contaminated materials lay in a pedestrian walkway around lem hotel in 22

## 5.5 SUMMARY OF CASE STUDIES

The building demolition practices on the three case studies are very similar except some of the following differences.

Demolishers in Addis ketema sub city which is American Gibi and Gojam Berenda organized by their employer and trained for averagely 3-6 days in Winget and Tykon Tero. However, demolition parties in Kirkos for AU expansion and Yeka for right of way expansion along the main west- east axis were not trained. Building demolishers, both in case (01) and case (02) were micro and small enterprises, but in the third case in the Yeka section they were individuals. In Addis Ketema and Kirkos the contract is given to micro and small enterprises by direct entrusting for job opportunity and to save seed money which is helping them transfer to medium enterprises. Nevertheless, in the Yeka sub city right of way section, the contract was given to individuals who satisfy the criteria of experience and finance capacity for the urgent need of demolition. However, the three cases had little difference but they are very similar in method of demolition, health and safety, waste management as well as recovery of materials for reuse.

The findings obtained from the case studies, demolition safety plan was not involving in all demolition process, which covered all the steps acquired to identify asses and control hazard which might occur at workplace during the demolition work. There is no demolition safety plan included like site investigation, long term training, and emergency procedures. No assessment of risk associated with demolition works and control measures were not taken in consideration, (street closure, warning signs, PPE for workers, dust control measures and noise minimization techniques).

These findings strengthen the results attained from respondents that reveal in the discussion and analysis of “building demolition practice and safety precautions with regard to methods, techniques, accidents and injuries at demolition sites as well as the environmental issues”. As a result the needs for safety measures are necessary in demolition work. Not only this but also the environmental effects of demolition (dust pollution, noise pollution and vibration). So stakeholders should aware to the importance of taking suitable technique for demolition, health and safety consideration waste management and environment as having all the permits needed.

## CHAPTER 6: CONCLUSIONS AND RECOMMENDATIONS

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This chapter seeks to summarize and provide conclusion to the research as well as suggest recommendations for future improvement and development. Conclusions for this study will be based on the objectives mentioned on section 1.5 of the introduction chapter. All the main objectives of this research have been achieved. Recommendations are forwarded to various stakeholders in order to improve the practice of building demolition. Therefore, the following conclusions and recommendations are drawn from the investigation undertaken on the research.

### 6.1 CONCLUSIONS

#### **Objective (01): Assess the Extent of Demolition Practice in the Inner City of Addis Ababa**

- This objective was set out to assess the extent of demolition in the inner city and has identified buildings were demolished for various redevelopments without adequate emphasis is given.
- The main reasons for the extent of building demolitions were; area redevelopment (i.e. increasing land values and economic prospects), building's physical condition (i.e. dilapidated, and deteriorated), infrastructure development (i.e. right of way expansion and LRT construction) and lack of the desired height regulation with the structural plan.
- From the total buildings that were demolished; the higher kebele houses were non-structural and made it the demolition process ease for dismantling or deconstruction. Furthermore, significant numbers of private, rental and commercial buildings were both structural and non-structural. However, the executions of all building types were done through non-qualified and inexperienced stakeholders.
- On the other hand, building demolition decisions were also made by those of non-qualified and inexperienced micro and small enterprises, individual temporary contractors as well as owners of the building. This implied that, the execution of demolition is endowed with lack of knowledge and it is value oriented from deconstruction without concern of other effects like safety precautions to human and surrounding environment.

**Objective (02): Investigate Methods of Building Demolition Practices and Procedures**

- The building demolition methods and techniques deployed in the inner city of Addis Ababa were dominantly by the “Classic method” through manual procedures which is „demolition by hand” using various hammers, woods and hand held metals like bucket lift.
- The current practice is restricted to buildings of few stories and in most cases it is a mixed practice of demolishing and dismantling for maximum material usage. Thus, manual methods with simple tools were used to do the job since there are no other alternative options of demolition techniques. However, the technique was typically performed on an unstructured intuitive manner with considerable reliance of the inexperienced and unskilled judgment of the demolition parties without any proper technical and economic decisions were considered.
- The study also sought to know the factors which influence for the selection of hand demolition and could result; the requirement for salvage value of recovered materials and cost to demolish, proximity of the adjacent structure, capacity of the micro and small enterprise to pay for machinery, degree (scale) of demolition as well as accessibility of sites respectively.

**Objective (03): Examine Stakeholders’ Level of Awareness on the Practice**

- Demolition projects were mainly carried out by micro and small enterprises organized by the woreda MSE development Bureau as well as woreda housing and construction development office. Besides, quite few individuals were participating as a temporary contractor in the case of right of way expansion and when urgent demolition is needed.
- This study has also revealed that buildings were demolished based on the administrative process; like select areas to demolish, relocation, compensation, salvage value estimation and organizing job seekers in MSE to create job opportunity. Local authorities were emphasized on creating employment opportunity for young people even though it is risky and waste generate activity.

- The demolition practice generally lacks professionalism. No specialist contractor was available; workers did not take long training to do the job, no licensed demolishing contractor and the implementation of the demolition work was not preceded by proper pre-planning.
- There is no longer available standard contract form, completion time is not specified and selection criteria set out. Besides, no legal enforcement to execute it appropriately and safely.

#### **Objective (04): Investigate Safety and Environmental Impact of Demolition**

- In the inner city majority of the employees from local authorizes, micro and small enterprise and individuals“ were agreed with the existence of accidents and injuries and further explained as the demolition practice is very sensitive workers to expose. Workers of demolition, neighboring property owners and the public in general were not given proper attention to health and safety precautions. Moreover, nothing was done to correct measures.
- As the result of the discussion indicated, the main reasons to accidents and injuries at site related directly to the workers and other peoples nearby were; „lack of proper protective personal equipment, and umbrellas to protect pedestrians or others nearby“, ‘unsafe attitude, i.e. negligence“, „lack knowledge and experience“ as well as the „poor site management“
- Furthermore, workers hadn“t any demolition code of practice to follow and give them guidance a demolition methods, safety requirements and waste management techniques.
- In many projects in the inner city sites, individual temporary contractors as well as micro and small enterprises used to select deconstruction techniques, like removing woods, bricks, iron sheets, tiles, , doors, windows, cabinets and steel bars, these materials that can be only for reused but not recycling. According discussions result toward the recycling from demolition debris is not yet began. Because of there are no demolishing parties to cooperate and participate in recycling, insufficient recycling facilities, lack of

recycling education and awareness as well as no contract provisions and specifications on recycling.

- The study discussion result revealed that, the most frequent types of environmental impacts that encountered during the execution of demolition projects belongings to people and surrounding were; pollution from dust, noise pollution and vibration in a rare case. This has been based on the community complaints to concerned demolition parties.
- Lack of environmental education and awareness, lack of initiative and commitment of demolition parties, nature of demolition itself, inadequate contract provisions and specifications on environmental management, were the constraints that cause an undesirable effect on the environment.

**Objective (05): Explore Contributions that will improve the Practice**

- The contribution gained from demolishers mostly relied on their personal benefits from dismantling and did not concern with the methods of demolition, technical problems that cause impact on health and environment. Hence, it reflects the lower awareness of demolition stakeholders on the execution of demolition work and it strengthens objective (03).
- Employees from local authorities suggested some important perceptions toward the improvements of the local demolition practice such as issues related to awareness creation of demolishers, information exchange between experienced and beginners, documentations of records, training on safety precautions as well as issues related to environmental consideration like recycling ,reusing demolition debris, and waste management. These suggestions, would be used as a base line for the recommendations listed below.

## 6.2 RECOMMENDATIONS

This section presents the research's practical recommendations that are targeted at proper selection of demolition methods, stakeholders' awareness, to improve health and safety as well as controlling of waste to prevent bad effects on the environment. The recommendations are aimed at the government Institutions like A.A city land development and urban renewal agency, TVET institutions, sub city and woreda Houses and Construction Development Offices that run the demolition projects. Therefore, the following recommendations are the most important ones that can be deduced by this research:

- The result of this research indicated that, the demolition industry is left behind in terms of research and development. Therefore, in terms of understanding the present need for demolition operations, local government authorities should establish demolition code of practices intended to give guidelines for various demolition methods, techniques and to provide guidance on the compliance with relevant requirements of the buildings ordinance and its subsidiary regulations. So, that the current safety and environmental problems associated with demolition work could be resolved and efficient use materials can be obtained. The Code of practice should also guide the different stakeholders involved in the sector. The aim of the code should not only be to improve the existing malpractices but also take into account the types of work that will emerge in the future.
- Meanwhile, the existing demolition method is only hand demolition using traditional hand held tools and other available demolition techniques are limited; it should develop options with more flexible, cost effective and environmental friendly demolition techniques, so that the industry can benefit from these.
- Increase publicity and awareness on the importance of demolition through conducting case studies to enhance information, experience and skills as well as other related practices in a local demolition scene.
- Establish an organization specifically to over sees the overall demolition operations and provide technical support, research and development as well as consultations to improve.

- As a first option the execution of building demolition especially for structural high rise buildings should be left to licensed demolition contractors, designers, structural engineers and planning supervisors. In general, all workers especially onsite should require possessing high skill and experience with respect to the nature of demolition work to be executed.
- Micro and small enterprise contractors should demolish nonstructural and simple houses as they have to be given training by skilled bodies like higher institute professionals. But this is as a last option if government emphasizes on the job creation for the unemployed youths.
- Developers could include clauses in the contract requiring contractors to implement methods, techniques, health and safety as well as waste management for both governmental and private buildings. The contract may also include insurance, contract provisions and specifications on environment management.
- Health and safety is an essential part for demolition operations, so as demolition parties should emphasize on the importance of proper usage of tools as well as consider the requirement for personal protective equipment. A specific health and safety plan should design, incorporating aspects such as risk assessment, identification of functions and responsibilities safety guidelines as well as comprehensive emergency responses.
- Demolishers should develop a plan for demolition waste management before the commencement of the work. The purpose of the plan is to provide details of the means and measures for reducing the environmental management impacts from the waste generated throughout the execution of work.
- As demolition is a sensitive and dangerous process, for the future the complexity of demolition in Ethiopia will increase. So institutes or universities should have specialization for demolition and dismantling programs to train stakeholders to be professionals like other field of study.

### **6.3 FURTHER RECOMMENDED STUDIES**

- (i) Considering the poor state of demolition waste management in Addis Ababa, research could be done to address the problems faced by the industry with regards to debris recycling. Further, research could also explore more positive and useful ways to ensure optimal and better utilization of waste materials.
  
- (ii) The study found that the demolition industry is overdue in terms of research and process management compared to the construction industry. No local available literatures on demolition and most of the demolition parties stand alone with their own ways of managing and doing their projects. Therefore, more research works should be necessary to develop a new building demolition process, which ensures that health and safety considerations are taken into account from the earliest stages; planning, design and execution of demolition works.

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## **APPENDIXES**

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### **APPENDIX- A (QUESTIONNAIRES)**

## **Investigation of Building Demolition practice and Safety Precautions in Addis Ababa; Msc. in Civil Engineering (COTM)**

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**Dear Sir;**

First of all I would like to extend my sincere thanks and appreciation to contribute a portion of your time and effort in filling out this questionnaire. This questionnaire aims at “Investigation of Building Demolition practice and Safety Precautions in Addis Ababa”. So, please answer questions of the questionnaire attached, thankful to you for your cooperation, and confirm that the information you will provide will be used only for academic research purposes only. For your opinion you can select more than one option by ranking them as 1, 2, 3...in ascending order.

Researcher;

Yirgalem G/Amlak

Supervisor;

Dr. Girmay Kahsay

## Part I. General Information and Demolition Overview

### 1.1 Your work in the company:

- a) Sub-contractor
- b) Site engineer/ Supervisor
- c) Project engineer
- d) Other(specify)\_\_\_\_\_

### 1.2 Educational level

- a) Secondary
- b) bachelor
- c) master
- d) Doctorate
- e) Other(specify)\_\_\_\_\_

### 1.3 How many years of working experience do you have?

- a) Less than 5 years
- b) 10 – Less than 15 years
- c) 5 – Less than 10 years
- d) Over 15 years

### 1.4 How demolition decision is usually made in your site? (You can select more than one opinion)

- a) Consultant's advice
- b) Contractor's proposal
- c) Previous experience on similar projects
- d) Owner decision
- e) Others ( specify )\_\_\_\_\_

### 1.5 Have you carried out any demolition work before?

- a) Yes
- b) No

### 1.6 If your response for **1.5** is yes; what types of structures demolished based on your demolition records.

- a) Residential
- b) Commercial, i.e. Offices/Shop lots/Hotels
- c) Industrial, i.e. Factories/Garages/ Workshops
- d) Others,\_\_\_\_\_

### 1.7 In your opinion, please choose the causes why buildings have been demolished.

- a) Building without a permit
- b) Lack of commitment to the desired height regulation
- c) Lack of staff expert restoration operations
- d) Not suitable for anticipated use i.e. outdated design and appearance, specific problem with structural material or systems
- e) Building's physical condition, i.e. dilapidated, deteriorated
- f) Area redevelopment, i.e. Increasing land values and economic prospects,
- g) Costs of maintenance too expensive
- h) Building refurbishment, renovation, conversion
- i) Destroyed or damaged due to fire
- j) Infrastructure development, i.e. construction, upgrading and expansion of highways
- k) Poor manufacturing
- l) Other reason (please specify)\_\_\_\_\_

1.8 Did you plan for your demolition? Yes  No

1.9 In your demolition; what types of labor are you used in?

- a) Skilled
- b) Semi-skilled
- c) No skilled
- d) Others (please specify) \_\_\_\_\_

## Part II. Demolition Method and Techniques

2.1 the method of demolition used by most often is;

- a) Classic method through manual procedures
- b) Mechanical method
- c) Controlled explosions
- d) Others (please specify) \_\_\_\_\_

2.2 The demolition technique most frequently used in the demolition project;

- e) Demolition by Hand – various hammers, cutting by diamond drilling and sawing, bursting, crushing and splitting
- f) Demolition by Towers and High Reach Cranes
- g) Demolition by Machines with mechanical attachments – balling, wire rope pulling
- h) Demolition by Machines with hydraulic attachments – shear, impact hammer, grinder, grapple, crusher, processor
- i) Demolition by Chemical Agents – gas expansion busters<sup>o</sup>, expanding demolition agents, flame cutting, explosives
- j) Water jetting
- k) Others (please specify) \_\_\_\_\_

2.3 On what basis the demolition selection techniques have been chosen by?

- a) Degree of demolition (scale and extent)
- b) Stability of structure
- c) Proximity of the adjacent structure
- d) Permitted levels of nuisance
- e) Health and safety considerations Environmental considerations Time constraint Past experience on a particular project
- f) The management and transportation of the generated wastes and debris
- g) The requirement for reuse and recycling
- h) Monetary cost Availability of plants and equipment<sup>s</sup>
- i) Site accessibility
- j) No selection technique
- k) Others (please specify) \_\_\_\_\_

**Part III. Stakeholders Awareness**

3.1 Who did take the contract of demolition?

- a) Contactors
- b) MSE (micro and small enterprise)
- c) Others ( specify ) \_\_\_\_\_

3.2 How did they obtain the demolition work by?

- a) Direct entrusting
- b) Contract participation
- c) Others (please specify) \_\_\_\_\_

3.3 Do you think that a methodology concerning the design and the execution of demolition would be necessary?

- a) Yes.
- b) No.
- c) I don't know.

If your response is no; why \_\_\_\_\_

3.4 Inside the company or MSE of demolitions , is it useful the existence of demolition procedures?

- a) Yes.
- b) No.
- c) I don't know.

3.5 Is there in your company personnel specialized or have license in demolition?

- a) Yes.
- b) No.

3.6 Estimate the cause for extra expenses during the execution of demolition;

- a) The lack of plan and specialized personnel
- b) The wrong assessment of execution terms" program
- c) Other causes(please specify) \_\_\_\_\_

3.7 In your company, how often is done an instructing, work protection and safety?

- a) No instruction
- b) At hiring.
- c) At the beginning of each new project step that needs it.

3.8 Do you have a risk manager and/or safety director who is responsible for safety activities?

- a) Yes
- b) no

**Part IV. Demolition Health and Safety**

4.1 Have you ever seen building demolition **accidents and injuries** at site? Yes  No

If your response is yes; what type of accidents and injuries;

\_\_\_\_\_

\_\_\_\_\_

4.2 Why the reason building demolition is **causing accidents and injuries** at site?

- a) Unsafe attitude, i.e. negligence
- b) Not wearing proper protective gear
- c) Lack knowledge and experience
- d) Poor site management
- e) Presence in dangerous places
- f) Fire and unexpected explosion
- g) Unsafe conditions, i.e. hazardous materials, dangerous elevations
- h) Lack of cooperation between workers and management
- i) Lack of protective umbrellas to protect workers and pedestrians
- j) Lack of regular maintenance of tools and equipment used
- k) Lack of an appropriate method of demolition
- l) Other causes (please specify)\_\_\_\_\_

4.3 What **corrective measures** did you take to ensure **health and safety** considerations in the demolition site?

- a) Get the Notice of Construction (NOC) permit from all services (electricity, water, roads, etc.) before demolition works
- b) Make an engineering survey of the building, to determine the outline and the state of the building, and the floors and walls and the possibility of a sudden collapse of any part of the building or any potential risks
- c) Examination of adjacent buildings that workers and employees can be existed in or property at risk
- d) Conduct a primary survey for the toxic gases and harmful substances (such as asbestos / lead)
- e) Make sure that there are no dangerous chemicals, gases, explosives, flammable materials or dangerous materials
- f) Make a comprehensive program of work for the health and safety considerations (site work / workers / visitors /surrounding areas)
- g) Others (please specify)\_\_\_\_\_

4.4 Do you have **insurance** for your company and your workers as well? Yes  No   
If your response is No; why\_\_\_\_\_

**Part V. Demolition Waste Management and Environment**

5.1 Do you select **deconstruction techniques to salvage material** prior to demolition for reuse or recycling?

- a. Yes
- b. No
- c. Sometimes
- d. Unsure

5.2 Do you conduct **on-site separation** of demolition debris and waste materials?

- a) Yes
- b) No
- c) Sometime
- d) Unsure

5.3 What materials are frequently **reused, recycled or disposed** from demolition projects?

a) **Reused/ Recycled**

- a) Concrete
- b) Steel
- c) Masonry
- d) Timber/Wood
- e) Plastics/ Vinyl
- f) Insulation material
- g) Others ( specify ) \_\_\_\_\_

b) **Disposed**

- a) Concrete
- b) Steel
- c) Masonry
- d) Timber/Wood
- e) Plastics/ Vinyl
- f) Insulation material
- g) Other(specify)\_\_\_\_\_

5.4 The **purpose of recycling** solid demolition debris such as masonry and concrete

- a) Concrete used as recycled aggregates
- b) Masonry used as recycled soil
- c) Asphalt processed and reused in new pavement construction
- d) Concrete and masonry used as road base courses and drainage bedding layers
- e) Concrete and masonry used as backfill material, for embankment construction
- f) Disposed off at landfills
- g) other purpose (please specify)\_\_\_\_\_

5.5 problems related to **recycling** from demolition

- a) Recycling delays the project completion
- b) There is usually insufficient space on site to recycle
- c) There requirements for separate containers and the presence of a variety of waste material makes recycling complicated
- d) There are insufficient contract provisions and specifications on recycling
- e) Recycling is too costly
- f) It is difficult to get contractors or subcontractors to cooperate and participate in recycling
- g) others (please specify)\_\_\_\_\_

5.6 barriers that affect the demolition recycling efforts

- a) Demolition debris are not statutorily banned from landfill
- b) Insufficient recycling facilities
- c) Lack of recycling education and awareness
- d) No demand for recycled content products or materials
- e) Inadequate cost-benefit data
- f) others (please specify)\_\_\_\_\_

5.7 In your opinion, please rate the following types of pollution on how they are affecting the environment in the process of demolition.

- a) Air (dust) pollution: \_\_\_\_\_
- b) Noise pollution: \_\_\_\_\_
- c) Water pollution: \_\_\_\_\_
- d) Soil contamination: \_\_\_\_\_
- e) Vibration: \_\_\_\_\_
- f) Other pollution type you can rate: \_\_\_\_\_

5.8 In your opinion, please rate the following **constraints** that are facing when **tackling environmental issues**.

- a) The nature of demolition works it self
- b) Weather conditions
- c) Lack of initiative and commitment from other project parties
- d) Inadequate contract provisions and specifications on environmental management
- e) Lack of environmental education And awareness
- f) Archaeology and Cultural Heritage
- g) Other constraint/barrier you can rate \_\_\_\_\_

5.9 What can be done to improve the existing demolition practice?

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5.10 Please if you have any comment to added about the overall work execution

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**APPENDIX-B: (INTERVIEWS)**

First of all I would like to extend my sincere thanks and appreciation to \_\_\_\_\_ & his colleagues for contributing a portion of your time and effort in filling this interview questions.

**1) To Know the Extent of Demolition:**

Sub city	Demolition sites	Area coverage	Year of demolition	No. kebele houses/ BLG.'s	Rental BLG.'s	Private BLG.'s	Commercial BLG.'s	If others	Total
Lideta	Senga-tara(01)								
	Senga-tara(02)								
	<b>Sengatera(03)</b>								
	<b>Wabe-shebelle</b>								
Kirkos	Sheraton								
	Sheraton expansion								
	Meskel entrance								
	Wollo sefer								
	<b>AU(01)</b>								
	<b>AU(02)</b>								
	<b>kassanchis(02)</b>								
Arada	Sheraton expansion								
	Basha wolde(01)								
	Basha wolde(02)								
	Parliament expansion								
	Aroge kera(01)								
	Aroge kera(02)								
	Deja.jube								
Addis ketema	American gibi								

2) For right off way expansion:

a) Number of buildings demolished due to North - South and East – West right off way expansion: \_\_\_\_\_

b) In particular if possible Mexico square to Haya-hulet \_\_\_\_\_

3) Is there any information about structural and non-structural buildings in your record?  
\_\_\_\_\_

4) The responsibility of various stakeholders who involve in the building demolition process:

a) *City*  
level: \_\_\_\_\_  
\_\_\_\_\_

b) *Sub city*  
level: \_\_\_\_\_  
\_\_\_\_\_

c) *Woreda*  
level: \_\_\_\_\_  
\_\_\_\_\_

5) Compensation trend  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

6) Challenges of building demolition:

a) **Socio-economic**  
\_\_\_\_\_  
\_\_\_\_\_

b) **Environmental:**  
\_\_\_\_\_  
\_\_\_\_\_

7) If you have guidelines, reports and other document related to building demolition:  
\_\_\_\_\_  
\_\_\_\_\_

**APPENDIX-C: (SAMPLING SIZE PROPORTIONS)**

Initially there are 166 numbers of demolition enterprises and individual temporary demolishers. From the total number of 166 enterprises or individuals due to dead filed enterprises, demolition not yet started and failed their enterprise; their number is reduced to 79. However, there are also 24 numbers of employees from local authorities based on their nearest involvement to demolition.

Sub city	Number of micro and small enterprise
Addis ketema	21
Lideta	50
Kirkos	51
Arada	34
Yeka	10 individuals
<b>Total</b>	<b>166</b>

Then totally micro and small enterprise + individual temporary contractors + employees = 103. Next by using the formula providing by research advisors it reduced to 81 population sample size. Finally, the population size is proportioned as indicated in the table below.

Sub city	Number of micro and small enterprise and their %		Proportioned and Conveniently Selected Samples		
Addis ketema	12	11.7%	9	} 54	
Lideta	20	19.4%	16		
Kirkos	23	22.3%	18		
Arada	14	13.6%	11		
Yeka	10 ind.)	9.7%	8		
Employees	24	23.3%	19		
<b>Total</b>	<b>103</b>		<b>81</b>		
Respondent category	Questionnaire		Percentage of returned	Valid response	Percentage of valid response
	Distributed	Returned			
Employees	19	17	89.5%	16	84%
Micro & small enterprises	54	47	87%	42	74.1%
Individuals	8	6	75%	6	75%
<b>Total</b>	<b>81</b>	<b>70</b>	<b>86.4%</b>	<b>64</b>	<b>79%</b>