Demolish-IT: the development of a process management tool for the demolition industry

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ABSTRACT

Today most demolition projects undertaken are complex and involve many parties who must comply with a myriad of regulations as well as other constraints (e.g. finance). The management of demolition projects requires individual team members to have a wide range of skills and knowledge in addition to practical experience.

Demolition processes currently operated are frequently performed in an unstructured, intuitive manner with considerable reliance on experience, skill, knowledge or subjective judgement of the demolition engineer or other individual responsible for a demolition project. Research on demolition ‘process management’ is a new area that has rarely been addressed. However, within the building design and construction management sectors, there are a number of intelligent solutions that have been developed to assist in the management of business processes and business process re-engineering. Process management systems and process mapping through the use of Information Communication and Technology (ICT) technology have been applied to help the construction industry significantly improve performance.

In an attempt to provide intelligent support to the management of dynamic demolition processes, this research reports upon that was developed using ICT applications a management system prototype entitled “Demolish-IT”. The prototype of Demolish-IT utilises four tiers of information which includes: (1) the standard demolition process map; (2) user-defined demolition process map; (3) demolition task manager; and (4) database of demolition process requirements. The prototype provides on ICT platform that unifies demolition processes and requirements to achieve improved process management.

The research involved a combination of face-to-face interviews with demolition experts; real projects document reviews and site observation to produce the generic demolition process map. Other products of the work included: database solutions to store demolition process requirements; and process modelling to manage demolition task compliance flow within relevant industry standards. Evaluation of the research work proved its validity, acceptance and applicability within industry. Future work will aim to transpose the outputs into commercially viable software.

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Special thanks to Miss Stella Wright (Total Demolition Reclaim Ltd., Nottingham, UK) for providing me with information on industry case studies. I am also grateful to Terry Quarmby (President of the Institute of Demolition Engineers) for his checking all the technical information and for corrections on the technical aspects of industry standards in the thesis.

I would like to extend my deep gratitude to two demolition organisations, the National Federation of Demolition Contractors (NFDC) and the Institute of Demolition Engineers (IDE) for formal and informal information support.

Finally, my great gratitude to my family, especially my mother for her constant encouragement and inspiration; and also my son for his English language support.
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<td>BPM</td>
<td>Business Process Management</td>
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<tr>
<td>BPR</td>
<td>Business Process Re-engineering</td>
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<tr>
<td>BRE</td>
<td>Building Research Establishment</td>
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<td>BS</td>
<td>British Standard</td>
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<td>CAR</td>
<td>Control Asbestos Regulation 2006</td>
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<tr>
<td>CASE</td>
<td>Computer Aided Software Engineering</td>
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<tr>
<td>CCDO</td>
<td>Certificate of Competence of Demolition Operatives</td>
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<tr>
<td>CDI</td>
<td>Controlled Demolition, Inc.</td>
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<td>CDM</td>
<td>Construction (Design and Management) Regulations</td>
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<td>CITB</td>
<td>Construction Industry Training Board</td>
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<tr>
<td>COSHH</td>
<td>Control of Substance of Hazardous to Health</td>
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<tr>
<td>CPD</td>
<td>Continual Professional Development</td>
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<td>CSCS</td>
<td>Construction Skills Certification Scheme</td>
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<td>Data Flow Diagram</td>
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<td>Demolition Process Management</td>
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<td>DPMT</td>
<td>Demolition Process Management Tool</td>
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<tr>
<td>EA</td>
<td>Environment Agency</td>
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<td>EDA</td>
<td>European Demolition Association</td>
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<td>GPM</td>
<td>Generic Process Modelling Method</td>
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<td>GDPM</td>
<td>Generic Demolition Process Map</td>
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<td>HRHE</td>
<td>High Reach Hydraulic Excavators</td>
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<td>HSE</td>
<td>Health and Safety Executive</td>
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<td>HTN</td>
<td>Hierarchical Task Network</td>
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<td>ICT</td>
<td>Information Communication Technology</td>
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<td>IDFM</td>
<td>Integration Definition for Function Modelling</td>
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<td>IDE</td>
<td>Institute of Demolition Engineers</td>
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<tr>
<td>IS</td>
<td>Information System</td>
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<td>Information Technology</td>
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<td>Old Dominion Demolition Corporation</td>
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<td>Program Evaluation and Review Techniques</td>
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<td>Register for Unconventional Structures</td>
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<td>SWMP</td>
<td>Site Waste Management Plan</td>
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<td>Waste and Resource Action Programme</td>
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1 Introduction to the Research and Thesis Structure

1.1 Research Background

The demolition industry has undergone a major transformation within the last 20 years (McGrath et al., 2000). Traditionally it has been a labour intensive industry that lacks skills and technology and is often quoted as being a poorly regulated sector, even when dealing with the deconstruction of relatively simple structures. However, in recent times the demolition sector has followed the trend of major industry and has replaced labour with machines and highly skilled operators (NFDC, 2005/2006; IExpE, 2006). It is argued that machines improve productivity, increase profitability and remove the need for people to complete dangerous works by hand - thereby reducing accident rates.

The British Standard “Code of Practice for Demolition” (BS, 6187:2000) defines demolition:

“As being the complete or partial dismantling or destruction of a building or structure, by planned and controlled methods or procedures.”

Various types of demolition methods are available in the industry (BS, 6187:2000), for example, hand-held tools, machines, chemical agents or any combination of these aforementioned methods. A broad range of approaches include: floor-by-floor deconstruction, high balling, super high reach mechanical demolition and explosives can be chosen for demolition of buildings and structures over 10 storeys (NFDC, 1997).

The British government proposed in its statement ‘Planning for the Communities of the Future’, that 60% of new homes in England should be built on previously developed land and through conversion of existing buildings (Planning Policies Division, 1998). Clearly this strategy will result in more demolition work as old buildings are removed for new ones in predominantly urban areas. This process of working within densely populated areas makes demolition a highly demanding task that requires detailed consideration from the various parties involved in the demolition process.

Indeed, the planning and management of any individual demolition project is not straightforward in practice due to the fact that consideration must be given to the constraints imposed by the
structure itself, the surrounding environment and the relative costs (BS, 6187:2000). These constraints include: increased complexity in building design; the financial pressures placed upon clients; health and safety issues; regulatory and legal requirements; and advances in plant design (Arham, 2003). In fact, these constraints and restrictions have made demolition projects complex in nature and thus demand greater skill, experience and precision on the part of the demolition engineer\(^1\) (Anumba and Barbara, 2004). Demolition contractors can no longer depend totally on past experience alone to manage a modern multi-functional demolition project. Furthermore, modern demolition is not only a complex and specialist business but also includes an inherent element of danger (NFDC, 1992). The demolition process requires that greater consideration is given to safety and any official company procedures must be adhered to. Even given severe competition for contracts, the use of correct working practices and the maintenance and adherence to a robust safety regime are of paramount importance. This owes much to the fact that: (1) the activities relevant to demolition processes overlap; and (2) design errors inherent within demolition methods employed tend to represent the major source of problems during demolition operations.

Thus, the demolition industry has increasingly recognised that efficiency and safety can be improved if the demolition operation is well planned and managed in a strategic way before operations commence on site. To deal with this situation, demolition contractor must re-think engineering process management systems. Any process management system must ensure that: (1) the demolition project undertaken is well-planned and properly managed; and (2) ‘fail safe’ procedures that may affect the safety and efficiency of the demolition process are not omitted. It is also important that the system can paint a clear picture for demolition engineers about the various demolition procedures involved at each stage of the process.

The current demolition process is typically performed in an unstructured, intuitive manner with considerable reliance upon the experience, skill, knowledge or subjective judgement of the demolition engineer or other individuals responsible for that demolition project (Arham, 2003). A survey conducted by Arham (2003) indicated that 47% of the respondents thought that the efficiencies of current procedures used by them were poor or very poor; and 78.3% of the respondents thought that all decisions for demolition were made purely based on past cases. The

\(^{1}\) The term demolition engineer means a single professional whereas demolition contractor refers to a team of professionals.
main source of guidance on appropriate demolition techniques comes from BS 6187: 2000, but this standard tends to focus the best engineering practices rather than the management of such; other similar guidance literature on current demolition processes is rare and incomplete in most cases. Complete guidance should contain demolition project operations management as well as demolition techniques. Typically Information Communication Technology (ICT) tools used in demolition projects can only produce text-only documents, such as demolition method statements, demolition risk assessments, demolition cost assessments and demolition health and safety plans. The management of demolition processes also stands independent from each other in discrete stages. Industry practitioners have suggested that there is a need to improve the method of sharing information or knowledge between the parties involved in the demolition process. There is also a need to learn from the experience of past projects in order to integrate and improve upon the demolition process.

Research completed by a number of academic institutions, construction organisations and clients, have attempted to more closely integrate all of the stages involved in design and construction operations. For example, the standardised process maps of the BAA project (BAA Plc. 1995) and the process protocol of construction process management (Kagioglou et al., 1998). However, the demolition industry neither possesses documented research that focuses on improving the understanding of the entire process, nor investigations which concentrate on detailing individual stages of the process.

The concept of Process Re-engineering (PR) has been explored by Nelson (1999) to evaluate the opportunities for, and barriers against, its implementation in the UK construction industry and examines some construction process models and their implementation. Also, the concept of lean construction has the goal of better meeting customer needs while using less of everything (Howell, 1999). Lean theory, principles and techniques combined with process re-engineering, provide the foundation for a new form of demolition process management. This new form should have the potential benefits to improve demolition operation planning. It challenges the generally accepted belief that there is always a trade off between time, cost and quality as well as new performance indicators including those relating to the environment and safety (Ballard and Howell, 1997).

ICT has been perceived as a driver used for much of the construction business and its operational process (Aouad et al., 1999). Many companies have applied a process-oriented view of their
business operation, replacing the traditional functional viewpoint to achieve a better integration of operations (Hammer and Champy, 1993). Software tools used to achieve this purpose can be classified as paper based diagrammatic tools or software enabled analysis tools (Wu et al., 2000). Paper based diagrammatic tools offer the integration of diagrams and illustrations with a wide variety of other features and abilities. Major products on the market include: (1) Flow Charter; (2) Flow Charting PDQ; (3) Smart Draw; and (4) Visio; these provide drawing support with templates or shapes, which can be customised to suit individual requirements. Software enabled analysis tools called Business Process Reengineering (BPR) tools or Computer Aided Software Engineering (CASE) tools usually encompassed a built-in event simulator, dynamic modelling and standard database support. Thus, by using or exploiting the Information Technology (IT) tools provided, a management system for better management of the demolition process is feasible.

A high-lever process management system using ICT can be achieved to fulfil the need, to provide a framework of demolition process that contributes to improve demolition process. This system should ensure that the demolition project runs as successfully and efficiently as possible, by choosing the correct techniques, maximising quality and minimising costs.

1.2 Demolition in General

Ultimately a building can be demolished when it is deemed to be of no further use, dangerous and in a ruinous or neglected state, especially in city centres or out of town shopping facilities. Against this backdrop, land is an invaluable and scarce commodity (Building Act, 1984). Demolition acts to 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.

Before any preliminary work for demolition takes place, relevant legislation must be observed and followed. Principal legislation and British Standards applicable to demolition are herein detailed. These include:

2. Health and Safety at Work Act etc. 1974, (Section 1-5, Section 53 (1)).
5. Ancient Monuments and Archaeological Areas Act 1979, (Section 2).
7. Building Act 1984, (Section 80, 81, 82, 83, 91, 92, 93, 94, 95, 96, 99, 100, 101, 102).
10. Planning (Listed Buildings and Conservation Areas) Act 1990, (Section 7, 8, 9, 74, 75).

The power to control demolition is granted to the Local Authority (LA) in section 80-83 of the Building Act 1984; and any person intending to carry out demolition of a building must inform the LA in writing and must include details of the following:

- Site details;
- Intended demolition methods; and
- The demolition contractor must also copy notice to:
  - Neighbours;
  - Utilities Suppliers (notable gas and electricity); and
  - Electricity supplier.

Demolition may commence after the LA has issued a counter notice, or after six weeks has elapsed from the submission of the notification. Any counter notice issue should take into account certain requirements regarding how the demolition is to be undertaken and include:

1. Request for a method statement;
2. Notifying the LA building control upon commencement;
3. Details of site security/protection of the public and highway;
4. Details of adjacent/included risk, i.e.
   - Asbestos removal/disposal.
   - Overhead hazards.
   - Adjacent services.
   - Damping down/burning restrictions.
5. Time restriction on vehicles entering and leaving the site requires notification to the Health and Safety Executive (HSE) under the Construction Design and Management (CDM) Regulations.

The CDM regulations provide a framework within which the management and co-ordination of health, safety and welfare is planned and co-ordinated for all stages of a demolition project. The regulations apply to all demolition works and the ‘health and safety plan’ (developed by the Principal Contractor) is the main document used in the planning and management of any demolition project. The regulations also describes the principal duties of the five ‘core’ parties involved in a contract and these are named as the Client, Designer, Planning Supervisor, Principal Contractor and Contractors and Self-employed.

1.3 Research Aims and Objectives

A culmination of background literature review and pilot work has lead to the following question:

What is the best means of providing intelligent support for the management of the dynamic demolition engineering process, and in so doing ensure that demolition specification and performance are compliant with relevant industry standards?

Given this fundamental research question, the main aim of the research was:

- to develop a prototype system, using advanced ICT, for demolition process management.

The resulting product of the research is entitled ‘Demolish-IT’ which is specifically designed to:

- provide a blueprint for managing the entire demolition process;
- provide specific guidance with regards to the management of demolition projects, by using ICT to improve the integration and co-operation between parties involved in the demolition process; and
- allow demolition contractors to combine a disparate range of individual elements of the demolition process into one structured procedure, which will make project planning more concise and structured.

It is envisaged that the products of research can be made commercially available once validation has been confirmed.
Chapter 1 Introduction to the research and thesis structure

The aim can be accomplished by fulfilling a number of objectives, these are:

1. To gain a more detailed understanding of the nature of the demolition industry and the characteristics of demolition processes.
2. To explore the potential of using ICT to improve demolition process management.
3. To identify current demolition processes used by demolition contractors, then create and verify a demolition process map that merges disparate protocols and procedures into one hybrid system. As a result the work will identify best practice procedures and protocols.
4. To generate a process requirements framework within a unified database format. A clear structured framework of demolition requirements will be produced and will help industry to improve their awareness and understanding of complex demolition projects.
5. To produce a comprehensive tool to assist demolition contractors document all demolition process requirements.
6. To develop a prototype of the process management system, and introduce the system to the industry, in order to demonstrate its impact and value.

1.4 Research Output

This research translated separate, unorganised and text-based demolition processes into an ICT supported and structured process management system, and improved practices within the demolition industry in the following three aspects:

1. Improved integration between the various demolition processes by:
   - Promoting demolition task compliance flow within industry standards;
   - Providing an unified approach for management of demolition process;
   - Providing Data Flow Diagram framework that details and clarifies various demolition processes flows; and
   - Developing a mechanism for co-ordinating and organising demolition processes.

2. Improved collaboration between various parties involved in demolition operations:
   - To support the social interaction between each party involved, which is critical to the success of the early stages of demolition planning;
• To introduce a system which ensures the smooth running of the entire demolition process; and
• To provide a requirement framework that allows problems to be addressed and externalised.

3. Improved understanding of demolition processes:
• Allowing the client to visualise and understand the reasoning behind process progression;
• Expressing phases, activities and ideas of processes required during demolition; and
• Providing a demolition process map to understand and aware the whole picture of demolition operations together.

1.5 Thesis Organization

This thesis has been compiled to reflect the manner in which the research investigation was undertaken. Broadly, the work was divided into five discrete phases that are illustrated in Table 1-1. Each phase comprises of a number of chapters as follows:

Phase One: Conceptualisation

Phase one covers chapters 1 and 2, and aimed to establish the overall direction of the research as well as define the problems of demolition process management to be solved.

• Chapter 1, Introduction, The introduction introduces the main theme and justifies the rationale for the work. Thesis aims and objectives are detailed and a summary of chapters is given together with a diagrammatic representation of the thesis structure.
• Chapter 2, The Overview of Demolition and Demolition Processes, An extensive literature review of the demolition industry and demolition processes, gained knowledge that defined the nature of the demolition industry and the characteristics of each demolition process. This chapter also provides direction for the research.
Table 1-1: Structure of the Thesis

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<tr>
<th>Phases</th>
<th>Chapters</th>
<th>Focus of inquiry</th>
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<td>Chapter One</td>
<td>1. Introduction and overview of the research background.</td>
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<td></td>
<td>Chapter Two</td>
<td>2. Identifying and conceptualizing the problems.</td>
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<td></td>
<td></td>
<td>3. Analysis and understanding of the problems.</td>
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<td>2. Research Strategy</td>
<td>Chapter Three</td>
<td>1. Introduction to the methods of process mapping and the design of complex IS.</td>
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<td>Chapter Four</td>
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<td></td>
<td></td>
<td>3. Describing pre-existing process management knowledge and IT tools for the modelling of processes and sub-processes.</td>
</tr>
<tr>
<td>3. Implementation of</td>
<td>Chapter Five</td>
<td>1. Identifies a logical framework of demolition processes.</td>
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<td>Strategy</td>
<td>Chapter Six</td>
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<td></td>
<td>Chapter Seven</td>
<td>3. Produces a database for demolition process requirements.</td>
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<td></td>
<td>4. To design a prototype of Demolish-IT for better management of demolition processes.</td>
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<td>Chapter Eight</td>
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Phase Two: Research Strategy

Phase two includes chapters 3 and 4, and sought to determine an appropriate research strategy through which to pursue aforementioned research aims and objectives.

- **Chapter 3, Project Methodology**, this chapter defined the methodology applied during this investigation to ensure that the research findings can be substantiated under the scrutiny of examination. It comprises of three sections. The first section reviewed fundamental concepts of qualitative, quantitative, and mixed methods research. The second section provided details about the methodology used in this research project. The third section explained and discussed overarching approach adopted as part of this research.
• **Chapter 4, Process Management and System Development**, this chapter discussed a number of techniques that are used in process mapping and process management. These include Microsoft Access for creating the database and Microsoft Visio for creating Data Flow Diagrams for process mapping. The chapter then reviewed the design methods of business process management system. The culmination of work assisted in the generation of process models of complex systems and business environments. Finally, the chapter planned the strategy achieving research goals.

**Phase Three: Implementation of strategy**

Phase three contains chapters 5, 6 and 7, and represented the implementation stage of the research work. Data Flow Diagrams (DFD) were used to map demolition processes and databases were developed to facilitate the storage of demolition requirements as a precursor to developing the Demolish-IT prototype. Then the prototype of Demolish-IT was discussed in greater detail. Two tools for Demolish-IT were created to allow demolition engineers to access documentation used for the management of demolition projects.

• **Chapter 5, Demolition Processes and Sub-processes Mapping**, this chapter generated the generic ‘best practice’ demolition process map by adopting a multiple case study plan, which reviewed documents of real projects and conducted semi-structured interviews with experts augmented with site observations. Sampling strategy was also conducted by selecting reliable data and information from documents of real demolition projects undertaken in the UK demolition industry. Processes and sub-processes in the demolition operation were then mapped during its four stages, which are tendering, pre-demolition, actual demolition and post-demolition.

• **Chapter 6, Database of Demolition Process Requirement**, this chapter conducted a detailed study of key demolition process requirements. Knowledge of database storage both data and information was then reviewed. Finally, key processes requirements identified were then stored in a central database system.

• **Chapter 7, Prototype Design of Demolition IT**, this chapter discussed the knowledge requirements for managing the dynamic engineering process and compliance flow of the processes and task within industry standards. The various attributes of the system are also described. Two tools were explored for assisting demolition contractors record
demolition documentation. These tools outlined the demolition process requirements and detailed the health and safety plan.

Phase Four: Validation

Chapter 8 serves to validate the prototype of Demolish-IT through the use of experts’ opinions gathered via a series of face-to-face interviews, a workshop and trial testing on demolition projects.

- **Chapter 8, Validation**, this chapter provides a functional specification version for Demolish-IT, based upon works discussed in chapters 5, 6, and 7. A carefully designed questionnaire was given to demolition experts and a workshop was conducted with a group of industry experts. Demolish-IT tool was then trialled on demolition projects to measure the validity of the prototype and elicit constructive feedback on how to improve the system.

Phase Five: Conclusions and Recommendations

The fifth phase represented the last phase of the thesis and provides conclusions and recommendations for future work.

- **Chapter 9, Conclusions and Recommendations**, this includes the conclusion of a four-tier system prototype of demolition process management, which included (1) the standard demolition process map; (2) user-defined demolition process map; (3) demolition task manager; and (4) database of demolition process requirements. The six contributions of the research are also elucidated upon, which included (1) unifying demolition processes within industry best practice; (2) visualizing the workflow of demolition process; (3) creating a database solution to manage the requirements of demolition processes; (4) designing two documentation tools using ICT; (5) introducing a new management system entitled Demolish-IT to the demolition industry; and (6) managing demolition tasks within a compliance flow. There are two concepts within compliance flow. The first is that demolition task flow should be comply logically with the demolition process. The second is that the user-defined demolition process flow of an individual project should be
compliant within standard demolition processes. The chapter concluded by stating the limitations of this research, and provided recommendations for future work.

These five phases and chapters within are also illustrated graphic shown in Figure 1-1.

**Figure 1-1: Breakdown of the Thesis Chapters**

- **Introduction and overview of the research domain**
  - **Chapter One**
  - **Chapter Two**

- **Introducing the project methodology and methods of process management, IT tools and methods for modelling the processes**
  - **Chapter Three**
  - **Chapter Four**

- **Development of the prototype of Demolish-IT**
  - **Chapter Five**
  - **Chapter Six**

- **Mapping demolition processes and sub-processes**
  - **Chapter Seven**

- **Validation of the research work**
  - **Chapter Eight**

- **Conclusions and recommendations**
  - **Chapter Nine**

*Figure 1-1: Breakdown of the Thesis Chapters*
2 The Overview of Demolition and Demolition Processes

2.1 Introduction

A review of demolition literature reveals that, historically there have been limited academic studies undertaken in the field. However, there is a wealth of industrial activity and documentation that makes the carrying out a comprehensive literature review on demolition a very practical task.

A detailed review of academic literature, and relevant text gathered from demolition contractors and professional institutes representing the demolition industry have provided varied opinions on the individual aspects of the demolition process. Demolition knowledge has been documented in books, legislative documents, guidance notes, journal papers and codes of practices, for example, Beyer, (2001); Blackhall, (2005); Rollinson, (1995); and BS, 6187:2000. However, that knowledge is either too general or too specialised for practical purposes and the task of searching through all relevant documents for information relating to a particular topic is time-consuming. As might be expected, increased interest in demolition as a budding area of construction science has started to generate an even wider spectrum of opinions, products and services on the subject (Arham, 2003). A structured literature review of the demolition processes, as well as demolition process management is therefore required.

This chapter provided an overview of demolition and demolition processes in its entirety. Its aims are fourfold:

1. To introduce readers to the latest developments within the demolition industry;
2. To understand the demolition process and its characteristics;
3. To discuss the types of demolition techniques and structural demolition methods available in the industry; and
4. To identify the problems of process management within the industry.
2.2 Development of the Demolition Industry of UK

2.2.1 The National Federation of Demolition Contractors (NFDC)

The National Federation of Demolition Contractors (NFDC) was the first demolition organisation to be established in the UK and was set up in 1941 during World War II (NFDC, 1992). The NFDC was created at a time when a large variety of infrastructure was damaged and required demolition. Government turned to the industry for help and requested that demolition works be organised in a safe and efficient manner. The NFDC’s first executive membership was drawn from a handful of specialist companies that existed at that time. Arguably amateurism was rife in this sector and building companies often undertook site clearance, relying on brute strength rather than thought-out procedures and specialist equipment. Since inception, the NFDC has gone from strength to strength, and it is now widely accepted that around 90% the annual UK demolition workload is carried out by NFDC members (NFDC, 2008).

Early NFDC members pooled their resources, shared expertise and worked cooperatively on the enormous tasks that faced them. Skills were transferred and problem solving techniques were shared between members (NFDC, 1992). This co-operation concept grew into the well developed technical support, training and safety awareness services that are now available to NFDC members (Wring, 2008).

The publication of the NFDC’s Form of Direct Contract (often shortened to ‘Direct Contract’) in 1960 marked a new phase in the federation’s development (NFDC, 1992). The contract made reference to fair wages but it also included clauses on ownership of materials covered, carting over footways and other items specific to demolition. The Direct Contract would operate increasingly in the public eye, promoting and setting the standards for this specialist industry. This contract has since been subsequently amended in 1974, 1979, 1982, and 2000 with the latest changes being made in 2007 (NFDC, 1992; NFDC, 2008). The contract can be used by any contractor contemplating demolition projects and consequently it encompasses issues which specifically arise from demolition work (Turner, 2007).

In the 70’s, demolition became the subject of a heated public debate (NFDC, 1992). Construction technology was advancing rapidly and many large buildings, notably tower blocks, had been built using new materials, technologies and building systems, for example, pre-stressed concrete.
The pre-stressed buildings were held together by tension and subsequently would tend to spring apart when they are demolished (Mark and Zvorsky, 2002). At this juncture, it is important to note that a demolition specialist’s view of an unusual new building type is different to that of other construction and civil engineering specialists. A demolition contractor is not concerned about whether a structure goes up, but whether it will come down. In September 1975, the Register for Unconventional Structures (RUS) was established in conjunction with LA (NFDC, 1992). The RUS is a joint liaison committee comprising of the NDFC, other professional bodies and the government, and aims to consider techniques for the demolition of unusual structures.

In 1971, the NFDC published its Code of Practice (CP94); a document that enshrined the business ethics of the federation alongside the procedures and safe working practices it was constantly developing (Tynan, 2005). This code also marked a milestone in the NFDC’s relationship with government bodies and it was published as a British Standard (BS 6187). The ‘British Standard Code of the Practice for Demolition’, has been revised three times since its introduction in 1971 (CP94), has since been superseded by BS 6187:1982 and currently by BS 6187:2000.

2.2.2 European Demolition Association (EDA)

The European Demolition Association (EDA) is the leading platform for national demolition associations, demolition contractors and suppliers, and it represents approx 1,000 demolition contractors in throughout Europe (Source from www.eda-demolition.com. 2009). Its organisation is illustrated in Fig. 2-1.

**Figure 2-1:** Organisation Chart of EDA
Chapter 2 The overview of demolition and demolition process

The EDA has the following objectives, which are to:

- Promote and protect the interests of the demolition industry in Europe;
- Set European standards on demolition techniques and promote recycling of demolition debris;
- Become involved in and have an impact on health and safety legislation;
- Exchange information on techniques, working methods and training; and
- Maintain contacts with similar organisations in the world.

2.2.3 Institute of Demolition Engineers (IDE)

The Institute of Demolition Engineers (IDE) was created with the specific aim of advancing the science of demolition engineering (Source from IDE website, 2008). The IDE exists to promote and foster the science of demolition engineering and actively encourages Continual Professional Development (CPD).

The main objectives of the IDE are:

- To promote the use of more efficient techniques in the industry;
- To encourage the use of safer methods of working; and
- To provide a qualifying body for the industry. The qualified demolition engineer is a professional within the industry.

2.2.4 Explosive Demolition Techniques

Explosive demolition techniques have developed rapidly, and are used worldwide (Jeff, 2005). A large number of commercial explosive demolition specialists have emerged and undertaken a wide variety of demolition projects. For example, in the ten years between 1978 and 1988, around one hundred bridges in East Germany and between 1979 and 1993, around 30-40 high-rise buildings in the UK were demolished using explosion demolition. In the last decade, explosion demolition techniques have been successful in demolishing a number of 80-storey buildings and 200-metre high chimneys (Liu, 2005). Fig. 2-2 shows some pictures of explosion demolition projects.


2.2.5 Safety Campaign

Demolition contractors launched the ‘Site Safe’ campaign when the Health and Safety at Work Act, etc. 1974 was introduced (NFDC, 1992). This arose from the realisation that safe and efficient working practices must be passed on to the operatives, who operate at the high risky end of the business. The demolition contractors have concentrated on evolving the best and safest techniques for demolition and turned to the subject of training. Safety and training go hand-in-hand and the demolition contractors took the opportunity to mount a sustained training action programme (Source: NDTG website, 2008).

2.2.6 Training and Competence Certificate

The Demolition Industry Training Unit embarked on its own training scheme in November 1979, and was rolled out nationally by 37 NFDC companies. Within four years of research, consultation and development, the Demolition Operative Training Scheme was born. It provided a specification for training operatives within the demolition industry. That demonstrated competence and safety awareness. It comprises of three main categories of demolition workers, namely Labourers, Mattockmen and Topmen (CSCS, 2007). It has Scottish/National Vocational Qualification (S/NVQ) status, which means that operatives in demolition and dismantling could
have their skills and specialist knowledge properly recognised with a government recognised standard of competence. Many of the training courses offered cover topics such as asbestos, general safety awareness and plant operations.

The training unit was named the National Demolition Training Group (NDTG) in early 1981. The training unit proved to be successful. There was large demand from demolition companies and today it employs a pool of experienced instructors and lecturers (NFDC, 1992). At this juncture, the NFDC also increased the scope of the scheme and a wide range of training courses are now offered (NFDC, 2008).

Today, the NDTG is operated jointly by the National Federation of Demolition Contractors Ltd (NFDC) and Construction Industry Training Board (CITB) ConstructionSkills. The NDTG organizes training courses across the UK that is delivered via the five NFDC regions: namely London and the Southern Counties; the Midlands and Wales; the North East; North West and Scotland and Northern Ireland. The NDTG also links closely with the NFDC in the delivery and development of demolition related S/NVQs via the NFDC S/NVQ approved centre (Source from NDTG website, 2008). “By the end of 2007 the NDTG was moving to the right direction and became an organization in its own right and had its own in-house trainer.” (Wring, 2008).

Within the demolition industry, The Certificate of Competence of Demolition Operatives Card Scheme (CCDO) has been used to recognise the competence of the industry professionals (Gilkes, 2008). There are seven card levels, which are colour coded to reflect the experience and roles that a person can fill. These range from green to indicate a temporary worker, to gold for an experienced site supervisor. Fig. 2-3 indicates the standard requirements for obtaining blue and gold cards which refer to a Demolition Operative Mattockman level and a Demolition Supervisor level respectively.
Chapter 2 The overview of demolition and demolition process

Figure 2-3: Demolition Operative Mattockman and Demolition Supervisor Card

or

Demolition Experienced worker card holder at Mattockman level

Achieved Demolition NVQ level 2 including 2 optional units

Has attended a recent Asbestos Awareness/Demolition Safety Awareness Course

Demolition or Construction Skills Operative Health and Safety Test passed during the last 2 years

Qualified Demolition Operative (Mattockman) Card issued

Qualified Demolition Operative (Topman) card holder with sufficient industry experience

Application from CCDO/1 available from NFDC

Has attended a recent Asbestos Awareness/Demolition Safety Awareness Course

Demolition or Construction Skills Operative Health and Safety Test passed during the last 2 years

Achieves required standard during Demolition Supervisor distance learning course

Demolition or Construction Skills Operative Health and Safety Test passed during the last 2 years

Industrial assessment via NFDC for Mattockman required

(see from Demolition Operatives Card Scheme, 2007)

2.2.7 Characterisations of Current Demolition Projects

Today, Demolition Contractors are required to do a great deal more than just knocking down and clearing a site (Menary, 2005). Demolition contractors have developed more sophisticated ways of dismantling existing buildings. Increasingly, these buildings must be demolished alongside other occupied buildings in densely populated areas without disrupting neighbouring residents or businesses and at all times public health and safety is paramount.

One example is project W8 which involved Keltbray Demolition Ltd, and was carried out near to the BBC Broadcasting House, London. Here the company carried out the demolition of
eleven buildings, retaining their facades, to enable the main contractor (Bovis Lend Lease) to construct a new mixed use development behind the historically listed facades. Keltbray’s tasks ranged from isolating all services in the eleven buildings, removing asbestos, carrying out soft-stripe demolition through to structural demolition, and concrete works for the retention of the basement. An impressive feat of project management which included decanting 1,500 BBC employees into temporary accommodation without interrupting their work (Source from www.Keltbray.com/key project/W8, 2009).

Demolition is destructive and potentially dangerous in the absence of planning and adherence to professional standards (Howard, 2008). To ensure a successful demolition project, Wring (2008) states that: “it all comes down to the same thing - better planning.” Keltbray’s successful bidding for the W8 project was based on six months of pre-contract project management. The demolition team planned the works to ensure that the transition from the demolition phase to the substructure reinforced concrete installation was seamless and trouble-free. Keltbray then produced a detailed scale model of the site and explained to the BBC exactly how it proposed to carry out the work (Taylor, 2005).

A prominent benefit of the demolition industry is that contractors regularly recycle as much as 90% of all waste from demolition contracts unlike other UK industries who struggle to meet government guidelines on recycling (Leong, 2005).

In short, demolition contractors are constantly looking to the future (Penny, 2008). Notably the:

- Demolition contractors have worked closely with the CITB and has formed with them the NDTG to promote the need for training at all levels in the demolition sector.
- Demolition contractors work closely with our European peers via the EDA.
- The NFDC work in conjunction with organisations such as the Building Research Establishment (BRE) and Waste and Resources Action Programme (WRAP) to further environmental and sustainable causes.

Wring (2008) indicated that:

“It is a great reflection of the entire industry working together - the NFDC, NDTG and the IDE, lobbying to the UK parliament to ensure that the voice of the UK demolition is heard loudly and clearly in the corridors of power.”
Thus the NFDC keep all of its members fully informed of all changes to legislation and health and safety guidelines that affect their businesses (Wring, 2008).

2.3 Developing Demolition Techniques: Historical Perspectives

From a historical perspective, demolition techniques have developed as follows:

- In the late 1950s, demolition work started using hand hammer breakers and the steel ball for the demolition of concrete structures (Kasai, 1988a).
- From 1967 onwards, chemical expansive demolition agents were developed in Japan and were made commercially available by 1978, using the rebar heating technique to remove the concrete surface (Kasai, 1988b; Brydon, 1991).
- In 1975, the introduction of concrete crushers in England was an important development in demolition (Polman, 2000). Many efficient concrete crushers have been developed since and can be seen in use today.
- In 1979, the proposed demolition of the Japan Power Demonstration Reactor (JPDR) by the Japan Atomic Energy Research Institute (JAERI) resulted in the need to develop an explosive demolition technique for reinforced concrete structures. Other demolition techniques were also developed in the coming year, for example, core boring machines, large diamond cutting and techniques for stripping surface concrete by the use of microwaves (Kasai, 1988b).
- At the end of the 20th century, an ever-expanding variety of structures could be explosively felled by demolition experts throughout the country (Liss, 2000).

Overall, during the last two decades, the demolition industry has been changed drastically (NFDC, 1992). Today practitioners employ High Reach Hydraulic Excavators (HRHE) and utilise a large amount of machinery. For example, attachments on HRHE superseded crawler cranes and the demolition ball. Demolition site safety and procedures have also changed and improved significantly. In addition, demolition contractors have become highly specialised experts in the art of demolition (Liss, 2000). They are committed to providing a quality service in the sectors of demolition, dismantling and soft stripping, site clearance, crushing and screening, remediation, materials recycling and reusing.
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2.4 Demolition Techniques

There are four main types of demolition techniques (refer to Figure 2-6) detailed in section 17 of the BS 6187:2000. These are: (1) demolition by hand; (2) demolition by machines; (3) demolition by chemical agents; and (4) demolition by high pressure water jetting.

2.4.1 Demolition by Hand

Progressively demolished structures and individual elements of structures can be demolished by operatives using hand-held tools. A general sequence is for the structure to be demolished in the reverse order to that of its construction. High-rise buildings should be demolished progressively storey by storey.

2.4.2 Demolition by Machine

There are a number of different machine types that can be used in demolition works. These range from modern robotic devices to HRHE. Each of the main techniques will now be discussed in greater detail.

2.4.2.1 Remotely Controlled Machines and Robotic Devices

When hazardous or potentially dangerous situations arise, consideration should be given to the use of remotely controlled machines and robotic devices. This is because any machine can be controlled by digital signalling system transmitted via cable or radio at a safe distance from the demolition work (BS 6187:2000). This can remove the operator from the work area, where risks and hazards exist.

Robore Group has the largest fleet of remote controlled demolition machines in the UK (Source from Robore website, 2008). The machines range from the Brokk 40 to the Brokk 330 (www.robore.com/robotic, 2008) which is manufactured by Brokk in Sweden. The machines can be operated in confined spaces and provide massive productivity gains compared with traditional methods. The operator controls the machine from a safe-distance using a remote control device connected by a cable or radio signal. All machines can be fitted with a variety of demolition tools including breakers, jaws and buckets, to suit a range of tasks. They are the ideal solution for most controlled demolition projects (www.sovereign-publications.com, 2008).
Fig. 2-4 is a picture of the Brokk 330. It is powered by a 30kw motor and can be equipped with tools weighing up to 550kg, such as buckets, hydraulic hammers, and concrete crushers and drilling equipment. The machine has a reach of 7 metres and a turning radius of 360 degrees. Despite its awesome power the Brokk 330 is compact and has the highest capacity of any demolition robot in the world.

**Figure 2-4:** Remote Demolition Machine Brokk 330

(Source from Tatten, 2000)

### 2.4.2.2 High Reach Machines

High reach machines are used to deconstruct high rise buildings, for example, using excavators fitted with suitable multi-stage booms and arms (refer to Fig. 2-5). Machines designed and produced by Komatsu Ltd range from the PC 200LC to the PC 750L, and are claimed to “demonstrate high operating efficiency and safety at high rise building demolition jobsites, while remaining environment friendly.” (www.Komatsu.com, 2008).

Super high reach mechanical demolition utilises specially designed high reach 360 hydraulic excavators, usually equipped with high capacity rotating shears/pulverisers (BS6187:2000). The machine cuts the structure from the top to ground level by reducing it to manageable sized rubble which can safely drop to the ground.
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Figure 2-5: High Reach Machines for Demolition

(Sources from Komatsu and kocurek website, 2008)

High rise demolition allows for level by level deconstruction and adaptability and flexibility is the key to demolition success (NFDC, 1997). Often high rise demolition can consist of both traditional demolition and other demolition services whilst the high rise demolition itself takes place (B and T demolition website, 2008). For example, high rise demolition can switch interchangeably from intricate demolition techniques using hand-held equipment to large-scale removals using high reach and super high reach machinery all on the same project.

2.4.2.3 Tower and Other High-reach Cranes

Towers and other high reach cranes are also used for demolishing high rise structures. For example, Eagle West Cranes introduced the Liebherr 270ton mobile crane. Because they claim it provides a total lifting solution to industry (Eaglewestcranes website, 2008). Another example is provided by W&M Thomson who successfully removed the Tall Oil Plant at Birtley by using a 400te telescopic crane rigged on super lift and using 120te crane for tailing. This included four columns demolition, each 40m high and weighing 120 tonnes – this task was completed in three days (Tatten, 2001a). Fig. 2-7 shows examples of the types of cranes available for use within the sector.
Figure 2-6: Demolition Techniques

(Source from BS 6187:2000)
Hydraulic attachments can be mounted onto the base machine or equipment (such as cranes and tracked excavators) for the progressive demolition of reinforced concrete or steel structures, which cuts steel and crushes or pulverizes concrete. The attachment can be mounted either directly on the boom or the dipper arm in place of a bucket (Haulmarkltd website, 2008).

1) Demolition by pusher arm: a pusher arm is made from steel, and exerts a horizontal thrust upon the structure (Source from: www.workcover.act.gov.au). Fig. 2-8 provides an illustrative example of a pusher arm at work.
2) *Demolition by impact hammer*: a machine-mounted impact hammer is used to progressively demolish masonry and concrete structures by applying increasingly heavier blows to a point of contact with the material and may be pneumatically or hydraulically operated (BS 6187:2000). Fig. 2-9 shows three types of impact hammers typically used in demolition projects.

3) *Demolition by hydraulic shears*: cold cutting of metal and reinforced concrete sections can be achieved by cutting and severing material using shear jaws. Shear attachments can be rigidly mounted to the machine or rotated to provide increased working versatility for cutting. Fig. 2-10 illustrates a typical rotational hydraulic shear.

4) *Demolition by pulveriser*: mechanical demolition by a machine mounted pulveriser is used for the progressive demolition of reinforced concrete or brick structures by crushing the material with a powerful jaw action. Teeth and wear plates can be replaced on site; the blades can be easily and quickly turned around providing a maximum utilization of these wear parts.

**Figure 2-8**: Demolition by Pusher Arm

(Source from: www.citycol.com, 2008)
5) Demolition by demolition pole: a telescopic or rigid demolition pole is fitted with attachments such as a claw or ripper hooks to achieve a greater working height and distance from the base machine during the progressive dismantling of structural components (BS 6187:2000). Fig. 2-11 (a) shows a Liebherr 972 fitted with hydraulic demolition pole. This machine configuration can reach up to 100ft high. Fig. 2-11(b) shows the Burnthills Demolition's Liebherr 972 with hydraulic demolition pole, and illustrates a typical application on structural brickwork.

6) Demolition by grapple: a grapple is designed for use in primary demolition and rehandling applications for steel and concrete beams, columns, walls and floor sections and roof joists. The parallel-jaw closing action ensures that material is drawn into alignment during the dismantling, lifting and loading cycle as appropriate (BS 6187:2000). Fig. 2-12 shows two types of demolition grapples currently in use.
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7) **Demolition by crusher**: concrete crushers for excavators demolish massive concrete slabs and chunks into small pieces of debris. The crushers have a moving jaw operated by an internally mounted hydraulic cylinder. The lower jaw screens material and can be fitted with rebar cutting blades (Demolition X, 2001). Fig. 2-13 shows the RM80 robust crusher for top recyclers and it crushes concrete. This machine has a secondary profit stream because it can produce aggregate from demolition debris.

8) **Demolition using hydraulic multi-purpose attachments**: multi-purpose attachments can be used to demolish reinforced concrete or steel structures including chemical and oil storage tanks by use of interchangeable jaws for steel cutting, concrete pulverizing or plate/tank cutting. Multi-purpose attachments can be mounted either directly to the boom or the dipper arm of an excavator. Fig. 2-14, 2-15 shows some of the machine attachments and hydraulic tools used for demolition works.

**Figure 2-11**: Demolition by Demolition Pole

(a) ![Demolition by Demolition Pole](Source from Shug, 2000)

(b)

**Figure 2-12**: Demolition grapples

(1) Grapple

(2) Scrap Grab

(Source from www.Haulmarkltd.co.uk, 2009)
**Figure 2-13:** Demolition Crushers

RM80 Robust Crusher

(Source: Allied Equipment, 2007)

**Figure 2-14:** Demolition Machine Attachments

(1) Backhoes  (2) Compactor  (3) Grab and Grapple

(4) Hammer  (5) Earth Drill  (6) Bucket

(Source from Haulmark Ltd Equipment, 2009)
2.2.4.5 Mechanical (non-hydraulic) Attachments

Demolition by mechanical (non-hydraulic) attachments can be broadly classified as both balling and wire rope pulling.

1). Demolition by balling: 'Balling' means to demolish by mechanically swinging a weighted ball into a structure. It is a technique which entails the use of a jib crane equipped with a demolition ball which is used to break up the concrete and masonry structures by dropping the ball onto the highest remaining floor (BS 6187:2000). The method has long been established and is relatively inexpensive, so it is one of the most common and popular methods available (Brydon, 1991). There are four types of demolition balls, namely spherical, rectangular, pear-shaped and cylindrical. Balling operations subject cranes to dynamic stresses and wear, and the ball chosen should have the minimum weight necessary for effective use. In many cases, lightweight demolition balls are adequate (Li, 1995). Balling demands a great deal of skill from the crane operator, and only a robust and well maintained plant of the right design can be used to
demolish by balling (BS6187:2000). The manufacturer should be consulted before a machine is used for balling to establish any restrictions on the type or length of jib or the weight of the ball. Fig. 2-16 is an example of demolition ball.

**Figure 2-16: Demolition Ball (Li, 1995)**

2). **Demolition by wire and rope pulling:** this method involves the application of a horizontal force at a high level by pulling with wire ropes attached to winches or vehicles, and allowing the impact on overturning to demolish the building or structure. An adequate steel cab or cage should protect the winch or the pulling vehicle and the operator (BS6187:2000). However, BS6187 (2000) recommends that buildings over 21m high should not normally be demolished by rope pulling and wire rope pulling should not be used on brick and masonry structures.

**2.4.2.6 Cutting by Drilling and Sawing**

Drilling and sawing methods are used to weaken and/or remove parts of (or the complete) structure, particularly where the work is carried out in a confined space, in locations where a high degree of accuracy is needed, or where the noise, dust, smoke and vibration resulting from other methods would be unacceptable or inappropriate (BS 6187:2000). Guidance on drilling and sawing work is given in the United Kingdom Drilling and Sawing Association Code of Safe Working Practice (Drilling and Sawing Association, 1999). There are several drilling and sawing techniques that can be considered for use in demolition works. For example, the diamond core drill and diamond floor sawing can be used to create holes for ducting or cut planks respectively.

1). **Pedestal diamond core drilling** (Picture of Fig. 2-14(5)): a quiet vibration-free method which produces holes in reinforced concrete and other solid materials. Core drilling machines can be operated in either vertical or horizontal directions and can be powered by electric, hydraulic or air sources.
2). *Diamond floor sawing:* self-propelled saws using diamond blades are capable of cutting trenches, expanding joints, removing slabs and carrying out motorway repairs and airport works (BS6187:2000). Other sawing methods are also available like rock sawing, tracked diamond sawing, hand-held ring and chain sawing, diamond wire sawing and dry cutting methods.

### 2.4.3 Demolition by Chemical Agents

Demolition by chemical agents includes hot cutting, demolition by explosives and bursting, all of which are highly specialized activities and must be undertaken only by, or under the supervision of trained personnel.

#### 2.4.3.1 Demolition by Explosives

The main purpose of explosives within demolition is the deliberate collapse of concrete and masonry structures. Demolition by explosives can be a fast, practical and economical technique where site conditions permit (Brent, 2002a). Recently it has been proven that explosion demolition techniques have many advantages over manual demolition (Guan, 1981). Explosives are cost effective and time saving; they do not require the use of heavy machinery; and they are particularly useful in cases where access to the demolition site is limited or where narrow unstructured space is (BS6187:2000). For example, when demolishing high-rise chimneys, controlled blasting demolition is much quicker, saves on manual labour and requires no scaffolding to be built. For massive concrete structures, the use of this method means that the more unsafe and difficult procedures, such as cutting is not necessary. Li (1999) found that explosion demolition methods in general are safer and shorten the project time by 75%, and save 90% on labour and dismantling fees.

When explosives are to be used for demolition, the planning and execution, including pre-weakening, should be under the control of a person competent (BS6187:2000). For large structures, the competent person is likely to be an experienced explosive engineer; for smaller work, a shot-firer may be sufficient. Recommendations on the use of explosives are given in the Code of Practice for the Safe Use of Explosives in the Construction Industry (BS5607, 1998).

Explosion demolition theory involves removing vertical support columns in a controlled, sequential way and then using gravity to collapse the structure (Jia and Yu, 1999). Falling
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direction can be controlled by taking out the relevant supports of the building (Source from CDI website, 2007). When the use of explosives is contemplated, it is usual to employ a technique that will ensure the total demolition of the whole building by staging a controlled collapse (BS6187:2000). The explosive charges are set and fired in a sequence that will weaken the structure in such a way that the building collapses in upon itself (Brent, 2002b).

An example is the Pacific Palisades Hotel which was a twenty-year old, reinforced concrete building. It took one year to design, one year and millions of dollars to build but was brought down in the space of 10 seconds (Source from www.Pacificblasting.com, 2008). The whole explosion demolition processes consisted of five steps that can be interpreted below as:

1). Planning: planning a successful drop is quite complicated and usually needs four pre-work activities to be undertaken (Jia and Yu, 1998). These involve:

- Considering shape and composition of the columns,
- Taking core samples for analysis,
- Studying original construction drawings, and
- Taking at least one test “shot” to verify the calculations made.

The charge (dynamite and detonating cord) has to be placed with great precision to be effective (Lin, 1995). The basic idea is to weaken the columns on one side of the building’s lower floors, starting at the bottom and working upward over a period of about ten seconds. Each charge will cut through the concrete of a column and the weight of the structure above will start the collapse. The explosives will shatter the concrete around the reinforced rods and since the concrete provides nearly all the strength of the columns, that part of the building quickly begins to fall. If enough columns are shattered, the building will collapse (Jia and Yu, 1999). The art of demolition is to know which part of the building to take out at each moment, over a period of ten seconds or so (Brent, 2002b). Errors in this kind of calculation can be rather embarrassing and dangerous, especially if the structure comes down where it is not supposed to. Therefore, the theory behind the calculation is essential to ensure that the demolished buildings and structures fall down in a planned way (Li, 1999).

2). Explosives: explosives come in all sorts of forms ranging from gels, granules, powders, cord, liquids, plastics (in blocks and sheets) and stick dynamite. All have properties designed for specific conditions (BS5607, 1998). Explosives detonate with a priming charge into a big firing
circuit and fire instantaneously with a single push of a button. Timed detonating caps allow to press that same single button and stagger single explosives by ten seconds or more (Source from www.implosionworld website, 2009). The direction and sequences of collapse can be controlled by designing how and where to put the charge on and the order in which the charges are fired (Liu, 2005).

3). **Test shot:** early in the design sequence, the column will be found, normally in the basement for a test shot (BS6187:2000). Based on a core sample and available information about the nature of the material in the column, locations will be marked for placement of explosives (Jia and Yu, 1998). After receiving the permission for the shot from the Local Authority, the holes are loaded and fired. Deep inside the building, the blast’s noise and “fly rock” are fully enclosed; then the crew re-enters the structure to inspect the damage. The column should be completely shattered, although the rebar will still be intact; if the column is not demolished, more holes and more explosives are required (BS6187:2000). Once the test shot confirms or refines the understanding of the structure, the exact location of each bore hole is marked. Then the drillers come along, bore the holes, and then mark each with a length of red-painted rebar. The exposed column will be wrapped in construction, and then everything is enclosed by chain link fencing, leaving the red rebar exposed to mark the bore holes (Source from www.Pacificblasting.com, 2008).

4). **Priming and loading:** the notion of dynamite is that it is extremely sensitive and dangerous (BS5607:1998). The priming process includes taking a stick of dynamite and using a sharp tool to make a hole in the blasting cap which is a bright aluminium tube with a long pair of detonation wires attached. The wires are extended, and then a quick pair of half-hitches are tied around the stick, and inserted in the bore hole. The stick is pushed into position at the bottom of the hole and the exposed end of the wire twisted together to create a fire circuit connection. The hole is sealed in order to concentrate the force of the explosion. Once all the charges are loaded, the wires are spliced together into an electrical circuit (Source from www.Pacificblasting.com, 2008).

5). **Blast time:** a button is pressed that connects the firing circuit, sending voltage to all the electrical blasting caps in all the holes through the structure.
2.4.3.2 Demolition by Bursting

Where the use of explosives would not be possible as a result of site conditions, it may be possible to use bursting techniques for the demolition of concrete, masonry and rock (BS6187:2000). BS 6187:2000 defines bursting as: “analogous to the use of explosive in that it makes use of the expansion of mass of gas or a mechanical device in a prepared crack in a mass in order to break it into fragments”. There are three bursting techniques have recommended by BS6187:2000, these are: (1) gas expansion bursters; (2) hydraulic bursters; and (3) expanding demolition agents.

1). Gas expansion bursters: the effect of the burster is obtained by inserting it into a prepared cavity in the mass to be demolished. Upon being energized, the resultant increase in pressure of the gas ruptures a diaphragm, releasing the gas into crevices in the surrounding structure which is then fractured (BS 6187:2000). To prevent the gas expansion burster from becoming projected in an uncontrolled manner, the gas expansion burster should be effectively restrained within the prepared cavity (Edwards, 2008).

2). Hydraulic bursters: the hydraulic burster works on the same principles as gas expansion bursters in that they use an expanding device to force apart a mass, but the process is not as rapid as in a gas expanding burster. Pistons or wedges are placed in a prepared cavity and are gradually jacked out under pressure; the resulting increase in size of the device fractures the surrounding material (Source from demolitiontools.com.cn/Product details of Hydraulic concrete bursters). The demolition work should be planned and controlled to ensure that dislodgement of the hydraulic bursting equipment is not a risk e.g. when failure of the structure occurs. This technique is normally used to split plain concrete and masonry (BS, 6187:2000).

3). Expanding demolition agents: this method of bursting employs the use of expanding chemicals that are mixed with water to form a liquid or paste. The mixture is then poured into pre-drilled holes in the material that is to be demolished and expands to cause a fracture (BS6187:2000). For example, a white crystalline oxide used in the production of calcium hydroxide is mixed with water and injected into the hole; the expansion of the mixture by hydration cause the splitting of the concrete (Demolition X, 2001).
2.4.3.3 Hot Cutting

BS 6187:2000 indicated that hot cutting should be selected only where the work system chosen avoids the risk of fire or explosion and should be commenced only after the structure to be cut and the surrounding area have been made safe from the risk of fire or explosion. Hot cutting techniques include thermic lancing and thermal reaction used in demolition that can potentially generate sufficient heat, e.g. in the form of friction, and sparks to ignite (Source from info@welwyntoolgroup.co.uk, 2008). The techniques commonly use oxy-fuel gases and disc grinders.

2.4.4 Demolition by High Pressure Water Jetting

BS6187:2000 indicated that “high pressure water jetting” covers all water jetting processes including those using additives and abrasives where there is energy input to increase the pressure of water. In demolition the process is used for cutting out concrete from around steel reinforcing bars where the latter are to remain in-situ. The process is highly specialized in accordance with the Water Jetting Association’s Code of Practice and should be carried out by suitably trained and competent people.

2.4.5 Demolition Techniques Application Areas

The aforementioned four main types of demolition techniques have been applied to the most suitable structural forms. However, demolition works can also be categorised into four key areas which are (1) demolition by hand; (2) demolition by machines; (3) demolition by chemical agents; and (4) demolition by high pressure water jetting. Fig. 2-17 provided a detailed description of these four techniques by the study.
### Figure 2-17: Four Types Demolition Techniques and Their Usage

<table>
<thead>
<tr>
<th>Demolition technique</th>
<th>Usage and application area</th>
</tr>
</thead>
<tbody>
<tr>
<td>Demolition by hand</td>
<td>To separate the structure to be demolished from adjacent structures or from adjoining structures. When working near to live services or public areas. Where site or safety restrictions prevent mechanical techniques from being employed. Where the demolition has to be carefully controlled. When the site contains contamination. When stripping out soft strip material such as door/window frames.</td>
</tr>
<tr>
<td>Demolition by machine</td>
<td>Wherever possible. Where structures are isolated. Where the machines can move around without obstruction.</td>
</tr>
<tr>
<td>1). Remotely controlled machines</td>
<td>Dangerous environments for operations.</td>
</tr>
<tr>
<td>and robotic devices</td>
<td>Internal demolition.</td>
</tr>
<tr>
<td></td>
<td>Pre-weakening of structures for demolition by explosives.</td>
</tr>
<tr>
<td></td>
<td>Confined areas and where there is danger of collapse or unstable structures.</td>
</tr>
<tr>
<td></td>
<td>Nuclear contamination.</td>
</tr>
<tr>
<td>2). High reach machines</td>
<td>Multi-story buildings or high structures.</td>
</tr>
<tr>
<td></td>
<td>Easy solution for demolition.</td>
</tr>
<tr>
<td></td>
<td>Where structures are isolated.</td>
</tr>
<tr>
<td></td>
<td>Restriction to deconstruct or use explosives.</td>
</tr>
<tr>
<td>3). Hydraulic attachments</td>
<td>In most situations wherever possible.</td>
</tr>
<tr>
<td></td>
<td>Breaking and cutting of steel structures and/or RC structures, bricks, foundations, labs (pulverizer) and cutting steel (shear).</td>
</tr>
<tr>
<td>4). Mechanical (non-hydraulic)</td>
<td>Very isolated or open areas.</td>
</tr>
<tr>
<td>attachments e.g. balling</td>
<td>Where there are no restrictions.</td>
</tr>
<tr>
<td></td>
<td>High rise structures.</td>
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<tr>
<td></td>
<td>Cheap avoids high cost of specialized plants.</td>
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<tr>
<td></td>
<td>In certain circumstances chimneys may be pulled down by steel hammers.</td>
</tr>
<tr>
<td></td>
<td>Where little collateral damage can be caused.</td>
</tr>
<tr>
<td>5). Cutting by drilling and sawing</td>
<td>Where separation is needed from the retained structures.</td>
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<tr>
<td></td>
<td>Partial demolition of concrete.</td>
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<tr>
<td></td>
<td>Bridges, walls, slab or concrete floor removal.</td>
</tr>
<tr>
<td></td>
<td>Where a clean cut edge is required.</td>
</tr>
<tr>
<td>Demolition by chemical agents</td>
<td>High structures, tower blocks, chimneys, bridges, large steel and concrete structures.</td>
</tr>
<tr>
<td>1). Demolition by explosives</td>
<td>Quickest and most effective way of demolition structures where speed of demolition is required. Only used where authorities will allow and the surrounding area will permit. Isolated areas.</td>
</tr>
<tr>
<td></td>
<td>Out of reach of long machines. Specialist projects, unstable structures.</td>
</tr>
<tr>
<td>2). Bursting</td>
<td>Water towers, mass concrete, foundations.</td>
</tr>
<tr>
<td></td>
<td>Where noise is a problem.</td>
</tr>
<tr>
<td></td>
<td>Rarely or hardly ever used. Commercially attractive.</td>
</tr>
<tr>
<td></td>
<td>Specialist projects. Where vibration cannot be tolerated.</td>
</tr>
<tr>
<td>3). Hot cutting</td>
<td>Generally to cut steelwork for steel framed buildings, vessels and bridges. Hot work is allowed and there is no chemical contamination.</td>
</tr>
<tr>
<td>Demolition by high pressure</td>
<td>Where hot cutting is not allowed.</td>
</tr>
<tr>
<td>water jetting</td>
<td>Where need to cold cut steel in areas such as refineries.</td>
</tr>
<tr>
<td></td>
<td>Where vibration must be avoided. Can be used with contaminated equipment or explosive atmospheres. Bridges vessels previously containing flammable or toxic material (radio active).</td>
</tr>
</tbody>
</table>
2.5 Types of Structural Demolition

In many cases, it is likely that a demolition project will be undertaken using a combination of these methods. There are three generic types of structural demolition indicated within the British Standard ‘Code of Practice for Demolition’ (BS 6187:2000). These are: (1) progressive demolition; (2) deliberate collapse mechanisms; and (3) deliberate removal of elements.

2.5.1 Progressive Demolition

Progressive Demolition is the controlled removal of sections of the structure, whilst retaining the stability of the remainder and avoiding the collapse of the whole or part of the structure to be demolished (BS 6187, 2000). Progressive demolition is particularly practical in confined and restricted areas and may be considered for the majority of sites. Progressive demolitions include machine and explosion demolition.

An example of explosive progressive demolition was undertaken by Controlled Demolition, Inc. (CDI) and involved the demolition of 17 buildings comprising the Villa Pan-American and Las Orquideas public housing complex in San Juan, Puerto Rico (Source from CDI website, 2007). Old Dominion Demolition Corporation (ODDC) of Norfolk, England (NFDC members) and CDI were selected as the Prime Demolition Contractor/Implosion Subcontractor Team by the Department de la Vivienda (the Puerto Rican Housing Authority). CDI’s international affiliate, CDI UK, Ltd. acted as a subcontractor for implosion preparation supervision and explosives-handling operations.

The 17 buildings were of modular construction, consisting of 42 ft x 15 ft, 1-story, pre-cast, light-weight concrete boxes, stacked in staggered formation (like bricks), and tied together via vertical post-tensioning rods through the columns. Initially, the post-tensioning rods (containing conduits and standard reinforcing bars) present in each individual column created problems for the drilling crews. The contractor (CDI)) determined that counter-drilling each column would permit the explosives charges to eliminate the concrete satisfactorily.

The 8 buildings in the Villa Pan-American Complex (built to house athletes during the 1979 Pan American games) and the 9 buildings in the adjacent Las Orquideas Complex had been built on fill material placed over a marsh area. CDI determined that during the implosion sequence, the delayed undermining of one side of each box would create rotation of that box as a unit, shearing
out the post-tensioning rods on the next column row, thus removing support from that vertical column of boxes. CDI UK Ltd., subsequently loaded 7,242 holes in supporting elements of the 17 structures. A total of 1,825 lb of explosives, 8,640 blasting caps and 37,200ft of detonating cord were used to initiate CDI’s carefully timed, non-electric detonation sequence. As predicted, CDI’s design created a progressive collapse which accelerated as it moved through the length of each structure. The buildings, up to 300ft in length in some cases, fell quickly and CDI’s preparation design resulted in superb breakage which facilitated the implementation of fast-track debris removal (as required by ODDC to meet the site clearance schedule).

2.5.2 Deliberate Collapse Mechanisms

This technique removes key structural members to cause complete collapse of the whole or part of the structure (BS 6187, 2000). Deliberate collapse is usually employed on detached, isolated, fairly level sites where the whole structure is to be demolished. The demolition by deliberate collapse includes deliberate collapse by explosives and/or deliberate collapse by wire rope pulling. The collapse is usually achieved either by removing key structural elements (e.g. with explosive charges) or by wire rope pulling at a high level to overturn the structure. The possible modes of failure must be studied to ensure that the method selected will produce the required pattern of collapse. If the operation is not successful, the remaining structure may be extremely dangerous for the completion of the demolition.

Demolition by deliberate controlled collapse is not usually appropriate for pre-stressed concrete except for simple pre-tensioned floor planks or slabs.

An example of deliberate collapse mechanisms is the now infamous World Trade Centre (WTC) tower collapse. The aircraft attack caused fire and explosion weakening the structure at first, creating a chain reaction that led to collapse of the structures (Source from www.911research.com, 2007).

2.5.3 Deliberate Removal of Elements or Deconstruction

This is the removal of selected parts of the structures by dismantling or deconstruction (BS 6187: 2000). Deconstruction involves dismantling a structure that proceeds from roof to ground in a general trend (NADC, 1996). The structures are carefully dismantled in order to maximize the recovery of valuable building resources for reuse and recycling. If instability of any of the
remainder might result in a possible risk to personnel on the site, sections of the structure should not be removed (BS6187:2000). The deconstruction can continue by hand or machine techniques (NFDC, 1997).

Floor by floor deconstruction is the dismantling of a structure on an element-by-element, floor-by-floor basis in the reverse order of construction (NFDC, 1997). It is usually undertaken using mechanical plant, which is first lifted by crane to the work level and transferred to each floor as the demolition proceeds. The plant usually uses mini-excavators or similar equipment to separate the structure into individual elements of appropriate size to be lifted off by crane (BS6187:2000).

2.6 Demolition Processes

Demolition processes can be divided into four main stages: (1) tendering stage; (2) pre-demolition stage; (3) actual demolition stage; and (4) post-demolition stage (Arham, 2003). Each stage has several processes which whilst critically important are not covered within relevant standards (refer to Fig. 2-19). The process of these four stages can be described as follows.

2.6.1 Tendering Stage

A demolition project starts when the client makes a decision to demolish a structure. The client needs to obtain an approval of the application for demolition and funding by stating its: objectives and requirements; the benefit and delivery systems; the project and feasibility studies; the project timeline; the budget; contingencies and the project financing. Then a bid invitation letter is sent to demolition contractors who are invited to submit their bids (CDM, 2007). During this stage there are two main jobs: (1) pre-tendering planning; and (2) post contract award.

1) Pre-tendering planning: in order to complete the project safely and efficiently, it is essential that demolition work of this kind be undertaken only by competent and suitably experienced contractors and personnel (BS6187:2000). It is recommended that a comprehensive health and safety plan is provided at the pre-tendering stage by the planning supervisor. This plan includes six points of the project (www.fta.dot.gov/document/construction, 2007):

- **Details of the structure to be demolished**: sufficient information (including information already available) should be provided to allow a contractor to assess suitable demolition methods (NFDC, 1997);
• *Construction drawings*: every effort should be made to obtain the original construction drawings from the client. They should include alterations, particularly those relating to the structural design and these should be checked for consistency with the structure to be demolished (HSE, 2007);

• *Details of existing services and utilities*: details of services and utilities entering the building and crossing the site should be obtained and any special requirements be identified;

• *Details of previous uses of the building and site*: where hazards have been identified, sufficient investigations should be undertaken so that the landowners can be suitably informed of the risks;

• *Details of asbestos and other hazardous material*: high risk buildings frequently contain asbestos based and/or other hazardous materials (CAR, 2006); and

• *Details of site environment*: types of nearby property, the presence of protected flora and fauna nearby, highways and transportation facilities, waterways, crime and vandalism rates should be considered and sufficient information should be provided to assist a contractor in the selection of an appropriate demolition method (NFDC, 1997).

The demolition contractor has to find out about the site and prepare the risk assessment. The knowledge of the site should be elicited by an initial desk study and followed by an on-site survey. Off-site features that can affect work on site should also be determined. A risk assessment and planning the removal or reduction of the risks must be carried out before the work commences (Management of Health and Safety at Work Regulations, 1999). The demolition engineer needs to select the demolition technique based on this risk assessment and other contributing factors such as legal constraints, insurance, technical and economical aspects (Wring, 2008). A method statement must be produced, which addresses the site’s particular needs and details the plan and demolition techniques selected by contractors (HSE, 2007).

The British government published the Waste Strategy for England 2007 (Department for Environment Food and Rural Affairs) on 24 May 2007, and the implications are that the demolition contractor must provide the project’s waste evaluation and disposal plan for any demolition project that commences after the year 2008.

When the principal contractor has been selected by the client’s representative, a tender evaluation panel should be established and in accordance with the evaluation criteria as agreed
by the Evaluation Panel (Health and Safety Guide for the Tendering Process, 2001). The following aspects of the project must be determined (Lloyd, 2006):

- Tender price/schedule of quantities;
- Compliance with specification/team/resources;
- Service provision/methodology/programme;
- Occupational health and safety; and
- Financial and commercial trading integrity.

2) Post contractor award: Under the CDM Regulations, the principal contractor will be responsible for the further development of the pre-tender stage health and safety plan. This further development must include comprehensive risk and COSHH assessments, together with detailed safety statements and programmes (CDM, 2007). In developing the health and safety plan, the following matters should also be investigated and the necessary action taken by demolition contractors (NDFC, 1997). Table 2-1 details that the tasks that the demolition contractors must undertake at this stage.

2.6.2 Pre-demolition Stage

The pre-demolition stage starts when the demolition contractor has secured the contract. The demolition contractor should set up a core management team as in Fig. 2-18 or similar. Each person in the team should undertake assigned tasks and should be integrated by the Managing Director.

At this stage, the work involved falls into four categories:

- **Documentation and notification:** the demolition contractor should obtain a section 80-82 notification from the Local Authority (LA). All properties situated on the boundary of the site and those adjacent the site must be informed of the impending demolition in writing. The contractor must also obtain service termination confirmation notices from the appropriate authorities, and write a confirmation of services to required parties (Building Act, 1984).

- **Compile a detailed health and safety plan and method statements:** make this available to all relevant parties;
### Table 2-1: Demolition Contractor Award

<table>
<thead>
<tr>
<th>Tasks</th>
<th>Activities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Asbestos and other hazardous materials</td>
<td>▪ Confirm the information given in the pre-tender stage health and safety plan, and further checks.</td>
</tr>
<tr>
<td>Structural survey and Design</td>
<td>▪ Work should be undertaken by a suitably qualified and experienced structural engineer. The survey will supplement, confirm and extend the information given in the pre-tender health and safety plan, based on direct observation, testing and examination of existing drawings.</td>
</tr>
<tr>
<td>Services and utilities</td>
<td>▪ Verification of the information given in the pre-tender stage and making sure that any live services that are to remain should be accurately located, marked and protected or diverted as necessary.</td>
</tr>
<tr>
<td>Scaffolding and protection</td>
<td>▪ Careful consideration should be given at the planning stage to the question whether scaffolding/sheeting of the structure is necessary.</td>
</tr>
<tr>
<td>Selection and use of cranes</td>
<td>▪ The required capacity of the crane and lifting gear should take into account any plant to be lifted. Also, it is important to establish the position of cranes to ensure safe working loads are not exceeded.</td>
</tr>
<tr>
<td>Environmental considerations</td>
<td>▪ The information from the pre-tender stage H&amp;S plan must be taken fully into consideration when assessing the environmental impact of the demolition operations and in determining demolition procedures.</td>
</tr>
<tr>
<td>Schedule of condition/dilapidation Survey</td>
<td>▪ In order to protect all parties’ interests, the client, with the appointed demolition contractor and relevant third parties, should carry out pre-contract and post-contract condition/dilapidation surveys of immediately adjacent properties, roads, pavements and the haul routes in conjunction with the local authority highway offices.</td>
</tr>
<tr>
<td>Protection of the public from nuisance</td>
<td>▪ It is necessary to provide protection against nuisance and damage to adjacent buildings during demolition and dismantling.</td>
</tr>
<tr>
<td>Perimeter security</td>
<td>▪ The perimeter should enclose all dismantling operations with appropriately secure entrances to prevent unauthorised entry to the site. Suitable statutory safety signs and notices should be prominently displayed.</td>
</tr>
<tr>
<td>Site security</td>
<td>▪ Prevention of vandalism to the building.</td>
</tr>
<tr>
<td>Exclusion zone</td>
<td>▪ An exclusion zone should be established around the structure.</td>
</tr>
<tr>
<td>Access and egress</td>
<td>▪ Good, safe access should always be maintained, using the existing facilities whenever possible.</td>
</tr>
<tr>
<td>Dust control</td>
<td>▪ Provisions should be made for an adequate supply of water and other appropriate measures to suppress dust arising from the procedure.</td>
</tr>
<tr>
<td>Noise control</td>
<td>▪ The noise pollution levels should be as low as possible.</td>
</tr>
<tr>
<td>Fire precautions plan</td>
<td>▪ Precautions should be taken to prevent the risk of fire and explosion caused by gas, combustible dust or vapour.</td>
</tr>
<tr>
<td>Safety method statement</td>
<td>▪ Safety method statements for all critical work should be prepared following Risk and COSHH Assessments and should fall in line with the health and safety plan.</td>
</tr>
<tr>
<td>Training</td>
<td>▪ Induction training must be given to all personnel before the commencement work on site. All demolition operatives engaged in work covered by those guidance notes should have, or be in the process of, undertaking the appropriate training: a. CITB/NFDC Certificate of competence, demolition Operatives and Supervisors; b. CITB Certificate of training Achievement–Plant Operatives; and c. S/NVQ level 2 and level 3 training.</td>
</tr>
</tbody>
</table>

*Contents adapted from NFDC, 1997*
Figure 2-18: Management Team of Demolition Contractor

(Source from Total Reclams Demolition Company, 2007)

- **Site set-up:** the work in this phase includes installation of welfare facilities, implementation of a fire plan, installation of segregation/signing of internal traffic routes and access/egress points, erection of site fencing; designation of overnight secure zones for machine and site parking; and

- **Decommissioning:** all hazardous materials are removed, wherever possible, at the initial stage of the project to prevent additional exposure/double handling and enable safe, uninterrupted execution of the soft-strip and demolition stages of the process.

### 2.6.3 Actual Demolition Stage

An appropriate demolition technique is selected by the contractor at the tendering stage. Following confirmation that all safety issues have been addressed and all operatives are aware of specific hazards, the following work will commence:

- **Soft stripping:** which involves removal of non-structural items such as fixtures and fittings, windows, doors, frames, suspended ceilings and partitions;

- **Structural demolition:** this is in a pre-determined sequence by hand or working/mechanical means; and

- **Reuse and recycling:** Some of the products eliminating from the soft stripping process can be reused and recycled.
The reuse and recycling can be completed after or concurrently with the structural demolition process (Reuse and recycling guide, 2008). This process can maximise the use of resalable materials and subsequently reducing waste disposal costs. Typical recycled materials were metals and concrete debris. Concrete debris is pulverised and can be used as fill material and sub-base (NADC, 1996).

Environmental monitoring will be carried out throughout the duration of the demolition works (HSE, 2005). The site supervisor will carry out monitoring on a continual basis with regards to noise, dust, disturbance, etc. Procedures, such as damping down and loading to ensure minimisation of noise, dust, disturbance, etc. to surrounding areas will ensure that pollution is minimised.

2.6.4 Post-demolition Stage

It is the client’s responsibility to ensure that the contractor leaves the site in a clean, safe and secure condition (CDM, 2007). All contaminants must be left or removed in a condition such that they represent no hazard to health or the environment (Environment Act, 2005). 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 (HSE, 2005). The overall demolition process can be summarised in two flowcharts (Refer to Fig. 2-19 and Fig. 2-20).

**Figure 2-19: Demolition Process**

(Source from Arham, 2003)
Figure 2-20: Demolition Process Flowchart

(Source from Li, 1995)

2.7 Statements on the Current Demolition Industry in the UK

From the demolition knowledge acquisition process carried out in the literature review it was determined that there is a limited amount of published research in the field, particularly, relating to the present state of the demolition industry. However, the work of Arham (2003) carried out an important ‘positional’ survey that has particular relevance to this research. Arham’s survey respondents were experienced demolition contractors who had mostly worked in the UK demolition sector for over 20 years (54% were demolition Company Directors, 34% were Managers, and 12% were Site Agents and Safety Officers). Given this particular relevance, this section summarises general findings on projects undertaken by the UK demolition industry from Arham’s survey.
2.7.1 Types of Structures Demolished in the Past 5 Years

Amongst other things, the results of the survey showed that types of structure demolished in past five years. Fig. 2-21 shows that 41.6% of all demolition projects were carried out on buildings, which made them the most common type of structure to be demolished. 15.9% involved bridges, 12.4% were independent chimneys and 11.2% involved basements and retaining walls.

**Figure 2-21:** Types of Structures Demolished in the Past 5 Years

![Chart showing types of structures demolished in the past 5 years](image)

2.7.2 Demolition Techniques Used for Each Type of Structure

Arham’s (2003) survey shows that demolition by hand was the most frequently used technique to demolish all structures apart from dams. The work also revealed that demolition by machines and chemical agents were used for all structures, and high pressure water jetting was used only to fell bridges, independent chimneys, basements and retaining walls, masonry and brick arches, vessels and tunnels. The results indicated that a combination of demolition techniques was used by respondents on all types of structures. Fig. 2-22 illustrates the various types of demolition methods used for the various types of structures.
2.7.3 The Selection Procedures for Demolition Methods

The survey also shows that guidance on selection of demolition techniques is also limited. Figure 2-23 shows that BS 6187:2000 and guidance supplied by the NFDC and IDE are predominantly used to select pertinent demolition methods.

Figure 2-22: Demolition Methods Used in Each Type of Structure

Figure 2-23: Guidance on Selection of Demolition Techniques

Figure 2-24: Decision Makers on Demolition Techniques
The demolition engineer is responsible for deciding which demolition method should be chosen for the project. Significantly 78.3% (Arham’s survey result) of all demolition method selections are based purely on the experience of the demolition engineer (Arham, 2003). Figure 2-24 indicated that decision makers involved in choosing the demolition methods to be employed is wide and varied albeit, the demolition engineer predominates. There are a few occasions where the choice of the demolition method is done by a combination of quantitative, quantitative analysis and experience. Fig. 2-25 illustrates that the efficiency of current procedures used by the respondents in selecting demolition techniques is questionable, with 47% of respondents selecting these two categories of ‘poor’ or ‘very poor’.

**Figure 2-25: Efficiency of Current Procedures**

**2.7.4 The Problems with Undertaking Demolition Work**

Using a variety of sources (interviews conducted with industry experts; review of literature from NFDC yearbooks and IDE magazines; internet search; and attendance at IDE seminars), the research identified frequent problems faced by demolition engineers in carrying out demolition work. These may be summarised as follows:

1. *The identification of risk:* such as site or structured contaminants, the history of the structure and its services;
2. *The health and safety issues:* ensuring that the demolition work can be carried out safely;
3. *Co-ordination and planning of numerous activities:* resources, information, time and cost constraints;
4. *The relationships between the contractor, sub-contractor and the client:* clients tend to provide incomplete information at the tendering stage. Working with clients who are only interested in the completion of the project can be tricky. It can be difficult persuading clients that the demolition method selected is the correct one. A careful balance between contractor profit one hand, and client cost on the other must be established;

5. *Selecting demolition methods and procedures:* whilst information on individual methods is available, guidance on how to develop an overarching strategy is largely based upon the experience of the demolition engineer; and

6. *Knowledge management:* use of ICT in demolition is limited to producing reports, accessing the Internet, compiling databases and running software programs (often in isolation to other programs used).

### 2.7.5 Potential Improvements to the Demolition Process

Overall, the demolition sector is a professional, highly skilled industry, with vast experience and expertise. But the management of information and efficiency of current procedures leaves much to be desired. The industry has changed over the last 25 years (Wring, 2008), as a result of demand for higher skilled operatives and technical advances. However, demolition is not a licensed industry, unlike asbestos removal, thus the industry needs to develop its own policies and to manage the project success with better plans and operations.

The demolition concept is simple (i.e. to knock structures down). But demolition contractors are fully aware of the complexities of the process, which must take into consideration a plethora of factors. Any development of the demolition industry has been mainly focus along the line of technical improvement rather than project management. Guidance from BS6187:2000, NFDC, IDE and the contractors either deals with the minutia of techniques or conversely provides broadly generic guidance on procedure.

Pilot works, which included a semi-structured interview and e-mail survey conducted for this research, determined that many within the demolition industry believe that the following could be implemented to improve the processes used in demolition work:

- Share information or knowledge between parties involved in the demolition process;
Keep far more comprehensive records so that other engineers can learn from experiences of previous projects;
Implement better planning and site management;
Conduct continual revision of construction techniques which are then related to demolition techniques;
Minimise interfacing problems between sub-contractors and ensuring that there are no overlaps during the operation;
Thoroughly collecting of detailed information on the structure of the building being demolished at the tendering stage, from the clients, and through a robust structural survey;
Training and education, e.g. HSE needs to educate clients about their responsibilities with regard to Construction Design and Management (CDM) Regulations;
Conduct intensive research on new demolition techniques and process re-engineering and management; and
Raise awareness on environmental considerations: recycling and reusing demolition debris, waste management.

Hence, consideration of re-engineering the demolition processes in an attempt to unify and structure process management system is clearly necessary.

2.8 Chapter Summary

This chapter has conducted an extensive literature review demolition works within the UK. It comprised of (1) a review of the development history of the demolition industry; (2) an outline of demolition techniques; (3) a description of the demolition processes currently used by the UK industry; and (4) characteristics of current demolition processes. This led to some constructive commentary on ways with which the demolition process can be better managed. It also indicated the necessity of better demolition process management for the industry. Therefore, the literature review confirmed that a management system to support the management of dynamic demolition processes would be of use and value to the sector. Such a system would give a clear and unambiguous route to safely managing all demolition works whilst maintaining professionalism and profitability.
3 Research Methodology

3.1 Introduction

The preceding chapters presented a background to the study, defined this research topic and annotated the findings of relevant literature related to factors which may influence demolition processes and management of these within the UK demolition industry. This culmination of work revealed that this research focuses on providing a better approach to improving demolition processes and its management within industry.

With the aforementioned in mind, this chapter offered a theoretical underpinning for how this research was designed and planned in order to accomplish its goals. The first section focuses on understanding the concepts of research and research methodology in social research. Then the importance of research methodology and an explanation of the relationships between theory, research methodology and research methods are discussed. The work then goes on to explain the specific methodology that was designed and utilised for this research work. Methods adopted are elaborated upon within the context of the overarching methodology and a method of validation briefly discussed.

3.2 Research, Research Methodology and Research Process

3.2.1 Conceptions and Classifications of Research

The Oxford Compact English Dictionary defines research as being:

“The systematic investigation into and study of materials, and sources, in order to establish facts and reach new conclusions.” (OCED, 1996)

Whereas the Oxford Dictionary (1989) proffers:

“A search or investigation directed to the discovery of some fact by careful consideration or study of a subject.”

Research can also be “an art aided by skills of inquiry, experimental design, data collection, measurement and analysis, by interpretation and by presentation.” (Greenfield, 2001).
According to these definitions of research, three major ingredients in social research are: (1) the construction of theory; (2) the collection of data; and (3) the analysis of data (Gilbert, 2008). In research, the theory constructs by induction or deduction from data available. The theory can be concluded using the research data intertwined by both induction and deduction. This is explained in Fig. 3-1.

Figure 3-1: Three Ingredients and Relationships in Research

![Diagram showing the relationships between theory, data, and explanation in the research world.]

(Source form Gilbert, 2008)

From the researcher’s point of view, research can be classified into two categories which are called pure and applied research (Kunar, 1999). Pure research is for seeking of curiosity and functions to advanced knowledge its own sake. Applied research is used for technological advancements where it is anticipated, that the results found will lead to the development of commercially viable goods or processes (Trochim, 2006). Table 3-1 describes the main difference between those two types of research.

Table 3-1: Pure and Applied Research

<table>
<thead>
<tr>
<th>Research type</th>
<th>Undertaken to</th>
<th>End User</th>
</tr>
</thead>
</table>
| Pure research      | • Develop knowledge.  
                     | • Contribute to/discovering theories. 
                     | • Discover laws of nature. 
                     | • Search for the truth. | Academics          |
| Applied research   | • Develop a practical application. 
                     | • Help solve a practical problem. 
                     | • Use scientific knowledge to determine ‘whether works’ | Practitioners 
                     |                      | Industrialists       |

(Source from Fellows and Liu, 2003)
Research can also be classified as either qualitative or quantitative. The research technique adopted depends upon different philosophical assumptions and research methods (Creswell, 2003).

Quantitative research is an inquiry into an identified problem, which is based on testing a theory composed of variables, measured with numbers and analyzed using statistical techniques (Neuman, 2000). Quantitative research also tends to measure how much or how often, and it uses a variety of research methods to provide an objective description and/or causal explanations about social phenomena or processes (Creswell, 1994). Methods of data collection in quantitative research include: surveys (questionnaires), structured interviewing, structured observation, secondary analysis, official statistics, content analysis according to a coding system, quasi-experiments and classic experiments (Whitten et al., 2004).

According to Cresswell (1994) a qualitative study is defined as an inquiry process of understanding a social or human problem, based on building a complex, holistic picture, formed with words, reporting detailed views of participants and is conducted in a natural setting. Denzin and Lincoln (1994) stated that qualitative research is multi-method in focus, involving an interpretive, naturalistic approach to its subject matter. This means that qualitative researchers study things in their natural settings, attempting to make sense of, or interpret phenomena in terms of the meanings people bring to them. Qualitative research involves the use and collection of a variety of empirical materials including case studies, personal experiences, introspective views, life story interviews, observational studies, historical studies, interactional and visual texts that describe routine and problematic moments and meaning in individuals' lives (Denzin and Lincoln, 2003).

In general, quantitative methods usually produce findings that can be summarized in numbers; qualitative methods produce results that are commonly summarized in words or pictures (Lincoln, 1994). Quantitative methods tend to provide less in-depth information about many people; qualitative methods give more detailed information about relatively few people (Neuman, 2000). The distinctions between quantitative and qualitative research can be summarized in Tables 3-2 and 3-3. Table 3-2 shows a summary of the comparison between quantitative and qualitative research methods adapted from (Amaratunga et al., 2002). Table 3-3 compares the characteristics of quantitative and qualitative research to explain the role that the researcher plays in those two types of research approach.
### Table 3-2: Comparison of Quantitative and Qualitative Research

<table>
<thead>
<tr>
<th></th>
<th>Quantitative Research</th>
<th>Qualitative Research</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Type of reasoning</strong></td>
<td>• Objective; and</td>
<td>• Subjective; and</td>
</tr>
<tr>
<td></td>
<td>• Inquiry from the outside.</td>
<td>• Inquiry from the inside.</td>
</tr>
<tr>
<td><strong>Type of questions</strong></td>
<td>• Pre-specified; and</td>
<td>• Open ended; and</td>
</tr>
<tr>
<td></td>
<td>• Outcome oriented.</td>
<td>• Process oriented.</td>
</tr>
<tr>
<td><strong>Sampling</strong></td>
<td>• Large.</td>
<td>• Small.</td>
</tr>
<tr>
<td><strong>Data collection</strong></td>
<td>• Numerical estimation.</td>
<td>• Structured, semi-structured or unstructured interview.</td>
</tr>
<tr>
<td><strong>Data Analysis</strong></td>
<td>• Statistical inference.</td>
<td>• Narrative description; and</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Constant comparison.</td>
</tr>
<tr>
<td><strong>Outcome/Finding</strong></td>
<td>• Conclusive; and</td>
<td>• Not conclusive; and</td>
</tr>
<tr>
<td></td>
<td>• Can be generalized.</td>
<td>• Cannot be generalized.</td>
</tr>
<tr>
<td><strong>Strengths</strong></td>
<td>• Provide wide coverage of the range of situations;</td>
<td>• Data gathering methods seen more as natural than artificial;</td>
</tr>
<tr>
<td></td>
<td>• Fast and economical; and</td>
<td>• Ability to look at change over time;</td>
</tr>
<tr>
<td></td>
<td>• Where statistics are aggregated from large samples, they may be considerable relevance to policy decisions.</td>
<td>• Ability to understand people’s meaning;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Ability to adjust to new issues and ideas as they emerge;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Contribute to theory generation.</td>
</tr>
<tr>
<td><strong>Weakness</strong></td>
<td>• Tend to be rather inflexible and artificial;</td>
<td>• Data collection can be tedious and require more resources;</td>
</tr>
<tr>
<td></td>
<td>• Not very effective in understanding process; and</td>
<td>• Analysis and interpretation of data may be more difficult; and</td>
</tr>
<tr>
<td></td>
<td>• Not very helpful in generating theories.</td>
<td>• Harder to control the pace, progress and end-points of research process.</td>
</tr>
</tbody>
</table>

*(Source from Amaratunga et al., 2002)*

### Table 3-3: Characteristics of Quantitative and Qualitative Research

<table>
<thead>
<tr>
<th></th>
<th>Research</th>
<th>Researcher</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Quantitative</strong></td>
<td>• Based on the assumption that social facts have an objective reality;</td>
<td>• Basis for advancing research questions and hypothesis;</td>
</tr>
<tr>
<td></td>
<td>• Uses standardised measures so that the collection of data can fitted into a limited number of predetermined response categories to which numbers are assigned; and</td>
<td>• Creates variables that are open to statistical analysis; and</td>
</tr>
<tr>
<td></td>
<td>• Involves experiments with variables and treatments (e.g. factorial designs and repeated measure design).</td>
<td>• Draws upon quantitative data and use literature deductively as use mathematical models, statistical tables and graphs.</td>
</tr>
<tr>
<td><strong>Qualitative</strong></td>
<td>• Takes place in the natural world;</td>
<td>• Views social world holistically;</td>
</tr>
<tr>
<td></td>
<td>• Draws on multiple methods that are interactive and humanistic;</td>
<td>• Engages in systematic reflection of their own roles in the research;</td>
</tr>
<tr>
<td></td>
<td>• It is emergent and evolving rather than tightly prefigured; and</td>
<td>• It is sensitive to personal biography and how it shapes the study; and</td>
</tr>
<tr>
<td></td>
<td>• It is fundamental.</td>
<td>• Uses complex reasoning that is multi-faced and iterative.</td>
</tr>
</tbody>
</table>

*(Source from Creswell, 2003; Marshall and Rossman, 1999; and Patton, 2002)*
According to the aforementioned theory study, this research has applied research mainly of a qualitative nature. This allowed the research to be conducted in accordance with industry practice and to the better management of demolition process.

### 3.2.2 Definition of Research Methodology

According to Crotty (2005), the methodology is “the strategy or plan of action: a processor design lying behind the choice and use of particular methods and linking the choice and use of methods to the desired outcomes”. Research methodology was defined by Mingers (2001) as: “structured set of guidelines or activities to assist in generating valid and reliable research results”. And by Robson (2002) as: “fundamental principles on which the methods of social research are based”. Methodologies used in social research have evolved to continue the interchange of ideas and information, which made it possible to establish common accepted rules and procedures, and to develop corresponding methods and techniques (Morris, 1962).

A scientific methodology is a “system of explicit rules and procedures upon which research is based and against which claims for knowledge are evaluated” (Cotty, 2005). It provides rules for communication, rules for reasoning and rules for inter-subjectivity (Frankfort-Nachmias and Nachmias, 2003). These can be explained as follows:

- **Rules for communication:** a major function of any methodology is to facilitate communication between researchers to other people who either have shared or share a common experience (Rapoport, 1969). In other words making the explicit, public, and following accessible rules to let people understand that the explanation and perdition by the research is accurate and the testing procedure is valid.

- **Rules for reasoning:** logic is the system or instance of reasoning and is crucial to the scientific approach. Logical procedures take the form of closely interdependent series of propositions that support each other. The elements of logic contains the rules of definition, classification, forms of deductive and inductive inferences, theories of probability, sampling procedures, system calculus and rules of measurement (Barker, 1988). Scientific methodology explains the accepted criteria for empirical objectivity, methods and techniques for validation. So an individual scientist cannot claim objectivity until other scientists have verified the findings.
• **Rules for inter-subjectivity:** the term inter-subjectivity is more appropriate than objectivity to describe the process. To be inter-subjective, knowledge in general, and the scientific methodology in particular, has to be communicable. So if one scientist conducts an investigation, another scientist can replicate it and compare the two sets of findings. Inter-subjectivity understands and evaluates the methods of others and to conduct similar observations so as to validate empirical facts and conclusions (Kaplan, 1968).

### 3.2.3 Research Process

Yin (2003) has described the research process as the overall scheme of activities in which scientists engage in order to produce knowledge and this is the paradigm of scientific inquiry. There are two criteria, which are scientific knowledge grounded in both reason and experience or observation; and logical and empirical validation to evaluate claims of expertise that are translated into the research activities through the research process (Frankfort-Nachmias, 2003). Anyone undertaking research should develop a research proposal with the purpose of developing fundamental research questions. The research process starts with a problem and ends with a tentative empirical generalization. This cyclic process continues indefinitely reflecting the progress of a scientific discipline; the ending of one cycle is the beginning of the next.

Fig. 3-2 illustrates main stages of this cyclical research process, which are: (1) problem; (2) hypothesis; (3) research design; (4) measurement; (5) data collection; (6) data analysis; and (7) generalization.

**Figure 3-2:** The Main Stages of the Research Process
This research started by defining the research topic, which evolved in direction, to recognise a need to achieve better management of the demolition process. In the design stage, the research set out a strategy and planned research procedures taking account of both ‘applicability to industry’ and technical aspects. Verification was achieved by pilot work using industry expert interviews to prove that the research was feasible. The ‘actual research’ started with collection of information and data from the UK demolition industry, followed by data analysis. In the final stages, the Demolish-IT prototype was developed and validated.

### 3.3 Methods of Research Design

#### 3.3.1 Fundamental Concepts of Research Design

Frankfort-Nachmias (2003) has explained that the research design is “the blueprint that enables the investigator to come up with solutions to these problems and guides him or her in various stages of research.” It is understood that research design is a process to generate the research questions, research strategies and research methods at the beginning of the research.

McNeill (1990) also explained that research design is concerned with turning research questions into projects. This means research design is an action plan for translating an initial set of questions to some set of conclusions (Robson, 2002). The general principal of research design should make sure that research strategies and methods or techniques employed must be appropriate for the questions posed. Fig. 3-3 provides a framework for a simple and logical structure for research design.

**Figure 3-3: Framework for Research Design**

(Source from Yin, 2003)
Chapter 3 Research methodology

A good research design possesses high compatibility among purposes, theory, research questions, methods and sampling strategy (Robson, 2002). If the research questions are not directly relevant to the purposes of the study, then the research question should change. If the research questions do not link to theory, it is unlikely that research will produce answers of value. If the methods and/or the sampling strategy do not provide answers to the research questions, then a change of the procedure should be conducted also. The purpose, theory, research questions, methods and sampling strategy are called the components of research design. Table 3-4 illustrates the fundamental components of research design and their requirements.

Table 3-4: The Components of Research Design

<table>
<thead>
<tr>
<th>Components</th>
<th>Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>Purpose(s)</td>
<td>• What is this study trying to achieve?</td>
</tr>
<tr>
<td></td>
<td>• Why is it being done?</td>
</tr>
<tr>
<td></td>
<td>• Are you seeking to describe, explain or understand something?</td>
</tr>
<tr>
<td></td>
<td>• Are you trying to assess the effectiveness of something?</td>
</tr>
<tr>
<td></td>
<td>• Is it hoped that something will change as result of the study?</td>
</tr>
<tr>
<td></td>
<td>• Is it in response to some problem or issue for which solution are sought?</td>
</tr>
<tr>
<td>Theory</td>
<td>• What theory will guide or inform your study?</td>
</tr>
<tr>
<td></td>
<td>• How will you understand the findings?</td>
</tr>
<tr>
<td></td>
<td>• What conceptual framework links the phenomena you are studying?</td>
</tr>
<tr>
<td>Research questions</td>
<td>• To what questions is the research geared to providing answers?</td>
</tr>
<tr>
<td></td>
<td>• What do you need to know to achieve the purpose(s) of the study?</td>
</tr>
<tr>
<td></td>
<td>• What is feasible to ask given the time and resources that you have available?</td>
</tr>
<tr>
<td>Methods</td>
<td>• What specific techniques will you use to collect data?</td>
</tr>
<tr>
<td></td>
<td>• How will the data be analysed?</td>
</tr>
<tr>
<td></td>
<td>• How can you show that the data is trustworthy?</td>
</tr>
<tr>
<td>Sampling strategy</td>
<td>• From whom will you seek data? Where and when?</td>
</tr>
<tr>
<td></td>
<td>• How do you balance the need to be selective with the need to collect all the data required?</td>
</tr>
</tbody>
</table>

(Source from McNeill, 1990)

3.3.2 Classification of Research Design

There are broadly three types of research design: (1) experiments; (2) social surveys; and (3) field research (Blaikie, 2000). Various major texts on research design provide an indication of the range of research design types available (Table 3-5). This research has adopted several research designs, these include case study, content analysis, observation, evaluation and action research.

There are three strategies for research design which are called: (1) fixed design; (2) flexible design; and (3) multiple designs.
Table 3-5: Classification of Research Design

<table>
<thead>
<tr>
<th>Type of research design</th>
<th>Sources</th>
</tr>
</thead>
<tbody>
<tr>
<td>Experiment and survey</td>
<td>Campbell and Stanley, (1963); Gold, (1958).</td>
</tr>
<tr>
<td>Case study</td>
<td>Babbie, (1990); Fowler, (1993).</td>
</tr>
</tbody>
</table>

Fixed design is an approach where the design of the study is fixed before the main stage of data collection takes place (Robson, 2002). Fixed design has several features, such as a preceding exploratory phase and it should always be piloted to test out the feasibility of what it being proposed. In addition, the central part of data analysis should be thought through in advance.

As Brewer and Hunter (1989) stated: ‘once a study is published, it is in many ways irrelevant whether the research problem prompted the study or instead emerged from it’. Notably, flexible design refrains from engaging with existing theory until the end of their project. Engagement with existing theory is an integral and ongoing part of the iterative research process (Hammersley and Atkinson, 1995).

Multiple research design (or mixed research design) is the use of two methods in a single research project (or research programme). Bryman (2004 and 2006), Creswell (2003), Tashakkori and Teddlie (1998 and 2003) reserved the term of mixed design methods for those projects that bring together qualitative and quantitative methods. Multiple researches can facilitate a deeper understanding about the topic studied, because multiple methods have been used to increase the accuracy of research findings and the level of confidence in research (Kelle, 2001). Also multiple researches generate new knowledge through a synthesis of findings from different approaches (Foss and Ellefson, 2002). Because of these reported benefits, a multiple research design was utilised as part of this research work.
Figure 3-4: Process and the Contents of Research Design

<table>
<thead>
<tr>
<th>Process</th>
<th>Contents</th>
</tr>
</thead>
<tbody>
<tr>
<td>Title</td>
<td>✓ It should have a clear statement of the topic at the beginning of the research design process. The title of the research project needs to be both concise and informative. It should capture the essence of what the project will be about and where and with whom it will be conducted.</td>
</tr>
</tbody>
</table>
| Aims                         | ✓ To state what the research is designed to achieve; what it is intended to contribute to the state of knowledge in a discipline(s), to some group, organization or community, or society as a whole. To be achieved in one or more of the following:  
  - The development of a particular area of theory or methodology;  
  - The collection or accumulation of a new body of information or data;  
  - The development of research methods or techniques;  
  - Knowledge about or understanding of an issue or problem; and/or  
  - Policy and practice in a particular area. |
| Research questions and objectives | ✓ Research questions constitute the most important element of any research design. Decisions about all other aspects of the research design are contingent on their contribution to answering the research questions. Research questions need to be clear and concise, such as ‘what’ questions seek description; ‘why’ questions seek explanation or understanding and ‘how’ questions are concerned with interventions to bring about change. |
| Review the literature        | ✓ A literature review is a major function that links the proposed research with the current state of relevant knowledge and provides the background and justification for the research. |
| Research strategy            | ✓ Research strategy provides a logic, or a set of procedures, for answering research questions. There are four research strategies, namely induction, deduction, inductive and abductive (Blakie, 2000). The induction research strategy starts with the collection of data and then proceeds to derive generalizations using so-called inductive logic; the deductive research strategy begins with some regularity that has been discovered which begs an explanation; the inductive research strategy also begins with an observed regularity but seeks a different type of explanation; the abductive research strategy grossly underestimates the complexity of the task involved. To choose a research strategy or a combination of them constitutes the second most important research design decision. Knowledge in social sciences can be advanced by using one or more of these strategies (Blakie, 1993). |
| Concept, theory, hypotheses  | ✓ Social research uses technical concepts specific to the discipline. Theory is a specific concept of general theoretical ideas or specific hypotheses. Hypotheses are tentative answers to research questions. Testing the theory and research question involves seeing if the associated variables have the same relationship as that predicted in the hypotheses. |
| and models                   |                                                                                                                                            |
| Data sources, types and forms| ✓ It is desirable to give consideration to these issues at the research stage so as to ensure that the methods for collecting and analysing data are selected appropriately, and that appropriate technology is available. It should consider which data will be collected and recognize the differences between them in terms of the nature of the data that can be produced. Data can be collected from natural, semi-natural, artificial and social artefact sources. Consideration must also be given to the format(s) in which data will be collected and analysed, such as quantitative and qualitative data. |
| Selection of data sources    | ✓ Data reduction and analysis; the specification and justification of the method to be used to reduce and analyse the data is the final core element of a research design. Transforming the qualitative data to quantitative data by numerical coding or re-coding existing numerical data into different categories. Meanwhile, to make sure that the data is organised in such a way that it can be transferred into an appropriate database for manipulation by computer. A variety of data analysis methods need to be used, depending on the type of research questions, objectives or hypotheses being explored. |
| Problems and limitation      | ✓ It is important to stand back and evaluate the research proposal and for the researcher to make an explicit assessment of particular strengths and weaknesses of the research design. |

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For a research design to succeed, several processes need to be considered (Fig. 3-4) and these consist of: (1) core elements; (2) choices; and (3) contexts (Blaikie, 2000). Fig. 3-5 presents these three components and provides a step by step elaboration of relationships that exist between them.

**Figure 3-5:** Elements, Choices, Contexts and Relationships in a Social Research Design (Adapted from Blaikie, 2000)
3.4 The Research Methodology

Having reviewed the literature pertaining to the demolition industry and research methodologies from previous studies, a suitable methodology for developing Demolish-IT was decided upon and this is discussed in detail, within this section. A research plan that was developed and applied for this work is presented in Fig. 3-6 whilst the approaches adopted to achieve objectives set, are illustrated in Fig. 3-7. The research work commenced with defining the research aim and objectives, then designing the research methodology (and methods within) to achieve the goal, as a prelude to presenting research findings and validation.

Figure 3-6: The Project Development Plan
Fig. 3-7 can be detailed as follows:

1. Defining the focus:
The research investigated demolition process management through the use of intensive literature reviews, expert interviews and demolition project document reviews. It sought to understand the demolition process and process management currently used by the UK demolition industry literary. Sources included magazines, academic papers and organisations’ websites. The studies undertaken involved the site observation, interviews with demolition engineers and synthesis of related demolition documents.

2. Developing the questions and methodology:
Having defined the focus of the work, the knowledge and experience of academics and practitioners were distilled into developing appropriate research questions. These included:

- Understanding the knowledge of demolition process and process management by: (1) widening the experience base; (2) using techniques to enhance creativity; and (3) thinking in terms of the purposes of the research.
- Choosing a research strategy: this research used a mixed design strategy to: (1) pilot works to confirm the research feasibility; (2) select samples of demolition contractors and demolition projects from the UK demolition industry; (3) allocate samples into different research stages and methods for mapping the demolition process and development of the management system; and (4) study the samples of project documents and site observations.
• Selecting methods: sought to determine appropriate strategies for: (1) site participant observation; (2) interviewing; (3) questionnaire survey; (4) standardized tests or real project tests; (5) sampling; and (6) validation methods.

• Arranging the practicalities: in order to accomplish the research tasks, several activities were undertaken. These were: (1) getting well prepared, and knowing exactly what research do before starting the information collection, and whether to use surveys, interviews, literature reviews, etc; (2) discussing access to demolition experts and engineers; (3) filing findings in a systematic and organized way; (4) piloting the work; and (5) working on the relationships with demolition engineers and IDE.

3. Emerging IT
It was clear that the research focused on demolition process mapping and process management, and provides intelligent support to the demolition industry. Therefore the literature review on IT tools available to the management of construction industry, especially on process management was carried out at this stage of the research. These involved two tasks: (1) understanding IT tools available and the advantages of using them in process management; and (2) choosing the right IT tools for this research.

4. Demolition process mapping
For the management of a complex demolition process, this research sought to deliver to industry and the engineer working within it, a clear picture of demolition processes. A process map can fulfil this propose. During this stage, the research studied the existing knowledge on process maps and currently used demolition processes in the UK industry. A multiple case study was conducted to generate the best practice demolition process map, and then a generic demolition process map was created using the Data Flow Diagrams (DFD) technique. This is because the DFDs’ four components exactly described the demolition process workflow; any parties involved at any stage during the processes; and any constraints and / or legal documents required at any level of a process. It also gave a clear picture and awareness of the process inputs and outputs from one process to another process. Therefore, the research applied DFD the method to demolition process mapping principally for these reasons.

5. Database for the requirements
To successfully accomplish a demolition project demands many physical requirements. It is necessary to understand where these requirements are applied during the processes.
Consequently, this research studied: (1) mandatory requirements of a demolition project; and (2) where and when they are applied to the demolition process. The research then utilised findings emanating from this work to create a database to store such in a structured format.

6. Prototype of Demolish-IT
Based on a previous study, where the research created the generic process map and generated a database store for the requirements, this research focuses on a management system design. Demolish-IT provides an intelligent management support system to the industry. Therefore, although the research is scientifically robust, there was a deliberate effort to produce a very practical product that could demonstrate impact and value.

7. Validation
The validation was carried out to prove that the research results are accurate and useful for the industry. A series of investigations were applied to the validation, such as interviews, workshops and real case testing.

3.5 Methods Adopted for the Research

The following section explains the important issues pertaining to the research methods adopted within this thesis. This section also sought to clarify how theory should be incorporated to in the research process and at what stage in the research it should be employed.

3.5.1 Literature Review

Literature reviews are used to provide background for the research and generate context and ideas for the work (Cooper, 1984). The main focus of a literature review is on planning an appropriate information search and in so doing, providing a thorough review of the subject area. A good literature review helps to frame and strengthen the research question as well as help to hone the research and analytical skills (Gilbert, 2008).

According to Greenfield (2001), there are several good reasons for spending time on a thorough literature review from a researcher’s viewpoint; these are:

- To gain knowledge about the subject.
- To find out where there are gaps in knowledge and be able to fill the gaps.
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- To gain feedback information in order to rethink and focus the research topic.
- To find out whether there are related or parallel literatures, information or methods from one area that could help another.
- To discover how others have researched the chosen topic area. By looking at literature and other sources to explore methods, research questions data availability and analysis as well as results.
- To justify how and why the research is undertaken.
- To have a body of information to compare with the research findings.

The literature review adopted as part of this research was conducted in the areas shown in Table 3-6.

**Table 3-6: Areas of Literature Review**

<table>
<thead>
<tr>
<th>Literature Review Structure</th>
<th>Literature Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Descriptions:</td>
<td></td>
</tr>
<tr>
<td>- What are demolition and the demolition process?</td>
<td>Books, journal articles, thesis, magazine</td>
</tr>
<tr>
<td>- What characteristics do demolition and the demolition process have?</td>
<td>organisations’ reports, project documents.</td>
</tr>
<tr>
<td>- How industries manage a demolition project?</td>
<td></td>
</tr>
<tr>
<td>Statistic/evidence:</td>
<td></td>
</tr>
<tr>
<td>- How is current demolition operations managed? Any problems in the operation process?</td>
<td>Reports and new articles</td>
</tr>
<tr>
<td>- Where is the evidence that demolition process mapping and management system are a topic worthy of research?</td>
<td></td>
</tr>
<tr>
<td>Theory:</td>
<td></td>
</tr>
<tr>
<td>- What are the main theories of process mapping and information systems design?</td>
<td>Books, journal, research reports.</td>
</tr>
<tr>
<td>- How to use the aforementioned demolition process mapping and customer built-in information system to design the prototype of Demolish-IT?</td>
<td></td>
</tr>
<tr>
<td>Methods:</td>
<td></td>
</tr>
<tr>
<td>- Are there special methods needed for the study?</td>
<td>Previous research articles and reports.</td>
</tr>
<tr>
<td>- How have people studied this topic before? Is there a need to explore a new or improved approach?</td>
<td></td>
</tr>
</tbody>
</table>

**3.5.1.1 Defining the Research Topic and Research Questions**

A research topic must fulfil the requirements of at least six quintessentially important properties (Cooper, 1984) that are listed in Table 3-7.

Several tasks were carried out during reviews of the demolition process and demolition industry and the following four subject areas were investigated.
Chapter 3 Research methodology

1) Demolition techniques currently in use.
2) The demolition industry and characteristics of the demolition processes.
3) Client requirements and site restrictions.
4) The potential application of demolition process management systems.

Table 3-7: Six Properties on the Research Topic

<table>
<thead>
<tr>
<th>Property of research topic</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interesting</td>
<td>✓ The research question should interest the researcher who needs the motivation and enthusiasm throughout the duration of the project.</td>
</tr>
<tr>
<td>Relevant</td>
<td>✓ It should also be interesting and relevant for the research industry of which the research forms a part. Research is generally of interest to a research community when it makes a contribution to the collective knowledge base of a study area or discipline. So formulating a question to which the answers are likely to be significant, novel or original is most relevant for other research in the area. The orientation, according to William (2006), is to “find a question, an unresolved controversy, a gap in knowledge or an unreported need within the chosen subject.”</td>
</tr>
<tr>
<td>Feasible</td>
<td>✓ The project must be feasible and have specific boundaries that make the project reliable within the timeframe, resources and cost.</td>
</tr>
<tr>
<td>Ethical</td>
<td>✓ To ensure that the research project fulfils its ethical obligations, both professionally and institutionally.</td>
</tr>
<tr>
<td>Concise</td>
<td>✓ Questions should be well articulated, its terms clearly defined, with as much precision as possible in written language.</td>
</tr>
<tr>
<td>Answerable</td>
<td>✓ Ensure the topic and questions can be solved and the research result should be the answer of the research question.</td>
</tr>
</tbody>
</table>

(Adapted from Cooper, 1984)

3.5.1.2 Identifying Sources of Information

Having identified the literature to be reviewed, information from various sources were accessed and included university libraries, Online Public Access Catalogues (OPAC), databases and search engines. OPAC is a free library catalogue which provides a facility to search for key words, book titles, and author’s name. There are also a number of databases that contain bibliographic records of wider social science literature. Key text searches on the International Bibliography for the Social Sciences (IBSS) and Social Science Citation Index (ISI) to gather further material for the research review was also undertaken. Once core reading materials had been identified and found search engines (such as Google, Yahoo, etc.) were then used to follow-up elements of the literature review that required additional elucidation.
Specialist publications on demolition were obtained from the IDE, the NFDC, the EDA and the NADC. Additional documents for existing demolition projects were collected from demolition companies, such as Total Reclaim Demolition Company, Armac Demolition, etc.

3.5.1.3 Reviewing the Theory behind Process Mapping

This research topic aimed to improve demolition process management based on the overall demolition operation processes. Although this topic is not new for construction management science, it is entirely new within the specialist demolition industry. Research on better planning and management of construction processes has been done with a number of universities ((Kagioglou et al., 1999); (Cooper et al., 1998) and (Baldwin et al., 1999)). The theory of construction process mapping can also be adjusted and applied to consult the demolition process mapping and to improve management of the demolition process in the same way that construction management has achieved recently (Egan, 1998).

3.5.1.4 Existing IT Tools for Process Mapping Review

Many IT tools, such as Microsoft office and software packages, such as Visual Basic and Matlab are available for construction management (Chung, 1998). However, all IT tools and software packages have their strengths and weaknesses.

In order to select the most efficient tools for drawing the process map and process management system for demolition, the following works were completed:

- Methods suitable for building a framework for demolition process mapping were reviewed. Those methods included Data Flow Diagrams (DFD) and databases for demolition process requirements. It was found that Microsoft Visio was the best tool for generating the DFDs whilst Microsoft Project and Microsoft Access are the best for demolition requirements databases. By using commercially available software, it was envisaged that the final products of the research could be used by a far wider proportion of demolition contractors.
- Visual Basic (VB) is a simple and arguably the most suitable software user-interface package to build a customer information system for demolition process management system.
3.5.2 Sampling Design

In the context of research sampling, Frankfort-Nachmias (2003) pointed out that “the entire set of relevant units of analysis, or data, is called the population. When the data serving as the basis for generalizations is comprised of a subset of the population, that subset is called a sample.” A single member of a sampling population is referred to as a sampling unit; it can be an event, a city, an organization, a project or a person. A sample is a selection from the population (Robson, 1993) and is a small-scale representation of a population from which it was selected and it is this resemblance that makes sampling useful in the study of populations too large to survey in their entirety (Seale, 2004). The ideal sample is linked and represented to that of a population, so the essential requirement of any sample is that it is as representative as possible of the population from which it is drawn (Robson, 2002).

There are typically 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. In probability sampling, statistical inferences about the population can be made from the responses of the sample because the sample is taken as representative of the population. The alternative type is based on non-probability samples where the probability is not known. In non-probability sampling, statistical inferences cannot be drawn albeit it is still possible to say something sensible about the population (Smith, 1983).

Probability samples consist of simple random sampling, systematic sampling, stratified random sampling, cluster sampling and multi-stage sampling; and non-probability sampling include quota sampling, dimensional sampling, convenience sampling, purposive sampling and snowball sampling (Robson, 1993). These sampling types are listed and explained in Table 3-8.

Sampling methods conducted during this research are the samples for interview, the samples for site observation and the samples for case study. The population with this research are UK demolition contractors and all demolition projects which contractors have either commenced or completed in the last five years. Demolition contractors from the NFDC organization include four regions and hundreds of member and non-member companies and contractors. The projects which the contractors have completed in the last five years vary in size depending on the volume and budget for the building or structure to be demolished.
Table 3-8: Probability Samples

<table>
<thead>
<tr>
<th>Probability samples</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Simple random sampling</td>
<td>✓ Sample selection is random from a list of the population. All units of the population have an equal opportunity to be selected. Requires a full list of the population.</td>
</tr>
<tr>
<td>Systematic sampling</td>
<td>✓ It randomly selects a starting point in the sampling frame, then selects the specific Nth person/item at each circle in every round.</td>
</tr>
<tr>
<td>Cluster sampling</td>
<td>✓ Dividing the population into a number of units or clusters, each of which contains individuals having a range of characteristics.</td>
</tr>
<tr>
<td>Quota sampling</td>
<td>✓ It involves selecting the sample in stages, taking samples from samples.</td>
</tr>
<tr>
<td>Dimensional sampling</td>
<td>✓ Considering the various dimensions importance in the research that are incorporated into the sampling procedure in such a way that at least one representative of every possible combination of these factors and dimensions is included.</td>
</tr>
<tr>
<td>Convenience sampling</td>
<td>✓ It involves choosing the nearest and most convenient persons as respondents. The process continues until the required sample size has been reached.</td>
</tr>
<tr>
<td>Purposive sampling</td>
<td>✓ From the researcher’s judgement as to typicality or interest, sample built up which enables the researcher to satisfy specific needs in a project.</td>
</tr>
</tbody>
</table>

3.5.2.1 Selection of Samples for the Interviews

Selecting the right person to interview was an important task because greater knowledge and experiences held, translated as a deeper understanding of demolition works. Therefore, the decision was taken to only interview senior engineers and experts who have worked extensively in the industry with a minimum of 25 years of experience and are a current IDE member. This is to ensure that information and opinions collected from them for the research are both reliable and trustworthy.

3.5.2.2 Selection of Samples for the Site Observations

As part of pilot research work, a construction site near to our Loughborough University was chosen because the site was convenient, saved time and provided an economic incentive. Site observations were recorded during the entire actual demolition process from site set up to the end of site clearance. The observation tasks were to monitor every procedure implemented during the actual demolition process and collect all relevant data.

3.5.2.3 Selection of Samples for the Case Studies

Case studies involved the sampling of project documents to extract current demolition processes and the requirements. The sample of projects documents should have the common features of demolition process and requirement included, and can be used to represent most demolition projects. Hence, this research decided to randomly collect ten project documents from the
different demolition companies, and selection of three-one large and two medium demolition projects as sample to review on (refer to Table 5-3). This ensured the generality of the samples are covered.

3.5.3 Interviews

According to Cohen and Manion (1989) the interview is “for the special purpose of obtaining research relevant information and focused by him [the interviewer] on content specified by research objectives of systematic description, prediction or explanation”. In other words, an interview is a conversation with a purpose. Interviews are a flexible and adaptable way of discovering facts and opinions and are widely used within research. Based on the degree of structure or formality of the interview, the interview can be fully structured, semi-structured or unstructured. Table 3-9 provides an illustrative comparison between these three interview types.

**Table 3-9: The Comparison of Interview Techniques**

<table>
<thead>
<tr>
<th>Process</th>
<th>Advantage</th>
<th>Disadvantage</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Fully structured interview</strong></td>
<td>Questions are set in advance.</td>
<td>Inflexible.</td>
</tr>
<tr>
<td></td>
<td>• Each interview is conducted in exactly the same way.</td>
<td>Participants must be forced into given responses.</td>
</tr>
<tr>
<td></td>
<td>• The questions and their order are the same for all respondents.</td>
<td>Gathers a limited amount of information.</td>
</tr>
<tr>
<td></td>
<td>• The range of possible responses is determined by the researcher.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Quick and easy to answer.</td>
<td>Requirements interviewing skill.</td>
</tr>
<tr>
<td></td>
<td>• Answers are easy to code and analyse.</td>
<td>Need to meet sufficient people in order to make general comparison.</td>
</tr>
<tr>
<td></td>
<td>• The direction of inquiry is clear.</td>
<td>Time consuming and resource intensive.</td>
</tr>
<tr>
<td></td>
<td>• High degree of reliability.</td>
<td>Preparation must be carefully planned.</td>
</tr>
<tr>
<td></td>
<td>• Produces ‘comparable’ data.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Reduced possibility of interviewer bias.</td>
<td></td>
</tr>
<tr>
<td><strong>Semi-structured interview</strong></td>
<td>Less intrusive to those being interviewed as this encourages two-way communication.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Very much like a questionnaire.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Open-ended questions.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Permissible to stray from the subject area and ask supplementary questions.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Two-way communication that can be used both to give and receive information.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Confirms what is already known but also provides the opportunity for learning.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Gives the freedom to explore general views or opinions in more detail.</td>
<td></td>
</tr>
<tr>
<td><strong>Unstructured interview</strong></td>
<td>Allows flexibility.</td>
<td>Requires interview skill.</td>
</tr>
<tr>
<td></td>
<td>• No prepared list of questions.</td>
<td>Lack of standardization.</td>
</tr>
<tr>
<td></td>
<td>• Exploratory approach.</td>
<td>The answers are difficult to analyse.</td>
</tr>
<tr>
<td></td>
<td>• Open-ended questions.</td>
<td>Depends on the ability of respondents to express themselves.</td>
</tr>
<tr>
<td></td>
<td>• The nature of the response is not limited.</td>
<td>Time consuming.</td>
</tr>
<tr>
<td></td>
<td>• The result of this more open-ended.</td>
<td>Largest potential for interviewer bias.</td>
</tr>
<tr>
<td></td>
<td>• More complex and sensitive questions possible.</td>
<td></td>
</tr>
</tbody>
</table>

(Source from Arham, 2003)
This research chose to interview the demolition experts to obtain knowledge of demolition processes and requirements using a semi-structured approach. This was decided because it allowed areas of interest to be explored, whilst also allowing new avenues of interest to emerge. Interview schedules were arranged before the interviews were conducted. The interview schedules, like questionnaires, provided filter questions to ensure that the interviewer moved smoothly from section to section (Cohen and Manion, 1989). The interview schedule began with a brief introduction, stating who the interviewer was, who they are employed by, and the purpose of the interview. Participants were also given assurance that all information provided would remain strictly confidential.

Throughout the interviews, instructions were explained to the interviewee and each interview followed the same guidelines. Gilbert (2008) provided the following notes which were used to guide the interview:

1) Focus on the purpose to keep the subject on track;
2) Present a natural front: be relaxed, affirmative and as natural as you can;
3) Demonstrate that you are interested in and aware of the subject, listen carefully;
4) Do not be satisfied with monosyllabic answers, be sure that answers offered are of the required standard;
5) Be respectful to the interviewee;
6) Practice; and
7) Be cordial and appreciative.

3.5.4 Observation

Observation is a natural and obvious technique used to watch what people do, to record actions and then to describe, analyse and interpret what has been observed (Robson, 1993). Directness is the major advantage of observation, since researchers can watch what people do and listen to what people say. Observation also is pre-eminently the appropriate technique for getting at ‘real life’ in the ‘real world’. Observation supports exploration research and is a supportive or supplementary technique used to collect data and experimental research.

Robson (2002) categorised the participant observation into the complete participant, the participant as observer, the marginal participant and the observer-as-participant. The task of interpreting this can only be achieved through participation with those involved (Manis and
Meltzer, 1967). Five methods of conducting research by observation were considered as part of this research and these are:

1) **Participant observation** is when the observer seeks to become a member of the observed group.

2) **The complete participant** involves the observer concealing their intentions and acting as naturally as possible in order to become a full member of the group. Kirby and McKenna (1989) indicated that “it is essential that as a participant who is also a data gatherer, the researcher recognises the obligation to inform those in the setting about the research. Research from a covert or manipulative perspective is not generally acceptable.”

3) **The participant as observer** ensures that the group are aware of research work from the start. The observer can ask members to explain various aspects of what is going on within the group and it is important to get the trust of key members of group.

4) **The marginal participant** is someone who does not take part in the activity and whose status as a researcher is unknown to the participants (Robson, 1993). As marginal roles are effectively indistinguishable from the complete observer, it is feasible and advantageous to have a lower degree of participation that envisaged in the preceding sections.

5) **The observer-as-participant** is someone who takes no part in the activity, but whose status as a researcher is known to the participants (Gold, 1958). Such a state is aspired to many researchers using systematic observation.

In this study, observation was used as a technique during the survey research. In particular, participant observation was conducted to gather information by observing and documenting as appropriate, a real demolition project through its entire range of demolition operation processes.

### 3.5.5 Case Study and Multiple Case Study

Yin (2003) defined the case study as “a strategy for doing research which involves an empirical investigation of a particular contemporary phenomenon within its real life context using multiple sources of evidence”. The case study is the method of choice when the phenomenon under study is not readily distinguishable from its context (Robson, 2002).
Case studies can be undertaken on an individual, a group, an institution, a neighbourhood, a decision, a service, on many other things, so case studies are flexible. Four elements were considered when designing the case study (Hamel et al., 1993):

- A conceptual framework that covers the main features (aspects, dimensions, factors, variables) of the case study and their presumed relationships.
- A set of research questions that formulates research questions at the initial stages of the work and ensures that all parts of the conceptual framework are covered by a set of questions.
- A simple strategy that answers your key questions raised.
- To decide on methods and instruments for data collection and good investigation skills are needed. Data collection from the start provides useful feedback on the research questions.

In order to understand current demolition processes used in the industry, this research employed a multiple case study approach. Using multiple sources provided a better understanding of current practices. The procedure adopted included:

- Overview: this was concerned with background information about the demolition projects.
- Procedures: this was concerned with identifying the major tasks involved in collecting demolition information, such as access arrangements, resources available, and schedule of information collection.
- Questions: this was concerned with identifying which set of research questions should be used with an accompanying list of the evidence and information to be gathered.
- Reporting: this related to outlining of a case study report and analysis of the information gathered.

### 3.5.6 Concept of Process Modelling (Process Data Flow)

Whitten et al (2004) defined process modelling as: “a technique for organising and documenting the structure and flow of data through a system’s processes and/or the logic, polices, and procedures to be implemented by system’s processes”. A process model is a pictorial representation of reality and is used to organize and document a system’s processes (DeMarco et
A logic model is a nontechnical pictorial representation that depicts what a system is or does (Karhu, 2001).

A Data Flow Diagram (DFD) is a process modelling technique that can document information flow through a series of project processes (Whitten et al., 2004). Generic guidance details the number of steps that can be followed while producing a DFD. These steps are summarised in Fig. 3-8 where processes, data and external entities (agents external to the examined system) are identified (Green, 1996). This classification is used to develop a basic context diagram which is later revised into more comprehensive DFDs (Baldwin et al., 1999). DFDs are easy to read and consist of only three symbols and one connection (Riaz, 2008). A DFD is graphical represented and described in Table 3-10.

<table>
<thead>
<tr>
<th>Table 3-10: DFD Elements and their Notations</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Element Name</strong></td>
</tr>
<tr>
<td><strong>Data Flow</strong></td>
</tr>
<tr>
<td><strong>Process</strong></td>
</tr>
<tr>
<td><strong>Data Store</strong></td>
</tr>
<tr>
<td><strong>External Entity</strong></td>
</tr>
</tbody>
</table>

Data flow is data in motion, and the flow of a data between a system and an environment or between two processes inside the system is a communication. A data flow represents an input of data or information to a process or the output of data or information from a process (Whitten et al., 2004).

It was fundamental to this research that a detailed concept of a demolition process was collected correctly and that the concept data or information flows were logical. To fulfil this purpose, the research built a physical process model of current systems, a logical model of current systems.
and a logic model of the target system. Each of these was built from (i) very general models to (ii) very detailed models. This requires:

- A system context data flow diagram to be constructed to establish initial project scope. It is normally a one page data flow diagram showing the process mapping interfaces with its environment;
- Drawing functional decomposition diagram to partition the demolition process mapping system and its logical subsystems/sub-processes.
- Compiling demolition project events lists to identify and confirm the demolition processes are connected and responded in the process mapping system. The list will also describe the demolition requirements or possible response to the each process of events.
- One diagram is constructed and validated for each processes or events. This is a simple DFD to show the inputs and outputs of each individual processes or events.

**Figure 3-8: Flow Chart for the Requirements of Creating a DFD**

(Source from Green, 1996)

3.5.7 Prototyping and Prototyping Input and Output Design

An important element of any methodology used for the objective of process management is the development of the system prototype. This involved designing a prototype system to demonstrate
The system design includes “design outputs and then make sure the inputs are sufficient to produce the outputs” (Turban and Aronson, 1998). The essential steps of prototyping output design are indicated by Whitten et al (2004), these are to:

- Identify the system outputs and review logical requirements;
- Specify physical output requirements; and
- Design any pre-printed external forms.

For this research, the process of designing, validating and testing outputs of the prototype used: (1) layout tools (e.g. layout charts); (2) prototyping tools (e.g. spreadsheet, database, Microsoft Access); and (3) project generation tools (e.g. user-interface).

For prototyping input design, two characteristics have been considered in this research. First, how is the demolition process data or information initially captured, entered, and processed? Second, is the research method and technology used to capture and enter the data or information correct? During the requirements analysis, inputs were modelled as demolition standard process flows and user-defined process flows. Demolition standard and user-defined processes should obey a compliance flow that consists of demolition process attributes. However, the input should be as simple as possible and be designed to reduce the possibility of incorrect processes being entered (Arham, 2003).

There are three tools that were used in the prototyping input design; these being: (1) MindGinues to produce a tree map of the standard demolition process; (2) Microsoft Excel to generate the forms, Microsoft Access to produce the database using the data collected from the demolition industry and Microsoft Project to produce the map of a user-defined demolition project process; and (3) Microsoft Visio to generate the user-interface webpage for demolition management system design.

### 3.5.8 Database Design

A database is a critical component of most information systems. According to Whitten et al (2004) “A database is built around a Database Management System (DBMS) that provides the technology to define the database structure and then create, read, update and delete records in the tables that make up that structure.”
Database design is the process of translating logical data models into physical database schemas and a database schema is a physical model for a database based on chosen database technology (Cardenas, 1985). The rules for transforming logical data models into physical database schema are generalized (Whitten et al., 2004). For example, each entity becomes a table; each attribute becomes a field (column in the table), each primary and secondary key becomes an index for the table and each foreign key implements a possible relationship between the tables (Microsoft Access, 2003). DBMS consists of front-end applications and the back-end database as illustrated in Fig. 3-9. Back-end databases are a number of information systems that are used to represent the application of another level information system. The front-end applications are responsible for complex calculations and for data formatting (Ursu, 2004).

**Figure 3-9:** Front-end Applications and Back-end Database

(Adapted from Ursu, 2004)

Before designing a demolition process database a decision needs to be made with regards to what is represented in the database for Demolish-IT. The content of demolition process requirements have a similar set of features and can be applied to all demolition projects (such as legal documents, method statements, cost estimating spreadsheets, design and construction data, environment data, site conditions and plant management, etc.). These are represented by outline tables, frameworks, forms and document records. Therefore, demolition requirements represent the contents stored in the Demolish-IT database.

**3.5.9 Evaluation**

An evaluation is a study which has a distinctive purpose, and that purpose is to assess effectiveness of research results (Robson, 1993). Robson stated that evaluation is “an attempt to
assess the worth or value of some innovation or intervention, some service or approach”. The practice of evaluation involves: (1) the systematic collection of information about the activities, characteristics and outcomes of programs; (2) considering personnel and products for use by specific people to reduce uncertainties; (3) attempting to improve effectiveness and make decisions with regard to those programs (Patton, 1982).

The purpose of conducting evaluation is to look at different aspects of the research and tends to improve them. Categories of evaluation are proffered by the Evaluation Research Society (1980) as follows:

- Front-end analysis (pre-installation, context, feasibility analysis): this takes place before the program starts, to provide guidance in its planning and implementation.
- Evaluability assessment: assesses feasibility of evaluation approaches and methods.
- Formative evaluation (developmental, process): this provides information for programme improvement, modification and management.
- Impact evaluation (summative, outcome, effectiveness): this determines programme results and effectiveness.
- Program monitoring: these check for compliance with policy, tracking of services delivered and counting of clients.
- Evaluation of evaluation: this critiques the evaluation reports, reanalyses the data and conducts external reviews of internal evaluations.

The plan for an evaluation needs to take into consideration the following features (Adapted from Harlan and Elliot, 1982):

1. From the purposes: what is the evaluation for? What kind of evaluation is required? How was evaluation applied for validation of the research work?
2. From the valuation: how can valuation prove that the research works done are precise and applicable?
3. From the methods: what kinds of methods are suited to the requirements of the evaluation?
4. From the interpretation: how the nature of the evaluation can agree the result?

For this research, the evaluation proposed to identify the functionalities for the prototype of Demolish-IT. Three methods were used for validation, these being: (1) interviews; (2) workshops; and (3) real case testing. The validation results proved that the research represents a
milestone for demolition research and has offered a better solution for management of dynamic demolition processes.

### 3.5.10 Questionnaire Survey

Social scientists regard surveys as an invaluable source of data about attitudes, values, personal experiences and behaviour (Gilbert, 2008). Surveys allow researchers to gather information from a specified target population by means of face-to-face interviews, telephone conversations, postal questionnaires and online surveys (Campbell and Stanley, 1963). A postal questionnaire is normally used to gather the views of large populations. Face-to-face interview presents a set of questions to the respondent in a pre-determined order at each interview. Interview schedules are also used for interviews conducted on the telephone.

The most important part of any survey is the development of questions (Blaxter, 2006). The survey question is central and a crucial step to design of a research project. The formulated questions that should obtain the most valuable and relevant information in the process of carrying out a research project. Gilbert (2008) states that there are two types of questions, e.g. closed question and open questions. According to Stacey (1969), a closed question should be used where alternative replies are known, are limited in number and are clear cut. For example, close questions willing a ‘Yes’ or ‘No’ response. Open questions are used where the issue is complex, where relevant dimensions are not known and where a process is being explored, for example, open questions are those that allow individuals to respond in any way they wish, e.g. what do you think can be done to improve the demolition process?

A questionnaire can be defined as “a list or grouping of written questions which a respondent answers” (Adams and Schvaneveldt, 1985). The procedure for designing a research questionnaire as recommended by Creswell (2003), Fellow and Liu (1997) and Fowler (1993) seek to ensure that:

- The questions must be clear and easy to answer;
- The questions should be in short sentences and brief;
- The language used for writing the questions should be simple;
- The questionnaire should be designed attractively and should be uncluttered; and
- The questionnaire must be designed for easy analysis of results.
A pilot survey is a process in questionnaire design that aims to pre-test the questionnaires validity before it is used in a survey interview. The pre-test should consider whether: (1) the questions have any mistakes that need correcting; (2) the questions have been placed in the best order; (3) the questions can be understood by all respondents; (4) additional or more specific questions are needed: (5) some question should be eliminated; and (6) the instructions to interviewees are adequate.

3.5.10.1 Design Questionnaires for the Case Study

In order to construct a successful study, the case studies conducted a questionnaire survey to understand demolition processes currently used by the UK industry. An outline of questions has been edited to cover the general knowledge of the demolition process.

3.5.10.2 Design Questionnaires for the Interview and Workshop Survey on Validation

This research used a questionnaire and a workshop at the validation stage, to capture the experts’ views on demolition process mapping as well as the Demolish-IT prototype.

Development of an effective schedule of questions followed the three steps below, which were:

- Determine the nature of the research investigation and objectives;
- Form an outline, list items relevant to the research; and
- Develop sets of questions relevant to demolition process mapping and management.

3.6 Chapter Summary

This chapter has offered an overview of the concept of social research, research methodology, and research process and design. Based on the knowledge gained, a specific research design and plan for the development of Demolish-IT was presented. This chapter has also provided an overview of the most effective methodology to facilitate and achieve the research aims and objectives. Adopted research methods were also discussed in detail. These included: (1) literature reviews; (2) sampling design; (3) interviews; (4) observation; (5) case study and multiple case study; (6) process modelling; (7) prototyping design; (8) database design; (9) evaluation; and (10) questionnaire.
4 Process Management and System Development

4.1 Introduction

Chapter two identified that positive improvement is needed in demolition processes management at both the strategic and the operational stages. Thus the need to create Demolish-IT to manage demolition process for the demolition industry is very relevant.

Demolish-IT is a management information system (MIS), which in itself is an arrangement of people, data, processes and information technology that interact to collect, process, store, and provide as output the information needed to support an organization (Whitten et al., 2004). Demolish-IT was based on a full understanding of procedures and processes involved in the demolition project and should be able to identify opportunities to increase the efficiency of information transfer in a consistent manner. The Demolish-IT intends to demonstrate that process management applies to all parts of the demolition project. It also attempts to give competitive advantages to the demolition contractors because it helps to:

- Reduce the costs of producing services by being efficient;
- Increase revenue by increasing customer satisfaction through good quality and services;
- Reduce the need for investment by using demolition resources effectively;
- Provide the basis for project planning and management by building a solid process management tool.

To satisfy all constraints involved in today’s complex demolition processes, and in order to succeed in competition, producing a good service to the client and using resources effectively are essential ingredients for any contractor who wishes to improve operational management. Process maps are one technique that can be used to enhance communications and better understand the demolition process, because the process map will be constructed based on best practices observed and/or cited in relevant standards, and will break the whole operation down into its constituent parts (Dandelion, 1996). Re-engineering this process will integrate functionally separated tasks of an individual project into a unified standard work processes (Hammer, 1995).

For the purpose of this research, this chapter studies and reports upon the fundamental theories of business process, process management and system design. Process modelling methods were
also discussed in order to implement the best suitable method to achieve the aforementioned research goals. Finally, a plan of developing Demolish-IT was generated and discussed.

4.2 Business Process and Process Management

4.2.1 Business Process

All organisations and sectors of industry use “Process” to deliver their business (Nelson et al., 1999). Davenport (1993) defined a business process as “a structured, measured set of activities designed to produce a specific output for a particular customer or market”. This definition contains certain characteristics that a process must possess. A process is a specific ordering of work activities across time and space, with a beginning and an end, and clearly defined inputs and outputs and a structure for action (Ould, 2005). Hammer and Champy (1993) also indicated that a process consists of smaller parts and activities and there must be a recipient of the benefits from the outcome of a process, that the transformations taking place within the process must add customer value. Johansson et al (1993) defined a process as “a set of linked activities that take an input and transform it to create an output. Ideally, the transformation that occurs in the process should add value to the input and create an output that is more useful and effective to the recipient either upstream or downstream.” This emphasizes the links between activities and transformations that take place within the process.

Rummer and Brache (1995) discussed the differences between primary processes and support processes. Primary processes result in a product or service that is received by an external organisation. Support processes produce products that are invisible to the external customer but essential to the effective management of the business. Primary and support processes differ in that the former is directly involved in the creation of customer value, and latter is concerned with the organization’s internal activities. Also, a process is cross-functional if it ranges over several business functions (Havey, 2005).

Summarizing the above definitions, the characteristics for a business process are six fold (Davenport, 1993; Hammer and Champy, 1993; Rummler and Brache, 1995; and Johansson et al., 1993):

1. Definability: it must have clearly defined boundaries, inputs and outputs.
2. Order: it must consist of activities that are ordered according to their position in time and space.

3. Customer: there must be a recipient of the process’ outcome.

4. Value-adding: the transformation taking place within the process must add value to the recipient.

5. Embeddedness: a process cannot exist in itself; it must be embedded in an organizational structure.

6. Cross-functionality: a process regularly can, but not necessarily, must span several functions.

The research understood the demolition process is represented by demolition tasks. Also, that there are requirements to complete these tasks, such as selecting suitable demolition techniques, proper equipment and facilities; and providing competent labour to carry them out. These requirements represent the ‘inputs’ of the demolition process and the output is accomplishing the demolition in complete fulfillment of the client’s requirements.

Demolition process management was considered the optimal means to satisfy demolition clients’ requirements. Demolish–IT is the process management system used to define the demolition act, measure and control demolition operations, and report upon and improve the demolition process.

To manage demolition processes, this research concentrated on these factors, i.e. identifying the demolition processes, investigating how the main demolition process associates to other sub-processes, optimizing the processes based on best practice observed and cited from the demolition documentations, imposing constraints involved in each process and modelling the processes.

4.2.2 Process Management

Process management is concerned with the application of knowledge, skills, tools, techniques and systems to define, visualize, measure, control, report and improve processes with the goal of meeting customer requirements (Becker et al., 2003). It is an ensemble of planning and monitoring the performance of a process, especially in the business process.
Business Process Management (BPM) is a method of efficiently aligning an organization with the wants and needs of clients (Smith and Fingar, 2002). Smith and Fingar (2002) also further describe the BPM as a holistic management approach that promotes business effectiveness and efficiency while striving for innovation, flexibility and integration with technology. The objectives of BPM are defining, measuring and improving processes (Burlton, 2001).

The activities which constitute the BPM life cycle to Demolish-IT can be grouped into five categories illustrated as in Fig. 4-1. These five categories are design, modelling, execution, monitoring and optimization (Jeston and Nelis, 2006).

1. **Process design** is a complex process requiring expertise and a correct set of design tools to accurately depict the process. It encompasses both the identification of existing process and designing the new processes (Kelvin, 2003).

2. **Process modelling** are the processes that are classified together into a model (Burlton, 2001). Use of a process model prescribes how things could be done in contrast to the process itself which what is really happened.

3. **Process execution** is automatic processes the user can develop or purchase that executes the required steps of the process. In practice, these applications rarely execute all the steps of the process accurately or completely. Business rules have been used by systems to provide definitions for governing behaviour and a business rule engine can be used to drive process execution and resolution (Rummler and Brache, 1995).

4. **Process monitoring** encompasses the tracking of individual processes so that information on their state can be easily seen and statistics on the performance of one or more processes can be provided. The degree of monitoring depends on what information the business wants to evaluate and analyze and how the business wants it to be monitored (Jeston and Nelis, 2006).

5. **Process optimisation** includes retrieving process performance information from the modelling or monitoring phase and identifying potential or actual bottlenecks and potential room for cost saving or other improvements. These improvements are then applied to the design of the process thus continuing the value cycle of business process management (Smith and Fingar, 2002).
The process management concept comprises of six aspects (Czerepak, 2007). These are: the process concept, the process relationships, the process attributes, the process constraints, the process definition and the process manipulation. Fig. 4-2 illustrates the framework of the Demolish-IT process focus by use of BPM focus perspectives.

(Source from Jeston and Nelis, 2006)

(Source from Czerepak, 2007)
Chapter 4 Process management and system development

There are four process managements have been identified by Hunt (1996) and they can be the outline to guide demolition process management and Demolish-IT system development. These are:

1. **Goal management:** the overall demolition process management goals should serve as the basis for the establishment of sub-goals throughout the management process (Harrington et al., 1997). Similarly, establishing Demolish-IT sub-goals after each step has an especially large impact on the ultimate demolition project driven process goals.

2. **Performance management:** establishing Demolish-IT for obtaining internal and external customer feedback on the process outputs; tracking demolition project process performance against goals and sub-goals; feeding back process performance information to each functions of the demolition process; establishing the mechanisms to solve demolition process problems and continuously improve demolition process performance; and adjusting goals to meet new clients’ requirements (Rummler and Brache, 1995).

3. **Resource management:** demolition resource allocation is a major part of the responsibility of managers. Process-driven resource allocation of demolition project is the result of decisions made regarding how much money and manpower is required for the demolition process to achieve its goals (Becker et al., 2003). Each demolition function is allocated its share of the resources according to its contribution to the whole demolition process.

4. **Interface management:** a demolition process map clearly displays the points at which one demolition activity function provides a product or service to another demolition activity. At each of these points, there is a customer-supplier interface (Hunt, 1996). The demolition client-contractor interfaces represent the greatest opportunity for performance improvement to the demolition process management.

### 4.2.3 Process Re-engineering

The manufacturing industry has been improving its competitiveness by addressing and optimising their key business and operational processes via a procedure called “Process Re-engineering” (Kagioglou, 1999). Research into manufacturing industry process re-engineering has identified the following as contributory factors to success (Cooper, 1993):

- Clear identification of requirements;
Clear strategy;
Well-understood and managed processes; and
Collaboration between all stakeholders in the process.

Business Process Re-engineering (BPR) was a relatively new concept in the UK construction industry which has borrowed the ideas from manufacturing sector. There has been an apparent desire to change the construction cycle since the 1930s (Emmerson, 1962) and (Banwell, 1964). But this desire was significantly acted upon only since the reports of Latham (1994) and Egan (1998). Kagioglou et al (1999) stated that the UK construction industry has been looking at the manufacturing industry for potential technology and practices transfer in order to effectively implement the construction process. This has required re-engineering of the construction process and sub-process involved in undertaking construction works. The main outcome and recommendation of the Latham (1994) report was that it called for significant cost savings by the utilisation and formulation of effective construction processes which will lead to increased performance of construction projects. These recommendations of the report were reaffirmed by Sir John Egan’s (1998) report “Rethinking Construction” which reported on the scope for improving the quality and efficiency of UK construction. Focus on integrated processes is one of the five identified drives of the Egan (1998) report. Egan (1998) also calls for annual reductions of 10% in construction costs and construction time and a reduction of 20% per annum of defects in projects. This total performance improvement by 30% required significant improvements in the way the construction process was enacted (Lee et al., 1999). A funded research project was undertaken by the University of Salford, which sought to develop a Genetic Design and Construction Process Protocol. This work proven that the development of a process map has gained momentum within the construction industry as a whole. The Latham inspired Construction Research and Innovation Strategy Panel (CRISP) has adopted the process protocol in principle as a basis for its activities in terms of promoting clearer processes in the construction industry (Cooper et al., 1998).

A key characteristic of Business Process Reengineering (BPR) was the focus on the business process (Raymond and Mark, 1996). Hammer (1995) defined business process reengineering (BPR) as “fundamental rethinking and radical redesign of business processes to bring about dramatic improvements in performance”. Fig. 4-3 shows the business process pictured as a set of triangles below. The purpose of this model is to define the demolition supplier and demolition
process inputs, process, the demolition clients and associated outputs. The feedback from clients and contractors can be back to the supplier in order to improve the demolition process.

**Figure 4-3:** BPR Picture for Demolish-IT Development

![BPR Picture for Demolish-IT Development](image)

*(Source from Burlton, 2001)*

An approach for reengineering the business process is pictured below in Fig. 4-4 (Carter, 2005) and guided to improve the demolition process. The demolition process re-engineering started with defining the scope and objectives of the reengineering demolition project, and proceeded through a learning process (with demolition contractors, employees, competitors and non-competitors, and with new demolition technology). From this learning process, it created a vision for the future and design new demolition processes and given the definition of the "to be" demolition process; then a plan of action based on the gap between current used demolition processes to where demolition process want to go can be created with technologies and structures. Finally the solution of best practice studied demolition process is implemented to the Demolish-IT.

**Figure 4-4:** Re-engineering Model to Demolish-IT

![Re-engineering Model to Demolish-IT](image)

*(Source from Carter, 2005)*

To succeed with demolition process reengineering, top management of demolition contractors should be able to understand, map and change (where needed) strategic processes so that the business can be improved. Fig. 4-5 identifies an optimum management system approach that can
produce the desired service to the clients. Based on the Knowledge gain from above study, the research has designed that works begin with understanding the current used demolition processes in UK demolition industry, identifying the inefficient then simplifying and improving it towards client’s satisfaction, better quality, and cheaper and faster accomplishing of demolition projects.

**Figure 4-5: Demolition Process-driven Improvement**

(Source from Hunt, 1996)

### 4.3 System Development Process

System Development Process (SDP) was defined by Whitten *et al* (2004) as “a set of activities, methods, best practices, deliverables and automated tool that stakeholders use to develop and maintain information systems and software.” The organisations’ SDP follows a problem-solving approach, and the approach typically incorporates the following general problem-solving steps of developing Demolish-IT. These steps are listed in Table 4-1 and explained as following:

**Table 4-1: Simplified Demolish-IT Development Process**

<table>
<thead>
<tr>
<th>System development process</th>
<th>General problem-solving steps</th>
<th>Demolish-IT development process</th>
</tr>
</thead>
<tbody>
<tr>
<td>System initiation</td>
<td>1. identify the problem and plan for the solution to the problem.</td>
<td>1. Identify the problem with demolition process and management.</td>
</tr>
<tr>
<td></td>
<td>2. analysis and understanding the problem, 3. identify solution requirements and expectations.</td>
<td>2. plan for development of Demolish-IT using ICT.</td>
</tr>
<tr>
<td>System analysis</td>
<td></td>
<td>procedure statement of demolition contractor, including of requirements, expectation and priorities.</td>
</tr>
<tr>
<td>System design</td>
<td>4. identify alternative solutions and choose the best course of action, 5. design the chosen solution.</td>
<td>Produce technical blueprint and specification for Demolish-IT.</td>
</tr>
<tr>
<td>System implementation</td>
<td>6. Implement the chosen solution, 7. evaluate the results.</td>
<td>Hardware and software solution for Demolish-IT.</td>
</tr>
</tbody>
</table>
1. Demolish-IT initiation establishes Demolish-IT project scope and the problem-solving plan. Demolish-IT development projects usually require a significant amount of time, effort and economic investment, thus, Demolish-IT projects should be carefully planned. A general plan is shown in Fig. 4-6.

**Figure 4-6: Demolish-IT Development and Problem Solving**

(SOURCE FROM Whitten et al., 2004)

2. Demolish-IT analysis produces more understanding of problems and requirements of demolition process that led to the commencement of demolition project. This includes: (1)
clarifying the demolition process requirements and expectations; and (2) establishing the schedule and budget to accomplish desired demolition process priorities.

3. **Demolish-IT design** is the specification or construction of technical, computer-based solutions for the Demolish-IT requirements identified in the system analysis. This involved: (1) exploring technical solutions, such as implementing demolition process required databases, programs, user-interfaces and networks; and (2) using the chosen technology to develop technical blueprints and specifications for Demolish-IT.

4. **Demolish-IT implementation** is the construction, installation, testing and delivery of Demolish-IT into production.

### 4.4 Process Modelling and Tools

#### 4.4.1 Process Modelling

Whitten *et al.* (2004) defined *the logical model* as a nontechnical pictorial representation that depicts what a system is or does, which includes essential models, conceptual models and business models. A *physical model* is a technical pictorial representation that depicts what a system is or does and how a system is implemented.

Construction logical models are a process of modelling. They can help to better understand business problem domains and business requirements (Havey, 2005). Havey (2005) also defined that “*process modelling is a technique used to organize and document a system’s process*”. A process is work performed on or in response to incoming data flow or conditions (Ahern *et al.*, 2001). Processes’ modelling focuses on what work or action is being performed and transfers the process by using the process modelling technology. Fig. 4-7 shows the classic process model of a system. The simplest process model has inputs, outputs and the system itself as a process (Smith, 2000). The system symbol defines the boundary of the system. The system is inside the boundary; the environment is outside that boundary and the system exchanges inputs and outputs with its environment. A well-designed system has a feedback and control loop to allow the system to adapt itself to changing conditions (Whitten *et al.*, 2004).
Figure 4-7: The Classic Process Model of a System

(Source from Ahern et al., 2001)

The data for process modelling can flow in diverging and converging ways (Chrissis et al., 2006). A diverging data flow that splits into multiple data flow; a converging data flow merger of multiple data flows into a single data flow (Smith, 2000). Fig. 4-8 illustrates the system modelling of diverging and converging data flow. In Fig. 4-8, the flows simply diverge from or converge to a common flow. The small square junction means “and” and it must input or output all the diverging or converging data flows. The black circle junction means “exclusive or”, and it must input (or output) only one of the diverging or converging data flows.

Figure 4-8: An Example of Modelling a Process of Diverging and Converging Using a DFD

(Source from Whitten et al., 2004)
A complex system has many processes (Smith and Fingar, 2003). In order to fully understand when viewed as a whole, the system should be separated into its component sub-processes, which are decomposed into smaller sub-processes. This is explained in Fig. 4-9. System analysis decomposes a system and partitions it into logical sub-systems of processes for improved communication, analysis and design (Havey, 2005). A decomposition diagram is also called a hierarchy chart, and shows the top-down functional decomposition and structure of a system (Whitten et al., 2004). It can be adapted to model complex demolition processes.

**Figure 4-9:** A System Consists of many Subsystems and Processes

![Diagram of a System Consists of many Subsystems and Processes](Source from Whitten et al., 2004)

To model complex processes in the system as Fig. 4-9 has illustrated, integration of the business processes is important. Process modelling was also performed in the problem analysis phase of systems analysis. This helps to build a physical process and a logical model of the current system and a logical model for the target system (Ahern et al., 2005). Fig. 4-10 illustrates the business process integration concepts that give the idea for building the demolition process model for
Demolish-IT. The logical demolition process model can be created by a standard demolition process map, and the physical model can be generated by a user-defined particular project process map. This standard and user-defined demolition process maps are implemented in chapter seven as two tiers of information in the Demolish-IT system.

**Figure 4-10: Business Process Integration to Demolish-IT**

![Business Process Integration to Demolish-IT](Source from Smith, 2000)

Process modelling can be organized according to a commonsense strategy called event partitioning (Whitten et al., 2004). Smith (2000) explained that event partitioning is a system that factored into sub-systems based on business events and responses to those events. The strategy for event-driven process modelling is illustrated in Fig. 4-11 and is described as follows:

1. A system context DFD shows only the system’s main interfaces with its environment.
2. A functional decomposition diagram is drawn to partition the system into logical subsystems or functions and each event.
3. An event-response or use-case list describes the required or possible responses to each event and it is compiled to identify and confirm the business events to which the system must provide a response.
4. One process (event) is added to the decomposition diagram and serves as the input and outline for the system.

5. An event diagram is constructed and validated for each event. This simple DFD only shows the event and the inputs and outputs for each individual event, and not the whole.

6. One or more system diagrams are constructed by merging the event diagrams. These DFDs show the main overview of the system.

7. Primitive diagrams are constructed for event processes that require additional processing details. These DFDs show all the elementary processes, data stores and data flows for single events.

8. Use of standard language to explain the logic behind each elementary process.

9. Use of the tools to describe the data structure of each elementary data flow.

Process models illustrate the essential work to be performed by the system as a whole (Ahern et al., 2005). However, the process must be distributed to locations where work is to be performed (Smith 2000). For example, a demolition health and safety plan must be produced by the clients at the tendering stage. Before designing the information system, the research has identified and documented what processes must be performed at which process. Some work is used in one process, but other work is used at multiple processes, while things such as documents of demolition risk assessment must be used throughout the whole duration of the demolition process.
Figure 4-11: Event-driven Process Modelling Strategy

(Adapted from Whitten et al., 2004)
4.4.2 Modelling Tools

As aforementioned, increasing competition and complexity of demolition projects undertaken have required demolition companies to re-think the way in which they manage the demolition operation process and many have sought new management systems for improving the existing systems’ capabilities. However, many of the potential benefits associated with an improved process can only be realised with significant IT support (Betts, 1992).

There are many software tools supporting various process modelling methodologies available in the market (Carter, 2005, Dodaro and Crowley, 1997). They are:

- Graphical interface for fast documentation.
- "Object oriented" technology that can change the data (e.g. job titles) in one place and moreover the change automatically appears throughout all the organization's procedures and documentation.
- Drag and drop facility so that the user can easily relate organizational and data objects to each step in the process.
- Customizable meta data fields, so that users can include information relating to their industry, business sector or organization in the documentation.
- Analysis, to show visually how responsibilities in a process are transferred between different roles, or where data items or computer applications are used.
- Support for value stream mapping.
- The ability to assess the processes against agreed international standards.
- Simulation software to support 'what-if' analyses during the design phase of the project to develop LEAN processes.
- The production of word documents or web site versions of the procedures at the touch of a single button, so that information can be easily maintained and updated.

Typically, these tools can be categorised into two major types, paper based diagramming tools and software enabled analysis tools (Wu et al., 2000). Paper based diagramming tools offer the integration of diagrams and illustrations, together with a wide variety of other features and abilities (Wu et al., 2001). The most advanced diagramming products have become an environment for creating applications (Yu and Wright, 1997). For example, the industry standard modelling languages, such as IDEFs, DFDs and Entity Relationship Diagrams have been
incorporated into those products (Karhu, 2001). Most of the tools provide the user with drawing support, such as templates which can be customised to suit individual requirements. In addition, Flow Charter, Flow Charting PDQ, Smart Draw and Visio software are the major products in the process management tool domain. Visio was chosen for this research to draw the demolition process maps, because this links into Microsoft Word which provides a platform for the management tools.

Software enabled analysis tools are called Business Process Redesign (BPR) tools or Computer Aided Software Engineering (CASE) tools. They usually encompassed within event simulators, static analysis, dynamic modelling and standard database support (Wu et al., 2000). For example, CASE technology provides the repository for storing the process model and its detailed descriptions (Ahern et al., 2001). Most CASE products support computer-assisted process modelling and support decomposition diagrams and data flow diagrams. Some CASE products also can help to analyze the data model for consistency, completeness and flexibility (Chrissis et al., 2006). One example of a CASE tool is System Architect 2001. It automatically catalogued all the processes, data flow, data stores and boundaries on stage process models into System Architect’s project repository (Arham, 2003).

For process modelling tools in particular, Chung (1998) suggested that the choice of modelling tool should be available to all participants of a process modelling effort, and that the tools should be compatible with other tools, and whenever possible with tools compliant with industry applicability. This philosophy was replicated within Demolish-IT.

4.5 Construction Process Modelling Methods

In order to understand the underlying reality of demolition processes, it is important to examine process modelling methods and how to develop demolition process models by these methods. Several process modelling methods have been used for construction process modelling, both descriptive and prescriptive (Austin et al., 1999). An integral part in all aforementioned process modelling methods is graphical presentation of the resulting models. For example, many research projects investigate how to model construction processes with a process map (Baldwin et al., 1999). Based on the knowledge of understanding the process, these methods, general and specific, to a particular application, have been devised.
In order to apply the process modelling method to the research, it was necessary to review currently used construction process modelling methods. There are five principal methods for construction process modelling that were identified and are reviewed in this section. These are:

- The scheduling method;
- The simple flow method;
- Data Flow Diagrams (DFDs) method;
- Integration Definition for Function modelling (IDEF);
- Generic Process Modelling (GPM) method.

### 4.5.1 Scheduling

The method ‘scheduling’ is used to denote familiar general project planning or networking techniques, such as critical path, resource levelling, precedence method, program evaluation and review techniques (PERT), etc. (Karhu, 2001). The resulting schedules can be presented in various forms such as Gantt charts (an example see Fig. 4-12) or PERT charts.

**Figure 4-12: Example of a Part of a Schedule**

<table>
<thead>
<tr>
<th>ID</th>
<th>Task Name</th>
<th>Start</th>
<th>Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Frame works 0 floor</td>
<td>03/01/2002</td>
<td>1d</td>
</tr>
<tr>
<td>2</td>
<td>Element work</td>
<td>03/01/2002</td>
<td>1d</td>
</tr>
<tr>
<td>3</td>
<td>column work</td>
<td>04/01/2002</td>
<td>1d</td>
</tr>
<tr>
<td>4</td>
<td>Base work</td>
<td>04/01/2002</td>
<td>1d</td>
</tr>
<tr>
<td>5</td>
<td>Earth pressure wall</td>
<td>18/01/2002</td>
<td>1d</td>
</tr>
<tr>
<td>6</td>
<td>Outer wall work 1</td>
<td>21/01/2002</td>
<td>2d</td>
</tr>
<tr>
<td>7</td>
<td>Outer wall work 2</td>
<td>05/02/2002</td>
<td>1d</td>
</tr>
<tr>
<td>8</td>
<td>Prestressed concrete</td>
<td>04/02/2002</td>
<td>1d</td>
</tr>
<tr>
<td>9</td>
<td>Inner wall work</td>
<td>15/02/2002</td>
<td>2d</td>
</tr>
<tr>
<td>10</td>
<td>Hollow core slab work1</td>
<td>28/02/2002</td>
<td>1d</td>
</tr>
</tbody>
</table>

(Source from [http://images.google.co.uk/Schedual](http://images.google.co.uk/Schedual))

A conceptual interpretation of a scheduling method in general is illustrated in Fig. 4-13 using the EXPRESS-G notation. EXPRESS-G is a standard graphical notation for information models. It is a useful companion to the EXPRESS language for displaying entity and typing definitions, relationships and cardinality (Seimens AG, 1994). In Fig. 4-13, a rectangular box is an entity,
and is used to connect the entity with its attributes. The data type name is written within a dashed line having a vertical bar at the end of the box. A solid or dashed line which is terminated by a circular arrowhead shows a relationship. The relationship name is written next to the line, and the direction of a relationship is towards the arrowhead. A solid line indicates a compulsory relationship, whereas a dashed line indicates optional relationship (ISO, 1994).

**Figure 4-13: The Concept Model of the Scheduling Method**

![Concept Model of the Scheduling Method](Adapted from ISO, 1994)

Scheduling methods have the problem that they do not make distinction between the different types of resources and between controls for tasks (Baldwin *et al.*, 1999). Therefore, it is difficult to understand what a task does with all its resources. Also iterative tasks in scheduling are difficult to model. But a scheduling method has the advantage of modelling the identification and sequence of tasks.

### 4.5.2 Simple Flow

The simple flow method has been applied in many variations to describe construction projects (Karhu, 2000). The simple flow method consists of three concepts and it includes activity, participation (mechanism) and a flow between the activities. The method can be classified as a functional method that is used to model activities, and as diagrams that represent cross-functional flowcharts that are used to describe the construction project. The simple flow method uses a simple ‘box-and-arrow’ notation.
Fig. 4-14 shows an example where two construction workers are responsible for two activities, and there is a flow between these activities. Fig. 4-15 illustrates one interpretation of the core entities in using the EXPRESS-G notation of the simple flow diagram method.

**Figure 4-14:** An Example of a Simple Flow Diagram

![Diagram of simple flow method](Adapted from Karhu, 2001)

**Figure 4-15:** An Interpretation of the Core Entities of the Simple Flow Method

![Diagram of core entities](Adapted from Karhu, 2001)

Simple flow method diagrams can be produced using general purpose graphical drawing software tools that are easy to understand (Karhu, 2000). But the process flow and the activities cannot be decomposed in the simple flow method.

**4.5.3 Data Flow Diagram (DFD)**

The Data Flow Diagramming (DFD) method has been explained by DeMarco *et al.* (1997). It has been used in software development, and in particular in modelling the construction process. For example, the study of communications between participants (Abou-Zeid and Russell, 1993) and to model the building designs process (Austin *et al.*, 1996; Baldwin *et al.*, 1999).
The DFD method has four basic components (Green, 1996) which are: (1) process (function); (2) data or information flow; (3) data store; and (4) external entity. For example, Austin et al (1996) applied the DFD method to construct a process model, interpreting processes as individual design tasks, flows as design information flows, data stores as drawings etc, and external entities (such as clients, local authorities, etc.).

Fig. 4-16 is an EXPRESS-G diagram illustrating an interpretation of the core entities of the DFD. Fig. 4-17 is a DFD that shows a company training process.

**Figure 4-16: The Core Concepts of DFD**

![Diagram](adapted_from_karhu_2001)

**Figure 4-17: Outline Process for Accident Investigation**

![Diagram](adapted_from_riaz_2008)

(Adapted from Karhu, 2001)

(Adapted from Riaz, 2008)
The DFD method is independent of time (Karhu, 2001). Therefore, it can be used effectively for modelling the functions and information flows between times. This also supports the iterative nature of many construction processes. For example, Baldwin et al (1995) produced a model of a concept and scheme design stages of a project and Austin et al (1996) developed a model of civil and structural engineering elements at the detailed design stage.

4.5.4 IDEF Method

The first generation of IDEF methods emerged from the US Air Force’s Integrated Computer-Aided Manufacturing (ICAM) program in the late 1970s (Mayer et al., 1995). IDEF method were developed and achieved through modelling information, dynamics, functions and processes (Bravoco and Yadav, 1985). IDEF methods were also designed to work together as a conceptually integrated suite of methods that can interlock to support the entire development process. The achievement of this goal facilitates the benefits of increased enterprise integration, flexibility, and responsiveness (Mayor et al., 1985). Fig. 4-18 displays part of an IDEF system engineer’s toolbox.

Figure 4-18: IDEF Methods

(Source from Mayer et al., 1995)
The main concepts of IDEF are the activity and the flow (IDEF0, 1993). Each activity in the process transforms an information input into an output. An arrow line represents a flow and it can be used as an input, an output, a control or a mechanism depending on where it enters the box from. IDEF diagrams are hierarchical, with diagrams at lower levels representing more detailed activities than those at the higher levels (Karhu, 2001). Fig. 4-19 (a) shows the notation of the IDEF method; Fig. 4-19 (b) shows an example of an IDEF diagram.

**Figure 4-19:** The Basic Concept of the IDEF Method (a) IDEF Notation (b) The Hierarchy of the IDEF Diagram

(Adapted and sourced from www.idef.com).

Because IDEF diagrams do not apply the time concept, it cannot derive a logical sequence of activities and cannot be used to model branching explicitly (SofTech, Inc. 1981). The IDEF appears superficially to be deceptively simple in its presentation and use (Austin *et al.*, 1999). Therefore, they require clear understanding in order to be used effectively. Also IDEF is very flexible in a sense that it can be used to model a large number of different processes at a specific level or at a more general level. Austin *et al.* (1999) indicated that the common features of an IDEF and a DFD are:

- They possess a top-down nature, so that the top levels can be read to obtain an overview of the system and if more detail is required, the lower levels can be studied;
- The models are of a manageable size;
- They represent a system from a viewpoint of data rather than a viewpoint of an organisation;
- The consistency of the diagram can be easily checked;
• They can model iterative procedures;
• They can model the aspect of choice; but
• They do not describe how a task should be done, just what is needed to perform that task and what it needs to transform into; and
• They do not show the sequence of activities.

4.5.5 Generic Process Modelling (GPM) Method

The basic idea of the GPM is that a number of views can be generated from a single model to serve different needs and requirements (Karhu, 2001). Fig. 4-20 illustrates that a simple flow diagram, a schedule and an IDEF can all be the GPM views.

GPM uses object-oriented principles and has borrowed features, such as activity, task, and temporal dependency from methods like IDEF and scheduling (Karhu, 2000). GPM is flexible that the conceptual model can be changed to achieve additional special features (Austin et al, 1999). One of the essential features of GPM is the distinction between activities and tasks, whereas tasks are activities with additionally specified starting and finishing times, duration and location (Karhu, 2001). Moreover, a task has a type-attribute that refers to an activity where its overall template is defined. This explained in Table 4-2. It explained the main entities, the attributes of the GPM and its views. It showed GPM’s advantages by combining the contents of GPM views.

**Figure 4-20: GPM Views**

(Adapted from Karhu, 2001)
Table 4-2: Comparison of GPM Views

<table>
<thead>
<tr>
<th>GPM</th>
<th>Scheduling</th>
<th>Simple flow</th>
<th>IDEF</th>
</tr>
</thead>
<tbody>
<tr>
<td>Activity</td>
<td>-</td>
<td>Activity</td>
<td>Activity</td>
</tr>
<tr>
<td>Task</td>
<td>Task</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Task type</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Activity decomposition relationship</td>
<td>Activity decomposition relationship</td>
<td>-</td>
<td>Activity decomposition relationship</td>
</tr>
<tr>
<td>Flow object</td>
<td>-</td>
<td>flow</td>
<td>Icon</td>
</tr>
<tr>
<td>Input</td>
<td>-</td>
<td>Input of</td>
<td>Input</td>
</tr>
<tr>
<td>Output</td>
<td>-</td>
<td>Output of</td>
<td>Output</td>
</tr>
<tr>
<td>Control</td>
<td>-</td>
<td>-</td>
<td>Control</td>
</tr>
<tr>
<td>Mechanism</td>
<td>-</td>
<td>Person</td>
<td>Mechanism</td>
</tr>
<tr>
<td>Resource</td>
<td>Resource</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Flow object</td>
<td>-</td>
<td>Flow dependency relationship</td>
<td>Icon dependency relationship</td>
</tr>
<tr>
<td>State</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Temporal dependency</td>
<td>Temporal dependency</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Dependency classification</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Location</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

(Source from Whitten, 2004)

GPM can be used for process improvement, process management, and for enhancing communication in a demolition process. The prototype application was called a GPM browser (Karhu, 2001). The browser was used to create a complete model of GPM (Karhu, 2000). In practice, it is appropriate to use separate and often well-developed software applications to generated partial models (Slack et al., 2004). Fig. 4-21 showed schematically the data exchange with a number of other tools that correspond to the GPM views.

Figure 4-21: GPM Structure

(Source from Karhu, 2001)
Having reviewed these five process modelling methods for construction management process modelling, the study came to the decision to use the DFD method for mapping demolition processes. This was because the DFD could accurately describe the demolition process workflow; it identified any parties involved at any stage during the processes; and identified any constraints and / or legal documents required at any level of a process. It also gave a clear picture and awareness of the process inputs and outputs from one process to another process.

4.6 Development of the Demolish-IT System

4.6.1 Plan for Developing Demolish-IT

The plan for developing the Demolish-IT system prototype for management of demolition process involved the following four steps:

Step 1: Involved the use of the standard process map as a logic model for Demolish-IT system.
In order to successfully create a new tool for demolition process management, existing methods were investigated and analysed before advanced ICT was applied to. The research conducted a multiple-case study investigation of currently used demolition processes and sub-processes by UK industry, to generate a standard demolition map by using a standard tree map model and mapping the processes and sub-processes by using the DFD modelling method. This is described in detail in chapter five.

Step 2: Adopted a user-defined project process as a physical model for Demolish-IT system.
For particular demolition projects, the process will have to be changed depending on the differences of project specification. But the project process defined by the demolition contractor must be in compliance with the standard demolition process. This user-defined process maps were generated using Microsoft Project as scheduling map or represented by an event process map.

Step 3: Employed a database solution for demolition process requirements.
Demolition process requirements involve many parties such as the client, contractor, sub-contractors, legal documentation, etc. This research applied a database solution to manage these requirements and restore them to a unified structured database, in order to apply it to the Demolish-IT when system operation is needed.
Step 4: Final prototype of Demolish-IT design.

The system of Demolish-IT is a better solution to demolition process management. It processes the function of intelligent support for the management of dynamic demolition engineering processes, whilst ensuring that demolition specification and performance are compliant with particular industry standards. This research applied a four-tier model to the Demolish-IT prototype. And a system compliance flow concept was used to ensure that system operation followed standard practice as closely as possible to achieve the optimum results.

4.6.2 A Development Model for Demolish-IT

A general model of the development process is shown in Fig. 4-22. This illustrates the strategy used to develop the Demolish-IT system.

Figure 4-22: The Strategy for Developing the Demolish-IT System

4.7 Chapter Summary

This chapter studied in detail the theory of process management and information system development. This knowledge gave a guideline to develop the research strategy for this research project, and helped to develop a step by step research plan. In turn, a framework for developing processes and content within Demolish-IT were established. For the purpose of modelling demolition processes, process modelling methods for demolition are also studied in detail. According to the strategy, the following chapters represent the implementation phase of the research work.
5 Demolition Process and Sub-process Mapping

5.1 Introduction

The demolition process was frequently described as ‘dynamic’ during face to face semi-structured interviews with demolition engineers. This attitude illustrates that most managers and engineers employed within demolition companies do not have a process map that exactly described what the full spectrum of demolition processes are, or how those maps can be used to improve the demolition process management.

Within the construction industry, the generic process mapping of construction and design process reengineering has helped to clarify the current design and construction process and has led to a significant improvement in the performance of the industry within the UK (Aouad et al., 1998; Baldwin et al, 1999). A process map visually depicts the sequence of events to build a product or produce an outcome (Lee and Brad, 2007). It is simple, intuitive and easy to use, even by untrained people (Burton, 2001). In order to better understand the demolition process and in so doing, significantly improve the demolition process management and bottom-line performance, it is necessary to apply the concepts of process re-engineering and process mapping within the demolition industry.

This chapter develops demolition process maps by understanding and reengineering the existing demolition processes. These process maps are described in workflow diagrams and supporting text. Significantly, this is the first time that such activity has been conducted within the demolition sector.

5.2 Process Mapping

Process maps and flowcharts help to make the working process transparent and increase visibility; and also improve communication and understanding within an organisation (Dandelion, 1996). Wilson and Hardin (1998) developed and introduced tools such as relationship maps, cross-functional process maps and flowcharts to clarify and managing work processes. Those three tools are detailed in Table 5-1.
Table 5-1: Description of Tools for Process Mapping

<table>
<thead>
<tr>
<th>Classification</th>
<th>Definition</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>Relationship map</td>
<td>Show the customer-supplier relationship or linkage between parts of an organization.</td>
<td>• Big picture view; and • Portrays how the major functions of the business interact with one another.</td>
</tr>
<tr>
<td>Cross-function map</td>
<td>Show how an organization’s major work process cut across several functions.</td>
<td>• Reveals what goes on inside the organization’s functions; • Shows sequence of steps that make up the work process; and • Provides inputs and outputs associated with each step.</td>
</tr>
<tr>
<td>Flowchart</td>
<td>An outline process map that provides a basic view of all the actions undertaken by simply setting out the sequences of activities and decision points.</td>
<td>• Provides basic overview of processes; • Identifies individual performance of work; • Defines detailed level document and analysis process; • Shows who does what; • Illustrates how process moves between person and agency; and • Develops a procedure for accomplishing a specific job responsibility.</td>
</tr>
</tbody>
</table>

(Source from Beard and Martin, 2004)

Process maps have many functions and advantages in the process management domain (Graham, 2004). Some of which are:

- They provide a common frame of reference for those involved with the work process and help document current pathways to customer satisfaction.
- They can be used to analyse the processes to increase productivity.
- They can draw organization charts for businesses which is a useful tool for communication.
- They can organize work where work is completed by people who are performing one or more steps of a process.
- They can clarify roles and contributions (such as the outputs (services and products) of the organization).
- They can identify improvement opportunities, for example, relationship and cross-functional maps can help to discover opportunities to do work better, quicker and using less resources.
- They can help measure performance. For example, by using maps to illustrate and understand how a given process impacts another process. It sets a benchmark that can help the entire organization manage its operations in real time, rather than relying on a final output measure (Graham, 2006).
Process mapping involves describing each process in terms of how the activities within the process relate to each other. Hunt (1996) stated that:

“Process mapping provides tools and a proven methodology for identifying your current “as-is” business process and can be used to provide a “to-be” roadmap for reengineering your product and service business-enterprise functions”.

Galloway (1994) has described process mapping as a management tool and approach that defined critical process needs and allowed business needs to be identified and prioritised so that necessary improvements to business performance can be made.

The function of process mapping has been explained by Beard and Martin (2004) as an exercise to identify all the steps and decisions in a process but in diagrammatic form which:

- Describe the flow of materials, information and documents;
- Display the various tasks contained within the process;
- Show the tasks that transform inputs into outputs; and
- Demonstrate the essential relationship and interdependence between the process steps.

Process mapping offers an easy and quick way for people to find the information they need to do the job properly and efficiently (Nelson et al., 1999). It is a tool for process documentation and improvement. Therefore, process mapping has been widely applied to business process management and has led to significant improvements in business performance (Sousa et al., 2002). Table 5-2 lists some the examples of process mapping applications that have been successful in construction process management.

**Table 5-2: Examples of Process Mapping Applications in Construction Management Science**

<table>
<thead>
<tr>
<th>Application name</th>
<th>Description to the application</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>A model of the detailed building design process.</td>
<td>✓ Clarifying construction design process. ✓ Containing inevitable cycles of rework together with associated time and cost penalties in both design and construction.</td>
<td>Austin et al (1999)</td>
</tr>
<tr>
<td>DFD for the process of on-site plant health and safety management.</td>
<td>✓ DFD for the specific health and safety process. ✓ DFD for accident investigation and in-house training.</td>
<td>Riaz (2008)</td>
</tr>
</tbody>
</table>
5.3 Development of the Generic Demolition Process Map

Creating a Generic Demolition Process Map (GDPM) is one of the main tasks set out at the outset of this research. The GDPM should be a structured, visible and provide a clear picture of the demolition process.

The aims of creating the GDPM are: (1) to generate the management system Demolish-IT; (2) to better understand the demolition process; and (3) to further improve industry performance when undertaking demolition project. This section explains the methodology and strategy for developing the GDPM. Fig. 5-1 is the plan of creating GDPM by using the DFD.

**Figure 5-1:** Multiple Case Study Approach to Mapping the Demolition Process
Fig. 5-1 explains the process of developing the GDPM through research. From left to right, the research involved creating a GDPM commences with the collection of current demolition process information used within the UK industry. For this task, initial primary data was sought from relevant trade bodies and companies within industry and relevant standards. A multiple case study approach adopted sought to identify current processes used in the industry. The limitations of these processes with legislation and physical requirements were identified and thereafter a conclusion illustrated (via the process map) the restraints in each process, in order to reach the best practical process map. Then the process mapping commenced.

Fig. 5-1 also illustrates the methodology of generating the fundamental elements of GDPM by DFD. The initial generic demolition process can be identified from reviewing all relevant literature on demolition processes, and then a multiple case study approach was applied to explore the knowledge contained within current demolition processes. The multiple case studies used three techniques as part of a case study, which are (1) semi-structured interviews; (2) direct site observation; and (3) examination of the project documents. This multiple case study collected the information on generic demolition processes within industry. These three methods were also used to the information correction later on to limit the number of constraints in the process operation. This ensured that demolition process maps generated represented industry best practice.

5.3.1 Current Demolition Processes in Practice

The sampling strategy for the examination of project documents is to choose three random projects from three demolition contractors. These three projects include one large project (defined as having a contract value of over £1 million UK Sterling, 2008) and two medium projects (defined as having a contract value of about half million pounds to a million pounds UK sterling, 2008). The projects were managed by three leading demolition contractors from the South and the Midlands regions. Table 5-3 provides a summary of the sample projects used for the multiple case studies. Samples project documents used and interview transcripts with participants can be found in Appendix A.
The multiple case study identified four main project operation stages in the demolition process, which are shown in Fig. 5-2 as the: (1) tendering stage; (2) pre-demolition stage; (3) actual demolition stage; and (4) post demolition stage represented by S1 (Stage 1), S2 (Stage 2), S3 (Stage 3) and S4 (Stage 4). Each stage contains several main processes for the demolition operation which are expanded in Fig 5-3, Fig. 5-4, Fig. 5-5 and Fig. 5-6, and each main process in the stages are represented by P1-1 (the first process in tendering stage), P1-2 (the second process in tendering stage), P1-3,…,P1-7; and P2-1 (the first process in pre-demolition stage), P2-2, …, P2-6; and P3-1 (the first process in actual demolition stage), P3-2,…, P3-6 and P4-1 (the first process in post demolition stage), P4-2, …, P4-4.

**Table 5-3:** Sample Projects Used for the Multiple Case Studies

<table>
<thead>
<tr>
<th>Project</th>
<th>Project location</th>
<th>Project tasks</th>
<th>Contractor name</th>
<th>contractor region</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project 1</td>
<td>Platt Lane, Keyworth, Notts, NG12 5GG.</td>
<td>Asbestos removal, demolition blocks A, B and C, site clearance.</td>
<td>Total Reclaim Demolition Ltd</td>
<td>Midland region.</td>
</tr>
<tr>
<td>Project 3</td>
<td>Cargate Water Reservoir, Aldershot, Hunt's QU11 3EL</td>
<td>Demolition and site clearance.</td>
<td>C.G. Comley and Sons Ltd.</td>
<td>Southeast region.</td>
</tr>
</tbody>
</table>

**Figure 5-2:** Four Main Stages of the GDPM in a Demolition Operation
Figure 5-3: Demolition Processes in the Tendering Stage

- Bid invitation (P1-1)
  - Go to Sub-process
- Knowledge of the site (P1-2)
  - Go to Sub-process
- Risk assessment (P1-3)
  - Go to Sub-process
- Selection of demolition techniques (P1-4)
  - Go to Sub-process
- Method statement (P1-5)
  - Go to Sub-process
- Cost estimate (P1-6)
  - Go to Sub-process
- Bid submittal (P1-7)
  - Go to Sub-process

Go to Sub-process

Figure 5-4: Demolition Processes in the Pre-demolition Stage

- Documentation and Notification (P2-1)
  - Go to Sub-process
- Health and Safety Plan (P2-2)
  - Go to Sub-process
- Method statement (P2-3)
  - Go to Sub-process
- Site preparation (P2-4)
  - Go to Sub-process
- Plant preparation (P2-5)
  - Go to Sub-process
- Waste management (P2-6)
  - Go to Sub-process
Figure 5-5: Processes in the Actual Demolition Stage

Figure 5-6: Processes in the Post-demolition Stage

Each main process then contains several sub-processes to complete the demolition project. Each sub-process also consists of numerous activities during the operation of the demolition project. For example, fulfilling the pre-qualification questionnaire to: appoint a project contractor; and to obtain legal documents from the Local Authority to permit the demolition works, etc. Those sub-processes and activities are detailed in Table 5-4. Table 5-4 provides a summary of the results from the multiple case studies. It shows currently used demolition processes, sub-processes and demolition process activities. It also serves to illustrate the complexity of the demolition processes.
### Table 5-4: Contents of Current Operational Demolition Processes and Sub-processes

<table>
<thead>
<tr>
<th>Tendering Stage $S_1$</th>
<th>Main process</th>
<th>Sub-process</th>
<th>Process activity</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>P1-1 Bid invitation</strong></td>
<td>P1-1-1 Bid invitation letter and P1-1-2 Contract.</td>
<td>✓ General information of the project from pre-tendering place and contract condition.</td>
<td></td>
</tr>
<tr>
<td><strong>P1-2 Knowledge of the Site</strong></td>
<td>P1-2-1 Desk study; and P1-2-2 On-site survey.</td>
<td>✓ Studying the design data; ✓ Studying the construction data; ✓ Studying the environment data; ✓ Inspection of site environment; ✓ Inspection of structures and Asbestos survey.</td>
<td></td>
</tr>
<tr>
<td><strong>P1-3 Risk assessment</strong></td>
<td>P1-3-1 Finance risk estimate; P1-3-2 Constraints risk assessment; P1-3-3 Environmental aspects; and P1-3-4 Project risk assessment.</td>
<td>✓ Mechanical risk assessment; ✓ Deconstruction and ✓ Environmental impacts.</td>
<td></td>
</tr>
<tr>
<td><strong>P1-4 Selection of demolition techniques</strong></td>
<td>P1-4-1 Client specification; P1-4-2 Physical factors; P1-4-3 Time constraint; P1-4-4 Environment considerations; P1-4-5 Health and safety requirement; P1-4-6 Refurbishment and P1-4-7 Partial demolition.</td>
<td>✓ Finance estimate; ✓ Time scale requirement; ✓ Stability of structure; ✓ Location and accessibility; ✓ Specific shape and size of the structure; ✓ Structural engineer approval; ✓ Extent of demolition; ✓ Transportation considerations; ✓ Availability of plant or equipment; ✓ Health and safety consideration; ✓ Recycling consideration; ✓ Presence of hazardous and ✓ Environmental consideration.</td>
<td></td>
</tr>
<tr>
<td><strong>P1-5 Method statement</strong></td>
<td>P1-5-1 Progressive demolition; P1-5-2 Deliberation collapse mechanism; P1-5-3 Deliberation removal of element or deconstruction; P1-5-4 Refurbishment; and P1-5-5 Pre-Weakening.</td>
<td>✓ High reach machine with attachment; ✓ Demolition bale ✓ Explosive; ✓ Wire rope pulling; ✓ Demolition by hand and ✓ Demolition by machines.</td>
<td></td>
</tr>
<tr>
<td><strong>P1-6 Cost estimate</strong></td>
<td>P1-6-1 Site overhead cost; P1-6-2 Decommissioning cost; P1-6-3 Soft stripping cost; P1-6-4 Waste disposal cost; P1-6-5 Structural demolition cost for progressive demolition; P1-6-6 Structural demolition cost for deliberation collapse mechanism; P1-6-7 Structural demolition cost for deconstruction and P1-6-8 General overhead cost.</td>
<td>✓ Temporary structures, facilities and services; ✓ Personnel protection equipment; ✓ Site clearing up; ✓ Asbestos remove; ✓ Contaminated substance removal; ✓ Disconnecting services; ✓ Soft stripping cost(sheet of toilets, sinks, roof, tiles, ceiling, doors, windows); ✓ Crushing on site; ✓ Trucking/tripping cost ✓ Labour cost (general labour, site supervisor and manager); ✓ Office administrator; ✓ Welfare facilities; ✓ Accommodation; ✓ Insurance ✓ Building permit; ✓ Study board and ✓ Equipment cost (machines, hand tools, machine attachments, explosion cost and scaffolding cost).</td>
<td></td>
</tr>
<tr>
<td><strong>P1-7 Bid submittal</strong></td>
<td>P1-7-1 Competence, experiences and management.</td>
<td>✓ Prequalification questionnaires ✓ Contractor's qualification, track records.</td>
<td></td>
</tr>
</tbody>
</table>
### Chapter 5 Demolition process and sub-process mapping

<table>
<thead>
<tr>
<th>Pre-demolition Stage S2</th>
<th>P2-4 Documentation and notification</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>P2-1-1 Obtain section 86(6)(2) notification from Local Council</td>
</tr>
<tr>
<td></td>
<td>P2-1-2 Posting of courtesy notices advising of the impending demolition to all properties situated to the boundary of the site and those adjacent to the site</td>
</tr>
<tr>
<td></td>
<td>P2-1-3 Obtain service termination confirmation notice from appropriate authorities</td>
</tr>
<tr>
<td></td>
<td>P2-1-4 Issue of written confirmation of services to acquired parties</td>
</tr>
<tr>
<td></td>
<td>P2-1-5 Compilation of H&amp;S plan</td>
</tr>
<tr>
<td></td>
<td>P2-1-6 Prepare demolition method statement</td>
</tr>
<tr>
<td></td>
<td>P2-1-7 Prepare site file</td>
</tr>
<tr>
<td></td>
<td>P2-1-8 Obtain subcontractors’ method statement</td>
</tr>
<tr>
<td></td>
<td>P2-1-9 F101 notice to HSE and</td>
</tr>
<tr>
<td></td>
<td>P2-1-9 A/5055 notice</td>
</tr>
</tbody>
</table>

|                         | ✓ Notification forms, textures and signs; |
|                         | ✓ CDM Regulation 2007; |
|                         | ✓ Building Act 1994 section 80(6); |
|                         | ✓ BS 5187:2000; |
|                         | ✓ COSHH regulation written confirmation |
|                         | ✓ Health and Safety Plan |
|                         | ✓ Fully detailed demolition and sub-contractor’s method statement |
|                         | ✓ F10 for HSE and |
|                         | ✓ AS 5 for HSE |

|                         | P2-1-2 Project in general |
|                         | P2-2-2 Programme of the works; |
|                         | P2-2-3 Existing services; |
|                         | P2-2-4 Access and egress; |
|                         | P2-2-5 Safety procedures and arrangement; |
|                         | P2-2-6 Identify the hazards; |
|                         | P2-2-7 Operatives and training; |
|                         | P2-2-8 Personal protection equipments (PPE); |
|                         | P2-2-9 Welfare arrangement to sites |
|                         | P2-2-10 Project management teams |
|                         | P2-2-11 Public/other employees safety; |
|                         | P2-2-12 Project resource; and |
|                         | P2-2-13 Special works. |

|                         | ✓ BGS for site location; |
|                         | ✓ General work list; |
|                         | ✓ Documentation and notification; |
|                         | ✓ Site setup; |
|                         | ✓ Service hazards investigation and protection; |
|                         | ✓ Removal of contaminant/hazardous substances; |
|                         | ✓ Demolition; |
|                         | ✓ M&E isolation/disconnection; |
|                         | ✓ CATGPR scan by specialist contractor; |
|                         | ✓ Electric equipments on site; |
|                         | ✓ Water drain layout on site; |
|                         | ✓ Existing traffic use and restriction; |
|                         | ✓ Internal traffic system; |
|                         | ✓ Controls at access/gress point; |
|                         | ✓ Operative awareness; |
|                         | ✓ Danger demolition sign and exclusion zone; |
|                         | ✓ Special care (fire, hot and cold cutting works); |
|                         | ✓ Site clear maintenance; |
|                         | ✓ Hazard lists (occupied facilities, premature collapse, fire, height works); |
|                         | ✓ Risk assessment of site hazards; |
|                         | ✓ COSHH and risk assessment; |
|                         | ✓ Type three Asbestos Survey; |
|                         | ✓ H&S Plans |
|                         | ✓ Site induction list; |
|                         | ✓ Tool box talk; |
|                         | ✓ All site personnel; |
|                         | ✓ Hot cutting operatives; |
|                         | ✓ Height operatives; |
|                         | ✓ Asbestos removal (Licensed and non-Licensed); |
|                         | ✓ Site office; |
|                         | ✓ Site welfare facilities; |
|                         | ✓ Project management team and person contact detail; |
|                         | ✓ Site fence; |
|                         | ✓ Adjacent properties’ list and protection list; |
|                         | ✓ Public dwelling path protectors; |
|                         | ✓ Required machines, equipments and tools list; |
|                         | ✓ Equipments check list; |
|                         | ✓ Fire caution; |
|                         | ✓ Crushing stations; |
|                         | ✓ Waste removal work; and |
|                         | ✓ Noise work.
### Chapter 5 Demolition process and sub-process mapping

#### To be continued from previous page

<table>
<thead>
<tr>
<th>Pre-demolition stage</th>
<th>S2</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>P23 Demolition method statement</strong></td>
<td>Site supervisor's duties; Site compounds layout plans; Welfare Facilities; Written confirmation to isolation the M&amp;E; Written confirmation to disconnection or capping off the service (Gas, Electricity and water); Electrical competence contractors for central and task lighting; Hiring steel lockable unit; Welfare cabin; Store for tools and materials; First Aid; Medicine assistants; Emergency plans; Site boundary layout plans; Highly visible marks for danger zones; Method and procedures for removal those elements and items; Procedures and transport arrangement for move them out from site; Identify and mark the drains run on the site; Handling damping down procedures for dust generation from; Demolition; Locations; Procedures and protections; Forms of the sample, location, material type and method to removal them; Marks on the site; Hand separation works; Mechanical demolition the structures; Environmental monitor; Crushing procedures; and Procedures to all machine involved in the demolition.</td>
</tr>
<tr>
<td><strong>P24 Site preparation</strong></td>
<td>Welfare facilities list and positions; Segregation signing of internal traffic rout and Site boundary fence plan.</td>
</tr>
<tr>
<td><strong>P26 Plant and equipment preparation</strong></td>
<td>List and Procedures for used plant and machines; Check list and Forms and PPE list and checking forms.</td>
</tr>
<tr>
<td><strong>P36 Waste management</strong></td>
<td>Calculate the amount of reuse and recycle material items, elements and units; Transport arrangement; and Water to landfill regulations, form and documentation.</td>
</tr>
</tbody>
</table>
## Chapter 5 Demolition process and sub-process mapping

### Actual demolition stage

<table>
<thead>
<tr>
<th>Section</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>P3-1 Service/hazardous investigation and protection</td>
<td>P3-1-1 Carry out CAT scan; P3-1-2 Layout of drainage; P3-1-3 Public sewers protection; and P3-1-4 Animals and plants protection.</td>
</tr>
<tr>
<td>P3-2 Site and plant set up</td>
<td>P3-2-1 Installation of welfare facilities; P3-2-2 Implementation of site fire plan including fire assembly point; P3-2-3 Installation-segregation/signing of internal traffic route and access/egress point; P3-2-4 Erection of site fencing; P3-2-5 Designation of machine over-night secure zone; P3-2-6 Designation of internal vehicle turning points; P3-2-7 Designation of site parking facilities; P3-2-8 Designation of further zones as required; P3-2-9 Scaffolding set up; and P3-2-10 Cranes set up.</td>
</tr>
<tr>
<td>P3-3 Removal of contaminants/hazardous substances</td>
<td>P3-3-1 ACM's and CFC's; P3-3-2 MMMF (Men Made Mineral Fiber); and P3-3-3 Glazing.</td>
</tr>
<tr>
<td>P3-4 Soft stripping</td>
<td>P3-4-1 Kinds of elements separation (Hot cutting); P3-4-2 Prevent fire from combustible material; P3-4-3 Prevent damage of structure; and P3-4-4 Use of Mechanic plant.</td>
</tr>
<tr>
<td>P3-5 Recycle and reuse</td>
<td>P3-5-1 Materials; P3-5-2 Structural elements; and P3-5-3 Doors, windows, sanitary ware units, etc.</td>
</tr>
<tr>
<td>P3-6 Structural demolition</td>
<td>P3-6-1 Structural demolition in pre-determined sequence; P3-6-2 Mechanical demolition; P3-6-3 Environmental monitoring; P3-6-4 Partial demolition; and P3-6-5 Completion works.</td>
</tr>
</tbody>
</table>

### Post demolition stage

<table>
<thead>
<tr>
<th>Section</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>P4-1 Site clearance</td>
<td>P4-1-1 Clearance site to suitable standard.</td>
</tr>
<tr>
<td>P4-2 final sign off</td>
<td>P4-2-1 Handover certificate.</td>
</tr>
<tr>
<td>P4-3 Contract document filed</td>
<td>P4-3-1 Contract; P4-3-2 Health and Safety file; P4-3-3 Method statement; and P4-3-4 Finance report.</td>
</tr>
<tr>
<td>P4-4 Post contract review</td>
<td>P4-4-1 Review report.</td>
</tr>
</tbody>
</table>

- Marks the finding;
- Road plate to protection; and
- Other protection.
- Liaise with any adjoining properties to make them aware of the work;
- Site layout;
- All license for specific area from local authority; and
- Site file (F10, H&S Plan, method statement, site rule, risk assessment, first aid, site induction list, section 80 form, etc).

- Soft stripping methods notes for site induction and tool box talk;
- toilet, doors, windows, roof tiles, ceiling;
- interior walls/partition. Separate;
- PPE provided; and
- Material and items removal from the site.

- Method and procedures.
- Mechanical demolition procedure;
- Breaking up of concrete slabs;
- Grubbing up the foundations;
- Crushing of clean inert materials;
- Dictate the damping down procedures;
- Monitoring the noise dust level;
- Ccreation of split lines; and
- Review report for the certification

- Certificate of completion.
- Percentage of profit.
- Detailed records of information on the project.
5.3.2 Problems with Current Management of Demolition Process

Because of the inherent complexity of demolition processes coupled with and generally accepted poor management of demolition process throughout the industry, a series of problems continually plagued demolition contractors; these are:

- **Demolition process management:** project complexity introduces many constraints upon the contractor and as a result, the project may be time consuming. In addition, a lack of communication combined with an ineffective system of process management resulted in ineffective process implementation.
- **Demolition process:** often managers and workers did not have a clear overview of the ongoing demolition process; consequently difficulties arise when implementing the process on site.
- **Information communication:** lack of project information from the client and ineffective communication from management to workers.
- **Training:** inadequate worker training led to inadequate knowledge of the demolition process.

Fig. 5-7 represents a cause and effect diagram that summarizes the problems with current demolition process management. In Fig 5-7, the words in italic represent the initial cause; the bold font represents both the effect from the initial cause and also the ‘knock-on’ cause of the next effect that is represented by bold text in the rectangular frame.

**Figure 5-7:** Problems of Demolition Process Management Using a Cause and Effect Diagram
A process map has the capability to solve these problems (Beard and Martin, 2004). GDPM can be well-structured, visible, and clarifies the generic demolition processes. This indicates that it is necessary to develop GDPM to demolition industry.

5.3.3 Demolition Process Mapping Development Strategy

The previous section indicated that the essential problems in demolition process management are that the process itself is not clearly presented to practitioners within the demolition industry. Process mapping aims to clarify this complex area by developing a GDPM that could be used by any demolition contractor. The strategy adopted is readily described in five steps below, and illustrated and justified in Fig. 5-8 and explained in Table 5-5.

A five steps strategy to develop the GDPM:

1. Collect information on currently used demolition processes;
2. Acquire knowledge of demolition processes and sub-processes;
3. Identify and validate the current demolition processes;
4. Generate a demolition map from the best practice studied; and
5. Model the generic demolition process via the process mapping technique.

Table 5-5: The Strategies to Develop the GDPM

<table>
<thead>
<tr>
<th>Development steps</th>
<th>Research approach description</th>
</tr>
</thead>
</table>
| 1. Collecting the information on current demolition processes. | • Literature from existing texts and relevant research projects; and  
• Project documents from the multiple case studies. |
| 2. Acquiring knowledge of demolition processes and sub-processes. | • Comparison to the three projects on current demolition process and sub-processes; and  
• Analysis of the three projects on current processes. |
| 3. Identifying and validating of the current demolition processes. | • One to one interviews with three leading experts;  
• Specific questionnaire investigation; and  
• Using a combination of the questionnaire investigation, expert views and site observation results. |
| 4. Generating of a new demolition process from the best practice studied. | • Identification of demolition constraints and process limitation of constraints; and  
• Generate the logical demolition process. |
| 5. Completing of the generic demolition process maps. | • Generic demolition process and sub-process map. |
5.4 Modelling Demolition Processes

A key part of improving processes is defining the sequence of activities undertaken by company policy, as necessary steps prior to any development of new joint working procedures, particularly combined processes (Havey, 2005). According to this axiom, this section describes the demolition process modelling method for generating the GDPM.

5.4.1 Demolition Process Elements and GDPM Levels

The overview of detailed GDPM is defined in terms of a number of sub-processes and demolition activities. Through the multiple case studies, a hierarchy of the demolition sub-processes was established. The GDPM elements consist of the four main stages which are illustrated as Fig. 5-9 and are explained as follows:
1. At the tendering stage, the contractor prepares a bid for a demolition contract. This involves (1) bid invitation; (2) knowledge on site; (3) risk assessment; (4) selection of demolition techniques; (5) method statement; (6) cost estimate; and (7) bid submittal. The client is required to write a project contract which includes general information about the project, a health and safety plan, etc. The Demolition Contractor must then provide the pre-qualification questionnaire to ensure that they meet the requirements of the demolition project.

2. During the pre-demolition stage, and after the contract has been approved, but before work on site commences, the demolition contractor needs to obtain all legal documents required for demolition. This involves obtaining the (1) legal documentations and notifications; (2) compilation of the health and safety plan; (3) selecting the most appropriate demolition technique; (4) a demolition method statement; (5) a plan for site and plant preparation; and (6) a waste management strategy.

3. During actual demolition stage, works begins in earnest on site. The processes involved at this stage are (1) services disconnection by selecting the appropriate competent company and hazard protection; (2) establish site and plant set up; (3) remove contamination sources and hazards (including licensed asbestos removal); (4) soft stripping (such as the elements and items apart from structure element); (5) recycle any reusable materials and structural elements; and (6) structural demolition.

4. Fourth processes are apparent at the post-demolition stage, these are (1) site clearance to a suitable standard, in order to obtain the certificate of completion for the project; (2) signing finances off to obtain payment for completion of the demolition project; (3) creating the
project documentation file which includes the health and safety file, contract, method statement and the financial report for experience evidence; and (4) a post contract review for final report.

The GDPM contains three process levels, level 1, 2 and 3 which are illustrated in Fig. 5-10.

*Level 1* is high level process that contains four main stage processes as identified in Fig. 5-9, which are tendering, pre-demolition, actual demolition and post demolition.

*Level 2* contains the sub-processes of the original processes at level 1, the process level two are major processes shown in Fig. 5-9 as four columns of elements.

*Level 3* contains the demolition process activities of level 2.

These three levels of the demolition process should comply with the demolition process requirements. The requirements of process activities will be discussed in detail later in chapter six.

**Figure 5-10: Processes Levels**

In the GDPM, two types of logic relationships exist, which are process decomposition and process logical dependency and these are used in the process mapping. Fig. 5-11 illustrates that a high level process can be decomposed into several lower level sub-processes. For example, the process of tendering (a defined stage) consists of seven decomposed sub-processes as listed that showed in Fig. 5-9. The relationship of logical dependency can be explained in a demolition process. i.e. one high level demolition process (Level 1 process A) is dependent on the
completion of another lower demolition process (Level 2 processes B, C and D). Fig. 5-12 provides an illustration of a dependent relationship between process A1 and A2. In practice, this means the demolition process A2 should be carried out after A1 completed, iteratively as they are dependent upon one another.

**Figure 5-11:** Process A is Composed by Process B, C and D

![Process A Level 1](image)

**Figure 5-12:** Process A2 is dependent on process A1

![Logical dependency](image)

### 5.4.2 Tools for GDPM and Process Mapping

IT creation tools should enable the production of a project process map. Although a range of software tools are available (refer to the section 4.4.2), this study chose ‘MindGenius’ as the modelling tool to create the demolition process tree map, and MS Visio to map the demolition processes, which are presented by DFD. These software tools were chosen because their functions include data retrieval, map creation and map customization. Users are able to define their processes and create their user-defined project process map by referring to the generic process provided by the standard process map.

Fig. 5-13 illustrates the modelling tools adopted to generate the GDPM and the arrow indicates ongoing direction of the generating procedures. The research used MindGenius, Microsoft Visio and Microsoft Word as modelling tools to place the generic demolition process in a unified standard demolition process map via creation process. The GDPM can be represented by a standard tree map, a decomposition system map and MS Project map. Generated GDPMs are detailed in Appendix B.
5.5 Demolition Processes and Sub-processes Mapping

5.5.1 DFD Process Mapping

DFD is a significant modelling technique for analyzing and constructing information processes, which has been widely used in business process mapping (Luo and Tung, 1999). Examples of DFD applications in process mapping together with its benefits are listed in Table 5-6.

<table>
<thead>
<tr>
<th>Application</th>
<th>Benefit</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Riguzzipersport (whole sales sport) An entity relationship through a network of branches.</td>
<td>Effectively delivered the actual price.</td>
<td>(Riguzzi, 2003)</td>
</tr>
</tbody>
</table>
| ISRA calendar application NET framework. | • Modify scheduler, event and group; and  
• High visible view calendar, event and group. | (Hodan, 2006) |
| “knowledge age” distributed process. | • Increased the global network capabilities; and  
• Highly visible and easy understand. | (Ranky, 1998) |
| Auction process (relationship between buyers, sellers and settlement system). | High level design for auction software. | (Kumar and Feldman, 1998) |
| Project management (Internet delay measurements using test traffic design note). | Software design for project. | (Uijterwaal and Kaeo, 2002) |
| Threat playsound model. | Threat playsound system. | (Osterman, 2007) |
Chapter 5 Demolition process and sub-process mapping

DFD represent data flows in a clear visual way as:

- *An arrow* between blocks represents a part and process of the system. The arrow explains the movement of information in a process.
- *A circle* represents a process that can be treated as an information system.
- *A rectangle* represents external agents involved in the businesses process and the data storage.

5.5.2 Demolition Process Mapping Using the DFD Method

Many parties are involved in a successful demolition process, such as the client, the contractor, the competent sub-contractor, etc. A demolition project is also constrained by many regulations and laws about the site and the real environment. A list of generic demolition processes does not illustrate any relationships between one process to another process, or any parties and constraints involved in the process. Yet, demolition processes have cross-functionality, which means that the fore-process must be completed in order to start the next process, which is simply illustrated as a functional map in Fig. 5-14. Fig 5-14 demonstrates that a functional map is not only difficult to display the relationship of each process, but is also impossible to indicate the sub-processes and all parties and constraints throughout the entire demolition process management system. This same figure also illustrates function flow and time flow to ensure the process is continues until it reaches the project goals.

Figs 5-15 to 5-18 inclusive were created by adopting the DFD method to overcome the problems associated with functional maps. These DFDs completed the analysis of demolition processes. Using DFDs in this way to map the demolition process is a novel application to the subject setting – such clarity of demolition process mapping has not been previously documented within the demolition literature.

There were several advantages of using the DFD method in this context, which include:

- It gives a clear picture of demolition processes and their relationships so that users can understand how a given process impacts on others;
- It indicates contractual parties and constraints involved in each process;
- It highlights pre- and post- conditions for each process, including documents and capacities needed; and
• It helps the entire organization to optimise its operation in overview.

**Figure 5-14:** Cross-functional Generic Demolition Processes Flow
Figure 5-15: DFD for the Tendering Stage Demolition Process

Chapter 5 Demolition process and sub-process mapping
Figure 5-16: DFD for the Pre-demolition Stage Demolition Process

- **Obtaining Documentation & Notification (P2-1):**
  - Notice advising of the impending demolition
  - All properties situated at the boundary of the site
  - Notice to local council
  - Approval by the Local Council
  - Section 80-82 of Building Act 1984

- **Develop Method Statement (P2-3):**
  - Demolished building information
  - Method statement references

- **Develop Health & Safety Plan (P2-2):**
  - Compilation of H&S plan
  - Fully detailed method statement and provision
  - Service termination confirmation
  - Confirmation notice from appropriate authorities
  - Relative policy to the demolition project
  - New H&S plan

- **Site Preparation (P2-4):**
  - Project site plan
  - Method statement for site set up
  - Site layout

- **Plant Preparation (P2-5):**
  - Method statement for project plants
  - Project plants plan
  - Plant list

- **Waste Management (P2-6):**
  - Method statement for Waste management
  - Reuse, recycle, landfill
  - Project waste management
  - Amount of waste to landfill
  - Environment Act 1995
  - Hazardous waste regulations 2005
  - Controlled waste regulations 1991
  - Material of metal, concrete, wood, etc rising up
  - Section 62

- **CDM 2007, H & S at work 1974, CAR 2006**

- **Local Council**
  - Approval by the Local Council
  - Notice to local council

- **Project H&S plan**
  - H&S plan for site
  - H&S plan to plant

- **Relative policy to the demolition project**
  - New H&S plan

- **Project Method statement**
  - Project method statement
  - New method statement

- **Controlled waste regulations 1991**
  - Environment Act 1995
Chapter 5 Demolition process and sub-process mapping

**Figure 5-17: DFD for the Actual Demolition Process**

[Diagram of the Actual Demolition Process with detailed steps and decision points.]

- **Services disconnection & Hazards protection (P3-1)**
  - Protection of public sewers, road plates used for protection of road damage
  - Principal contractor
  - Project initial
  - H&S plan, on site survey

- **Site & Plant set up (P3-2)**
  - Plan of welfare facilities, site fencing, vehicle turning points, traffic route, access/egress point

- **Removal of contaminants & Hazardous substances (P3-3)**
  - All findings (ACM’s, MMMF and glazing) from CAT scan of the site
  - Marks of the findings

- **Soft stripping (P3-4)**
  - Building structure
  - The method statement for soft stripping

- **Recycle & Reuse (P3-5)**
  - Arising of all kinds of materials from demolition building
  - Amount of the materials to recycle and reuse

- **Structural demolition (P3-6)**
  - Plant for structural demolition
  - The method statement for structural demolition

- **Waste management**
  - Plan to material reuse and recycle

- **CAT scan of the site**
  - Scan results
  - A competent contractor
  - The site set up to a suitable standard
  - Site induction to operators

- **The H&S plan**
  - Principal contractor
  - Project initial
  - H&S plan, on site survey

**Details:**
- Services disconnected hazards protected
- Appropriate authorities for gas electric and water services
- Written confirmations
- Sub-contractor engaged to carry out the scan
- Demolition contractor
- Plant preparation
- Plant for structural demolition
- Site induction to operators
- The method statement for soft stripping
- Building elements classification
- Materials’ classification
- The method statement for structural demolition
- Plant for structural demolition
- The method statement for soft stripping
- The H&S plan
- The H&S plan to structural demolition
- The method statement
- The method statement
- The method statement
- The method statement
- The method statement
- The method statement
- The method statement
- The method statement
- The method statement
5.6 Chapter Summary

This chapter has studied the knowledge of process modelling and process mapping for business process management. This knowledge was then been applied to the management of the demolition process via the use of a multiple case study. The multiple case studies were conducted to obtain preliminary knowledge of currently used demolition processes and problems associated with each process. Using the findings of the demolition process map, the chapter has mapped the demolition process from the four stages by adopting the DFD modelling method within the demolition industry.

The use of mapping and DFD modelling for demolition process mapping is novel and innovative in both industrial and academic contexts. It represented a significant product of this study.

The next chapter extends work presented here by generating a well-organized database system that can be used to store the demolition process requirements.
6 Database of Demolition Process Requirements

6.1 Introduction

During the study of demolition project documents, it was found that requirements within the processes have the similar features. The outline of demolition requirements can be applied to all demolition projects no matter what the project is. Therefore, these requirements can be stored in a well-structured system. The storage of demolition requirements aims to unify demolition documents and improve document quality, as well as provide guidance on the demolition requirements that can be used for all kinds of projects to save time at the planning stage.

The study also found that conventional files currently used for storage of demolition process requirements, for example, the health and safety file or method statement file, are typically designed to support a single demolition project’s requirements. The inflexibility of current demolition document files, in written language makes reusing and reorganizing existing demolition files impractical and complicated. For example, previous written language files cannot be used effectively to support new requirements of a new demolition project. All the programs based on the supporting outlines of these files also have to be rewritten again. Although these files can easily be used for a different demolition project under similar conditions, often the new demolition projects require that these files are completely restructured.

A database has become the most popular way of storing and assessing data, because it has the ability to share the same data across multiple applications and store data in flexible formats (Whitten et al., 2004). Therefore, it is valuable to build an integrated and well-structured system database which contain all the demolition requirements, and can be used for various demolition projects under similar outlines of the requirements. This can be beneficial not only to record keeping of demolition projects, but also organizations and demolition contractors who gain from previous experiences and save on the expenses needed to repeat the initial stages of planning.

This chapter details a study on generic demolition process requirements in eight main sections. These are: (1) gathering demolition project information; (2) demolition health and safety plan; (3) demolition cost estimation; (4) selection of demolition methods; (5) demolition method statement; (6) risk assessment of demolition process; (7) asbestos removal; and (8) demolition
waste management. These requirements are then input into a bespoke database system linked to Demolish-IT.

6.2 Physical Database Management by Applying Repository Technology

The repository is a knowledge base that contains metadata about the information that an enterprise keeps and accesses, the processes it performs in order to be successful, and how it has implemented its application systems to support its information processing needs (Ma et al., 2007). Alta Van et al., (2007) defined the process repository as a place where data is stored. A repository system’s purpose is to record and manage the information about the data models, the designs and implementations of the enterprise databases, applications and systems (Rennhackkamp, 1996). In other words, the repository system records and manages the metadata for the organisation. A typical repository system is illustrated as Fig. 6-1.

Figure 6-1: An Example of a Typical Repository System

(Source from Rennhackkamp, 1996)

The repository system can not only track metadata such as physical data elements, screens, forms and tables, but also it can track the business rules by which some data elements might be related to other data elements (Rennhackkamp, 1996). A repository system can provide the following functions to reflect lifecycle requirements as (Choi, 2007):

- It provides a robust reporting environment to users and technical specialists;
- It can store multiple process and data models of business units with multiple versions of each;
• It maintains descriptions of development objects for analysis, design, code generation, help screens and recovery; and
• It maintains component engineering information.

The repository can be a database or a file, and can be distributed over networks or be directly accessible to the user (Choi et al., 2007). Cardenas (1985) indicated that the process model representation, the physical storage of the data and the ICT tools are three concepts used to access and view the data in building a repository. Fig. 6-2 shows the core components in the process repository system. It illustrates the concepts where a process model representation, such as a demolition process map, is used as a guideline in the development of physical structures.

**Figure 6-2: Components of the Process Repository System**

![Diagram showing components of the process repository system](Source from Alta Van et al., 2007)

In the Fig. 6-2, process model representations drawn of schemes or models to present the structure of data are represented (Trappy and Lai, 1999). For example, in a database environment an entity relationships diagram is used to show the entities and the relationship between the entities (Malone et al., 2003). In this study, this would be the demolition process map. The physical storage of data is on data storage devices such as hard drives and typically managed through selected IT tools. In this case, research has selected the database as storage to store the demolition process requirements.
Hence, the database of demolition requirements is a physical storage for developing Demolish-IT that can store metadata for demolition process requirements including relationships between processes, such as tables, processes’ key requirements, and details of those requirements, formats, integrity constraints and rules applied to the demolition process. Also, the Demolish-IT database can be guidance to help provide the documentation for the demolition contractor that includes process requirement documents, design document templates, diagrammatic guidance, structured charts and demolition project plans.

Database management covers the entire life cycle of all of an organization’s databases, from defining the requirements of the process through to logical and physical database design, to the implementation and performance tuning of various target databases (Ma et al., 2007). Processing lifecycle requirements for the process repository has four stages (Chor et al., 2007). These are: (1) the process modelling stages; (2) the process pre-analysis; (3) the process enactment; and (4) the process post-analysis/evolution. They are explained in detail within Table 6-1.

**Table 6-1:** Process Lifecycle Requirements for the Process Repository

<table>
<thead>
<tr>
<th></th>
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<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Data from</td>
<td>• The process and its analysis results.</td>
<td>Process.</td>
<td>Process and its analysis results.</td>
<td>• Process. • Analysis results.</td>
</tr>
<tr>
<td></td>
<td>• The activity set.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Resource information.</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>• Business data information.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>To</td>
<td>• New/changed business process.</td>
<td>Pre-analysis results.</td>
<td></td>
<td>• Post-analysis results. • Evaluation plan.</td>
</tr>
<tr>
<td></td>
<td>• New/changed activity.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• New/changed business data.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• New/changed resource info.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Function</td>
<td>• Store and view process and its related information.</td>
<td>• Store pre-analysis result. • State management. • Interface for software and human.</td>
<td>• State management. • Interface for software.</td>
<td>• Store post-analysis results. • Version Management. • State management. • Interface for software.</td>
</tr>
<tr>
<td></td>
<td>• Classify processes.</td>
<td></td>
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<tr>
<td></td>
<td>• Search a process.</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>• Version management.</td>
<td></td>
<td></td>
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</tr>
<tr>
<td></td>
<td>• State management.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Interface for software.</td>
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<td></td>
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<tr>
<td></td>
<td>• Human.</td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

(Source from Ma et al., 2007; Choi et al., 2007; and Rennhackkamp, 1996)

According to Table 6-1, the storing process database for demolition requirements can be started from a detailed study of demolition requirements first, then the management and integration needs must be stated, and finally a repository should be applied to store the data/information of demolition process requirements. This procedure will be followed when developing Demolish-IT.
6.3 General Requirements of the Demolition Process Operation

6.3.1 Gathering Project Information for Demolition

In a demolition process, any plans and decisions are made based on the projects’ physical information (Penny, 2008b). Better decisions on the demolition project process can be made if accurate information has been gathered (Wring, 2008).

The satisfactory supply of information is often crucial to a successful project (Howard, 2008). This means that data/information collection is an important task involving a lot of work and it is also essentially important to the success of the project planning. However, in practice, a senior demolition project manager from Keltbray indicated that often: “we [the demolition project manager] could find out this information for ourselves, but we are not given the time.” In Wring (2008) the president of the NDFC said that in general, about four weeks after a tender is awarded, the demolition contractor has got to assemble all the paper work including the health and safety agreements, liaising with HSE over the disposal of hazardous waste material, and double check the disconnection of services. This needs to be done promptly because the project time constraints limit the contractor’s ability to gather information.

In order to save time for demolition contractors, this research produces an outline of all information that contractors need for carrying out the demolition project by reviewing project documents and gathering expert viewpoints. Specifically, the information needed for the demolition project includes the building design data, construction data and environment data. This information can be collected from existing documents and on-site surveys of the building structure and its surrounding environment. This data/information gathered is used for project planning at the pre-tendering planning stage and post contract award stage, and it involves the following aspects:

1. Health and safety plan;
2. Details of the structure to be demolished;
3. Construction drawings;
4. Details of existing services and utilities;
5. Details of previous uses of the building and site;
6. Details of any asbestos and other hazardous materials; and
7. Details of the site environment.
The procedure for gathering necessary data/information at this stage is summarized by the following four steps: (1) data/information collection; (2) data/information verification; (3) data/information analysis; and (4) conclusions of how the information relates to the demolition project. This procedure is shown in Fig. 6-3 and explained as follows:

- Data/information collection: seven aspects discussed earlier provide the general framework for this task.
- Data/information verification: an on-site survey collects and confirms that the information already available is accurate.
- Data/information analysis: establishes relationships between the available information in demolition process.
- Conclusion: a result summary to help compile a demolition health and safety plan, a demolition method statement and a demolition design for the project.

Figure 6-3: Procedure for Gathering Effective Information on the Demolition Project

Providing the appropriate information to demolition contractors in advance is the most efficient and effective way of providing information required to decommission the building (Howard, 2008). Hence, this research gathered all information required, and converted this information into a protocol guide for demolition. Tables 6-2 and 6-3 were generated as a result of the case study. They provide outlines of information collected at the pre-tendering and post contract award stages of the demolition project planning.
### Table 6-2: Detailed Outline of Information Gathering at the Pre-tendering Planning Stage

<table>
<thead>
<tr>
<th>Main contents of information</th>
<th>Details of the information collection</th>
</tr>
</thead>
</table>
| Contractors Pre-qualification and competence                            | - Track record in successful planning and execution of work based on the size and type of structure being considered.  
- Experience and competence of contractors design/management/site team.  
- Accident record statistics and enforcement history.  
- Commitment to and extent of management and operative training and maintenance.  
- That full specific demolition, public and employers liability insurance cover is in place at all times.  
- Health and safety policy, its monitoring and reviewing of procedures. |
| Details of structure to be demolished (access to choose suitable demolition method) | - Identifying the structural form of the building (including large panel system, reinforced concrete beam and column frame with in situ r.c. slabs, steel frame concrete or brick clad).  
- Identifying how overall structural stability is maintained (including shear walls, braced bays and shear cores).  
- Identifying any pre-stressed elements (including Pre-tensioned and Post-tensioned).  
- Identifying any gross structural defects in the building or known major alterations made since construction (including strengthening instalments following the structural defect). |
| Construction drawings (original drawing from client)                   | - Relating to the structural design and checked for consistency.  
- Other alterations. |
| Details of existing services and utilities (entering the building and crossing the site) | - Electricity and underground cables, overhead lines, building supply, equipment and transformer rooms.  
- Gas mains.  
- Oil and other fuel lines.  
- Hydraulic pressure mains.  
- Services and drainage.  
- Telecommunications and optic fibre cables.  
- Radio and TV cables. |
| Details of previous use of the building and site (informing the risk)   | - Identify any previous use of the building which may indicate the presence of hidden hazards (including laboratories handling hazardous substances where pockets of contamination may remain).  
- Identify any previous use of the site, which may cause a physical or health hazard or influence selection of demolition method or plant (including contamination of land, underground cellars or voids, tunnels or underpasses).  
- Identify the extent to which the facility has been decommissioned and request a copy of any decommissioning plan which should itself be checked against the current state of the facility. |
| Details of asbestos and other hazardous materials (survey and properties’ test) | ➢ Asbestos:  
- Lagging to pipes and boilers.  
- Fire insulation.  
- Insulation under window sills.  
- Linings to ducts and airing cupboards.  
- In room heaters.  
- Floor and ceiling tiles.  
- ‘Dry riser’ water pipes.  
- Insulation within curtain wall cladding.  
- Type 3 survey.  
➢ Hazardous materials:  
- Chlorofluorocarbon (CFC).  
- Polychlorinated Biphenyls (PCB).  
- Manmade Mineral Fibre (MMMF).  
➢ Other:  
- Used syringes and hypodermic needles.  
- Pigeon droppings.  
- Rodent infestation.  
- Human excrement.  
- Contamination of air conditioning tanks— legionnaires disease. |
| Details of site environment (to assist contractor selection of demolition method) | - Proximity and types of nearby property (including residential, commercial, industries, schools, retirement, nursing homes, hospital).  
- Existence of flora and fauna and whether or not these are to be protected.  
- Highways, transportation systems, watercourses and waterways.  
- Crime and vandalism rates in the area with instructions on minimum levels of security (hoardings, watchmen, etc.) to be provided to ensure site security. |
### Table 6-3: Information Gathering at the Post-contract Award Stage

<table>
<thead>
<tr>
<th>Main contents of information</th>
<th>Details of the information collection</th>
</tr>
</thead>
</table>
| **Asbestos and other hazardous materials** | ✓ Confirm the information given in the pre-tender stage health and safety plan.  
✓ Undertake further checks. |
| **Structural survey** (direct observation, testing and examination of existing drawing) | ✓ Confirm the form of construction.  
✓ Confirm the existing condition of the structure, including identification of vandal damage or local corrosion of reinforcement and pre-stressing tendons.  
✓ Provide information on the loading, which may safely carried by the existing structure so that any propping arrangements may be designed.  
✓ Confirm the size of all elements to determine craneage requirements.  
✓ Provide sufficient information to ensure that the structural integrity of all parts are maintained in order to prevent unplanned collapse. |
| **Temporary propping and shoring design information** | • Plant loads on floors.  
• Debris loads on floors or against any wall, including the perimeter.  
• Arrangement of the structure and its safe load capacity.  
• Structural form changed affect the safe loading capacity of floors. |
| **Design programme consideration:** | • The form and condition of the structure.  
• That due care is taken to ensure that no components are unsupported during or in advance of demolition/dismantling or deconstruction.  
• The possible presence of post-tensioned concrete and the possible structural effects of cutting the stressing tendons. |
| **Services and utilities** | ✓ Verify the information given in the pre-tendering stage health and safety plan.  
✓ Physically check and locate the routes of all notified incoming services to the site.  
✓ Physically, check that no unidentified services remain in the building or cross the site. |
| **Scaffolding/sheeting for protection** | ✓ Intended method of deconstruction.  
✓ Whether or not external access is required at each working level to demolish external brick wall panels.  
✓ The risk presented by falling debris to site personnel and the general public.  
✓ Measures which can be put in place to control dust and noise.  
✓ Provision of protection to exposed leading edges during partial demolition of sections to the building/structure.  
✓ Provision of boarding up external openings in order to contain dust and debris.  
✓ Design of exclusion zone.  
✓ Edge protection around openings created during demolition. |
| **Environmental consideration** | ✓ Proximity and type of nearby property (including of residential, commercial, industries, schools, retirement/nursing homes, hospital).  
✓ Existence of flora and fauna and whether or not these are to be protected.  
✓ Highways, transportation systems, watercourses and waterways.  
✓ Crime and vandalism rates in the area, with instructions on minimum levels of security (boarding, watchmen, etc) to be provided to ensure site security. |
| **Selection and use of cranes** | ✓ For cutting and lifting during demolition the centre of gravity must be correct.  
✓ Weight of the item to be lifted has to be within the capacity of the crane.  
✓ Safe spare capacity 10% at least.  
✓ Position of cranes to ensure safe working loads are not exceeded. |
| **Schedule of conditions/dilapidation survey** | ✓ Client, with the appointed demolition contractor and relevant third parties, carry out pre-contract and post-contract conditions/dilapidation surveys of immediately adjacent properties, roads, pavements and haul routes in conjunction with the local authority highway officers. |
| **Protection of public from nuisance** | ✓ Attention to adjacent/adjoming building and their uses, provide protection against nuisance and damage to those buildings during demolition and dismantling. |

To be continued to next page
The outline in Tables 6-2 and 6-3 are strategic plans for information collection that provide a guidance checklist to the project management team.

### 6.3.2 Health and Safety Plan of Demolition

The general requirement of a health and safety plan for demolition projects always has the same content as the project document review. Accordingly the research collected three projects’ health and safety plans from three different demolition contractors. The research used the strategy of comparison and combining the three of them together, and generated hybrid compiled content for a health and safety plan. The detailed content of the health and safety plan for demolition works can be found in next chapter, together with the research work undertaken to create an IT tool that is capable of editing the health and safety plan of demolition, and a full version of the health and safety tool can be found in Appendix D/D2. The outline of the demolition health and safety plan contents is described as follow:

- Scope of demolition work: location of work, extent of work and special works;
- Description of existing structures with existing drawings;

<table>
<thead>
<tr>
<th>Post Contract Award Stage</th>
<th>Perimeter security</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Boundary walls, fencing/board.</td>
</tr>
<tr>
<td></td>
<td>Enclose all demolition/dismantling operations with secure entrances.</td>
</tr>
<tr>
<td></td>
<td>Suitable statutory safety signs and notices prominently displayed</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Site security</th>
</tr>
</thead>
<tbody>
<tr>
<td>Security of building/structure out of working hours.</td>
</tr>
<tr>
<td>Provision of watchmen.</td>
</tr>
<tr>
<td>Entrance gates security.</td>
</tr>
<tr>
<td>Reporting arrangements for visitors.</td>
</tr>
<tr>
<td>Immobilising plant out of working hours.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Exclusion zone</th>
</tr>
</thead>
<tbody>
<tr>
<td>Space encompassing the demolition/dismantling activity from which all persons are excluded.</td>
</tr>
<tr>
<td>Size of area selected by the risk of collapse and risk posed by falling debris.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Access and egress</th>
</tr>
</thead>
<tbody>
<tr>
<td>Using the existing facilities whenever possible maintain good safe access.</td>
</tr>
<tr>
<td>Materials should not impede safe access and egress to all floor levels.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Dust control</th>
</tr>
</thead>
<tbody>
<tr>
<td>Provision for an adequate supply of water and for other appropriate measures for suppression of dust arising from the works.</td>
</tr>
<tr>
<td>COSHH regulations in the case of toxic and hazardous dusts arising during the demolition/dismantling of contaminated building.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Noise control</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time limits on plant and equipment (imposed by Local Authorities).</td>
</tr>
<tr>
<td>The provision of noise control measures and ear protection for site personnel.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Fire precautions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Precaution to prevent the risk of fire and explosion cause by gas, combustible dust or vapour.</td>
</tr>
<tr>
<td>The provision of fire fighting equipment.</td>
</tr>
<tr>
<td>Storage of gas and oxygen cylinders.</td>
</tr>
<tr>
<td>An escape route.</td>
</tr>
<tr>
<td>Provision for early removal of flammable material.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Safety method statement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prepared following risk and COSHH assessments.</td>
</tr>
<tr>
<td>Co-ordinated and appended to the health and safety plan.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Training</th>
</tr>
</thead>
<tbody>
<tr>
<td>CITB/MFDC Certificates of competence— demolition operatives/supervisors.</td>
</tr>
<tr>
<td>CITB certificate of training achievement— plant operatives.</td>
</tr>
<tr>
<td>NVQ Level 2/3 — demolition.</td>
</tr>
</tbody>
</table>
• Services information on retained services and disconnection notification;
• Section 80/81 demolition notice/party wall agreement;
• Site welfare arrangements;
• Sequence of demolition works;
• Safety procedures and agreement;
• Resources;
• Setting up site and site security;
• External scaffolding and calculations for demolition;
• Details of cranes, plant and equipment;
• Survey and removal of asbestos and other hazardous materials;
• Storage of gases for hot work;
• Safety requirements, including risk and COSHH assessments and resultant safety demolition method statement to cover:
  i. Removal of non-load bearing elements, fixtures and fittings;
  ii. Removal of roof structures; removal of existing lift cars;
  iii. Removal of partition walls; temporary lateral propping of wall panels and columns;
      Removal of external walls;
  iv. Removal of floors and propping requirements for plant and debris loads; and
  v. Dismantling of stair/lift core;
• Disposal of materials off-site;
• Personnel access to work area;
• Personal protective equipment;
• Safe means of exit in case of an emergency;
• Management structure;
• Induction training;
• Programme of works; and
• Monitoring of health and safety.

A framework containing the above content about the process of health and safety management has been created by using the DFDs shown in Figs. 6-4, 6-5, 6-6, 6-7 and 6-8. According to the CDM Regulations 2007, it is the responsibility of the principle contractor that puts together a demolition project health and safety plan to ensure that the demolition operation is safe, which is the top priority wherever construction work is conducted (HSE, 2007).
Figure 6-4: Outline of Health and Safety Plan Framework

*Inspection and Audit record includes:
- Weekly Audit Report
- Environment Quality Audits
- Scaffold Inspections
- Excavation Inspections
- Welfare Inspection
- Fire Inspection
- Toolbox Talks and Activity Inspection
- Supplier Audits
- Control of Substances and Hazard to Health (COSHH)

*Training includes:
- First Aid
- Fire Protection Training
- Risk Assessment
- Hazard Awareness
- Hands and Arm on Vibration
- CITB NVQ Course
- CDIO Card
Figure 6-5: Outline of Health and Safety Plan for On-site Plant Operation

(Adapted from Ruiz, 2008)
6.3.3 Risk Assessment

Risk has been defined as a measure of the probability, the severity and the exposure of all hazards of an activity (HSE-Risk Management, 2008). Risk assessments form the cornerstone of UK health and safety legislation and the requirement for organizations to prepare risk assessments are clearly outlined in a number of health and safety acts and regulations (APS, 2008). The HSE (2006) requested that the risk assessment must be appropriate, suitable and
sufficient to the nature and scale of the work, the likelihood of hazards, the extent and severity of the risk(s), and be understandable and repeatable. Also, it recommends “5 steps to risk assessment”, which are:

1. Look for and identify the hazards;
2. Decide who might be harmed;
3. Evaluate the level of risk(s) arising from the hazards and decide whether existing precautions are adequate or more should be done;
4. Record your findings; and
5. Review your assessment from time to time and revise it if necessary.

In addition, HSE-risk assessment (2008) provides a standard format checklist of risk assessment to enable the employer to record details of precautions, controls, training, instructions, the provision of information, systems and procedures. These allow the employer to identify potential hazards and risks. All hazards can be easily accessed by using a combination of the risk assessment process and this form. Table 6-4 shows the form used to describe the fundamental theory of risk assessment. In the table, rows from 1 to 4 represent the likelihood of a hazardous happening; column from 1 to 4 represents the severity of the hazard. If the hazard with severity 4 has likelihood 4 of happening, this means the hazard is likely to pose significant risk.

**Table 6-4: The Risk Assessment Theory**

<table>
<thead>
<tr>
<th></th>
<th>Degree of likelihood</th>
</tr>
</thead>
<tbody>
<tr>
<td>Degree of severity</td>
<td>1</td>
</tr>
<tr>
<td>1</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td></td>
</tr>
</tbody>
</table>

This procedure of risk assessment is illustrated by Fig. 6-8. Fig. 6-8 describes the risk assessment process from four stages. They are: (1) raise risk; (2) register risk; (3) assign risk assessment actions; and (4) implement risk actions.
Risk assessment is a key requirement to any demolition project undertaken. According to five steps of the risk assessment, is research created a risk assessor for demolition risk management. This is illustrated in Fig. 6-9. The research concluded five pre-analysis sections with eight identification areas as listed in Fig. 6-9 for the demolition project undertaken. The risk assessment goes on to determine the probability (P), severity (S) and exposure (E) of those demolition risks in the identified areas. Finally, the risk justification factor can be given to reduce the chance of the risk happening or to correct the risk. It ensures that the risks have been properly controlled and managed.
6.3.4 Cost Estimation

There are two cost estimation methods in demolition, a preliminary estimate and a detailed estimate. The preliminary estimate is the most common kind of estimate used by demolition engineers and it provides approximately 20% accuracy in the basics of demolition estimate (Kackman, 2001). The detailed estimate can proceed with an accurate and realistic estimate by establishing the costs of the key components.

In practice, estimating the square metre and the cubic metre methods are used to calculate preliminary estimates. Estimating the cost by the preliminary estimate method for a new project involves, dividing the total price charged for a similar project that has been completed before by the total area or volume of the structure, and then multiplied by the total number area or volume of the new project.

For a detailed estimate in demolition, a ‘take-off” action needs to be undertaken to establish the quantities of key elements/components of the demolition project (Arham, 2003). The take-off action is based on the study of the structural drawings and specifications available and the evaluation of risk, safety and environmental considerations of the project.
The key components used in the estimate are listed in Table 6-5. They are divided into six sets; namely: (1) site overheads; (2) decommissioning; (3) soft stripping; (4) waste disposal; (5) structural demolition; and (6) general overheads.

Table 6-5: Key Components of Demolition Costs

<table>
<thead>
<tr>
<th>Main elements cost</th>
<th>Sub-elements cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Site overhead cost</td>
<td>Temporary structures, facilities and services.</td>
</tr>
<tr>
<td></td>
<td>Personnel protective equipment.</td>
</tr>
<tr>
<td></td>
<td>Site clearing and cleanup.</td>
</tr>
<tr>
<td>Decommissioning cost</td>
<td>Asbestos removal.</td>
</tr>
<tr>
<td></td>
<td>Contaminated substance removal.</td>
</tr>
<tr>
<td></td>
<td>Disconnecting services.</td>
</tr>
<tr>
<td>Soft stripping cost</td>
<td>Toilet.</td>
</tr>
<tr>
<td></td>
<td>Sink.</td>
</tr>
<tr>
<td></td>
<td>Roof tiles.</td>
</tr>
<tr>
<td></td>
<td>Ceiling.</td>
</tr>
<tr>
<td></td>
<td>Interior walls/partition.</td>
</tr>
<tr>
<td></td>
<td>Doors.</td>
</tr>
<tr>
<td></td>
<td>Windows.</td>
</tr>
<tr>
<td>Waste disposal cost</td>
<td>Crushing on site cost.</td>
</tr>
<tr>
<td></td>
<td>Trucking cost/tipping cost.</td>
</tr>
<tr>
<td></td>
<td>Landfill cost.</td>
</tr>
<tr>
<td>Structure demolition cost</td>
<td>Labour cost.</td>
</tr>
<tr>
<td></td>
<td>- General labour, site supervisor, site managers.</td>
</tr>
<tr>
<td></td>
<td>Equipment cost.</td>
</tr>
<tr>
<td></td>
<td>- Demolition excavator with standard attachment.</td>
</tr>
<tr>
<td></td>
<td>- Tracked mounted crane with demolition ball.</td>
</tr>
<tr>
<td></td>
<td>- Other machine with optional attachments.</td>
</tr>
<tr>
<td></td>
<td>Hand tools and scaffolding.</td>
</tr>
<tr>
<td></td>
<td>Implosion cost.</td>
</tr>
<tr>
<td></td>
<td>- Drilling cost.                    explosive cost, initiation system, protection cost.</td>
</tr>
<tr>
<td></td>
<td>- special services cost, evacuation cost.</td>
</tr>
<tr>
<td></td>
<td>special techniques hydro-demolition.</td>
</tr>
<tr>
<td></td>
<td>propping and temporary ramp.</td>
</tr>
<tr>
<td>General overhead cost</td>
<td>Insurance.</td>
</tr>
<tr>
<td></td>
<td>Building permit.</td>
</tr>
<tr>
<td></td>
<td>Surety bond.</td>
</tr>
<tr>
<td></td>
<td>Office administration.</td>
</tr>
<tr>
<td>Profit</td>
<td>Percentage of total cost.</td>
</tr>
</tbody>
</table>

(Source from Arham, 2003)

A basic software package such as Microsoft Excel can be used to transform the above table into a more practical spreadsheet. It can then be normalized to establish the relative cost of each element, and to calculate the total cost. Arham (2003) applied Microsoft Excel to create six cost estimate hubs on the spreadsheet and research has also established a cost estimate sheet for demolition based on cost hubs. Together with other information collected and modelled, this work therefore extends the work Arham, (2003) and in so doing provides a commercial software
tool. Fig. 6-10 represents a screen shot of parts of the detailed cost estimate sheets for a demolition project.

**Figure 6-10:** Screen Shot of Parts of the Cost Estimate Sheet for Demolition

The detail estimate sheet for demolition comprises of seven sheets in Microsoft Excel. The total cost estimates for demolition are accumulated from six parts of the cost estimate. These are represented by C1 (site overhead cost); C2 (soft stripping cost); C3 (decommissioning cost); C4 (waste disposal cost); C5 (general overhead cost) and C6 (structural demolition cost). The grand total cost estimate \((C) = C1+C2+C3+C4+C5+C6\). The detailed cost estimate sheet is displayed in Appendix D/D1: R5.

### 6.3.5 Selection of the Demolition Techniques

Demolition techniques studied in chapter two falls under four main categories, but structural demolition techniques can be classified as progressive demolition, deliberate mechanical
Chapter 6 Database of demolition process requirements

collapse and deliberate removal of elements by BS6187:2000. The research has re-grouped the
techniques as show in Fig. 6-11.

**Figure 6-11: Type of Demolition Techniques**

### Progressive demolition
This is the controlled removal of sections of the structure, at the same time retaining the stability of remainder and avoiding collapse of the whole or part structure to be demolished (BS 6187:2000)

### Deliberate collapse mechanism
Demolition by deliberate collapse is the removal of the key structural members to cause complete collapse of the whole or part of the building structures of the whole or part of the structure to be demolished (BS6187:2000)

### Deliberate removal of elements or deconstruction
Deconstruction or top-down techniques proceed from roof to ground in a general trend. On a floor by floor downward sequence, depending on site conditions and structural elements to be demolished (BS60087:2000)

### Demolition ball
- The demolition ball application consists of a crane equipped with a steel ball.
- It involves the progressive demolition of a structure by the use of an iron ball that is suspended from a lifting appliance (crawler crane) and released to impact the structure repeatedly in same or different locations.
- Suitable for tumble down structures.

### Explosive
- Use of explosives.
- Restrictive entry to work areas.
- Adequate clear space of 2.5 times of the building height.
- Qualified blaster.
- Notification and evacuation.
- Could shorten the work period and reduce labour.
- Risk assessment required to be continued.

### Wire rope pulling
- Involves the use of an earth mover machine or mechanical winch device equipped with heavy steel wire for pulling down structure members.
- Restrictive work areas.
- Adequate clear space of 2.0 times of the building height.
- Qualified blaster.
- Notification and evacuation of neighbourhood.
- Risk assessment required to be continued.

### Deconstruction by hand
- Breaking away the concrete by hand held jack hammer or pneumatic breakers.
- On a floor by floor downward sequence.
- Effective in a narrow and localised place.
- Efficient for simple structures.

### Deconstruction by machines
- Breaking away the structure by machine mounted percussive breakers.
- Adequate floor support for machines.

(Source from Arham, 2003)

To choose the most suitable techniques for the project is crucial to the demolition engineer (Anumba et al., 2003). Research that has been completed to offer guidance on choosing the appropriate demolition techniques includes Arham (2003), Abudayyeh et al (1998) and Hurley et al (2001). A paper written by Holdsworth (2008) called “What factors do engineers have to
consider when selection a method for demolishing a structure?” indicated 12 factors, which must be considered when selecting a technique, and they are listed in the order of the importance of the points in Table 6-6.

Table 6-6: Key Factors in Selecting Demolition Techniques

<table>
<thead>
<tr>
<th>Ranking</th>
<th>Factor</th>
<th>Importance points</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Client specification</td>
<td>12</td>
</tr>
<tr>
<td>2</td>
<td>Structure form</td>
<td>11</td>
</tr>
<tr>
<td>3</td>
<td>Scale of construction</td>
<td>10</td>
</tr>
<tr>
<td>4</td>
<td>Extent of demolition</td>
<td>9</td>
</tr>
<tr>
<td>5</td>
<td>Location</td>
<td>8</td>
</tr>
<tr>
<td>6</td>
<td>Previous use of the structure</td>
<td>7</td>
</tr>
<tr>
<td>7</td>
<td>H&amp;S workforce</td>
<td>6</td>
</tr>
<tr>
<td>8</td>
<td>H&amp;S general public</td>
<td>5</td>
</tr>
<tr>
<td>9</td>
<td>Time scale</td>
<td>4</td>
</tr>
<tr>
<td>10</td>
<td>Nuisance tolerances</td>
<td>3</td>
</tr>
<tr>
<td>11</td>
<td>Proposed fate of building</td>
<td>2</td>
</tr>
<tr>
<td>12</td>
<td>Profit</td>
<td>1</td>
</tr>
</tbody>
</table>

(Holdsworth, 2008)

Another, Arham (2003) listed the 14 criteria for the selection of demolition techniques. By adding Table 6-6 to Table 6-7, the research gave a more detailed view of criteria used for selecting the most suitable demolition techniques for the projects.

6.3.6 Demolition Method Statement

The demolition health and safety plan and the risks identified by the demolition risk assessment, help formulate a demolition method statement. The method statement for a demolition project is an important document that has proved to be important and practical in demolition operation management. The statement includes a description of procedures of all control measures to be implemented and guides the engineer on how a demolition job is to be carried out safely. The research developed a detailed outline of method statement from the multiple case studies in chapter 5. This is shown in Fig. 6-12.
<table>
<thead>
<tr>
<th>Criteria</th>
<th>Additional information/considerations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Health and safety</td>
<td>• H&amp;S is the most important consideration and should be considered throughout the demolition process.</td>
</tr>
<tr>
<td></td>
<td>• H&amp;S aspects for the person on and off site need to be considered before selecting a demolition technique.</td>
</tr>
<tr>
<td>Stability of the structure</td>
<td>• Different types of techniques need to be considered depending on whether a structure is stable or unstable.</td>
</tr>
<tr>
<td></td>
<td>• Workers working inside a structure that is unstable must be avoided.</td>
</tr>
<tr>
<td></td>
<td>• If the structure is unstable, this becomes the top criteria in the selection of a demolition technique.</td>
</tr>
<tr>
<td>Location and accessibility</td>
<td>• Different locations have an effect in selecting demolition techniques.</td>
</tr>
<tr>
<td></td>
<td>• The deconstruction technique is probably the best choice for structures that are located in a town centre.</td>
</tr>
<tr>
<td></td>
<td>• All demolition techniques available should be considered if the structure is located in a remote area.</td>
</tr>
<tr>
<td>Presence of hazardous material</td>
<td>• Hazardous material should be removed before structural demolition is carried out.</td>
</tr>
<tr>
<td></td>
<td>• Not much effect on the selection of demolition techniques since it was done in the decommissioning stage.</td>
</tr>
<tr>
<td>Environmental consideration</td>
<td>• Certain level of nuisance imposed by Local Authorities or based on specified regulation.</td>
</tr>
<tr>
<td></td>
<td>• The choice depends on the permitted level of noise, dust and vibration.</td>
</tr>
<tr>
<td></td>
<td>• Minimize the size of demolition debris. The smaller the debris the easier it is to crush or to transport to a landfill site.</td>
</tr>
<tr>
<td>Shape and size of the structure</td>
<td>• A single demolition technique or a combination of techniques is selected depending on the shape and size of the structure.</td>
</tr>
<tr>
<td></td>
<td>• A high rise building probably needs a combination of techniques. Deconstruction should be used for the top part of the building that can be reached by a demolition excavator.</td>
</tr>
<tr>
<td></td>
<td>• The demolition engineer might only use a demolition excavator to demolish a single storey house.</td>
</tr>
<tr>
<td>Client specification</td>
<td>Clients forbid some types of demolition techniques.</td>
</tr>
<tr>
<td>Structural engineer approval</td>
<td>• Did not need any approval from the structural engineer.</td>
</tr>
<tr>
<td></td>
<td>• Engineers’ opinions are a guide on determining the stability of the structure.</td>
</tr>
<tr>
<td>Time constrain</td>
<td>Duration of the job.</td>
</tr>
<tr>
<td>Extent of demolition</td>
<td>• Partial demolition used in conjunction with building refurbishments.</td>
</tr>
<tr>
<td></td>
<td>• Complete demolition used to make way for new structure.</td>
</tr>
<tr>
<td>Financial constrains</td>
<td>• Economical consideration for different technique selection.</td>
</tr>
<tr>
<td></td>
<td>• The costs considered include machinery and manpower.</td>
</tr>
<tr>
<td>Recycling and reuse</td>
<td>The amount of reusable and recyclable materials affects the techniques selection. The less reusable materials there are, the wider the choice of demolition techniques.</td>
</tr>
<tr>
<td>Transportation consideration</td>
<td>The condition of the site may restrict the accessibility of heavy machinery.</td>
</tr>
<tr>
<td>Availability of plant or</td>
<td>• Plant and equipment can be purchase or rented</td>
</tr>
<tr>
<td>equipment</td>
<td>• The capability of the plant and equipment must be considered.</td>
</tr>
<tr>
<td></td>
<td>• The easily available plant and equipment, which offers the best value for money, should be selected.</td>
</tr>
</tbody>
</table>

(Source from Arham, 2003)
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Figure 6-12: Detailed Outline of Method Statement

SITE SET UP

1. SITE SUPERVISOR DUTIES
   - Liaise with any adjoining properties to ensure that all are aware of the work.
   - Collate all applicable information relating to requirements of adjoining properties regarding access, movement etc.
   - Liaise with main office/local Authority to ensure all applicable licenses are in place for the specific work area.
   - Site all applicable signs (all visitors report to site office/ danger demolition hard hat sign) including main contract sign as depicted within tender documentation.
   - Erect additional fencing as required.
   - Carry out inspection of all fencing etc to ensure security is maintained and put in appropriate additional measures where required.

2. SITE COMPOUND
   - Designate and position the following.
     - Site welfare facilities.
     - Fuel storage area.
     - Cylinder storage area (vented cage showing empty and full).
     - Equipment plant storage area.

3. WELFARE FACILITIES
   - Site supervisor/designated person.
   - To post P1Q H&S poster, Site rules, Method statement, Risk assessment, First aid requirements section 80 building control etc within site cabin.
   - Inspect washing/toilet facilities and provide additional materials (cleaning, soap, towels).
   - Set up hot water facilities.
   - Arrange for competent contractor to inspect electric supply and issue certificate of same.

SERVICE INVESTIGATION/ INSTATMENT

1. INVESTIGATION
   - Information concerning existing services within the site and surrounding area has been obtained by TRD.
   - All isolation/diversion of M&E supplies are to be carried out by the service providers therefore written confirmation will be received by the site supervisor before commencement of structural demolition works.
   - Any retained services will be marked with suitable high visibility materials and road plates positioned at all require points.

2. DISCONNECTION/CAPPING OFF OF SERVICES
   - Ensure written confirmation that all necessary documents are contained within this file.

3. INSTAMENT OF CENTRAL AND TASK LIGHTING
   - Where necessary central task lighting will be installed by a competent electrical contractor. Particular attention will be paid to all emergency exit routes and hazardous areas.

RECORDS

The site supervisor will ensure that all information relating to location of all capped services is relayed to the CDM Co-Coordinator for inclusion in the file.

<table>
<thead>
<tr>
<th>ASSOCIATED RISK ASSESSMENT No. s</th>
</tr>
</thead>
<tbody>
<tr>
<td>ASSOCIATED LEGISLATION</td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>

- S2 of the health & safety at work Act 1974
- The electricity at work regulations 1989
- Institution of electrical engineers wiring regulations
- Road & street works act 1991.

WELFARE/STORAGE FACILITIES

1. Hiring (duration of the project)
   - Lockable unit.
   - Serviced stand-alone toilet.
   - Welfare cabin with sink, canteen, hot water facilities.
   - Seating and tables and
   - Storage unit for tools and materials.

2. Task list
   - Site supervisor to designate sitting zone.
   - Benchmen to be allocated and made aware of exact zone and engaged to ensure safe manoeuvring of vehicles/positioning of units.
   - Site supervisor make sure locks available for both units.
   - Welfare unit to be "hooked" up to services' plumber to be engaged to connect to water supply for washing. Electrician to be engaged to connect to suitable supply and test Certificate to be issued.
   - Toilet to be positioned as instructed by the site supervisor.
   - Nominated operative to set up welfare facilities in cabin and ensure adequate cleaning/furniture rubbish/drinking and cooking facilities are available.
   - Operative to be assigned to ensure cabin is cleaned regularly.
   - Site supervisor to post notifications and site notice/rules etc. within unit.

<table>
<thead>
<tr>
<th>ASSOCIATED RISK ASSESSMENT No. s</th>
</tr>
</thead>
<tbody>
<tr>
<td>ASSOCIATED LEGISLATION</td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>

- The Electricity at work Regulations 1989 CDM 2007
### Chapter 6 Database of demolition process requirements

- Continued from previous page:

#### EMERGENCY PROCEDURES

1. **SET UP OF EMERGENCY PROCEDURES**
   - Site supervisor to:
     - Position First Aid equipment within site cabin.
     - Designate Fire Marshall, including:
       - Preplanning and positioning of fire extinguishers and air hones.
       - Reinstatement of same at start of day prior to works commencing.
       - Inspection of stairwell lighting daily.
   - Inspect of emergency exit route daily (particular stairwell) to ensure clear.
   - Oversees any 'hot' work via permit system and direct emergency vehicles into the site.
   - Designate muster point.
   - Organise instatement of fire extinguishers with site supervisor.
   - Post emergency exit signs and emergency layout fire plan to all floors.
   - Post emergency procedures within site welfare unit.

**Note:** Following site and emergency procedures set-up the site supervisor or company safety advisor will carry out the site specific induction talk. This include interaction with other trades/site restrictions/site rules/emergency procedures/site communication etc.

#### EMERGENCY PROCEDURES TASK

- **First Aid:** If the requirement for first aid provision, if the first aid box, if the site first aider responsibilities, if a trained first aider on site.
- **Medical assistance:** If phone number of nearest hospital and route, if a copy of the A-Z map for the area with the route to the nearest hospital.
- **Emergency plan:** The management of health and safety at work regulations require every employer to prepare a plan which sets out the action to be taken in the event of any emergency.
  - Introduction: to highlight any situation which require the evacuation and outline the procedures; if rescue procedures, if possible hazardous situations.
  - Control: site supervisor control over any incident and one person as a guide for emergency services needed.
  - Communication: representative from the company will have the on site mobile telephone throughout the emergency and responsible for alerting the emergency services.
  - Assembly point needed.
  - Action on fire.
  - Action on explosion or LPG escape.
  - Action on confined space accidents.
  - First aid kit.

#### 1. SCOPE OF WORK

- **ERECTION OF FENCE**
  - Erection of fencing to define site boundary line.
  - Internal fencing to designate zones as required.
  - Erection of overheads from hazardous areas; and
  - Openings to floors, segregate further contractors from demolition zones.

**ASSOCIATED RISK ASSESSMENT No’s**

**ASSOCIATED LEGISLATION**
- CDM2007
- The Manual Handling Regs

#### 2. TASK LIST

- Site layout plan showing exact layout of fencing and access points.
- Calculate required number of panels/sheets and design drop off area at each elevation.
- Placement amount at each designated point to reduce manual handling risk.
- Phase works to ensure unimpeded access for further operations.
- PPE protection applied to workers.
- Two operators needed and using correct lifting procedures.
- Affix warning notice to all elevations; and
- Ensure the boundary fencing at start and end of shift all panels/hoops in place etc.

#### SOFT STRIPPING

1. **PRIOR WORK NOTES**
   - Ensure known all locations of asbestos.
   - Stop work if any suspect materials.
   - Risk assessment needed of work area.
   - Materials remove progressively in a safe manner.
   - No smoking.
   - Adequate escape routes.
   - Prevent damage the structure.
   - PPE applied at all times.
   - All hazardous materials removal by appointed specialist before commencement.

2. **SOFT STRIP INTERNAL FITTINGS LIST**

- Loose fixtures and fittings (cupboards, shelving).
- Redundant heating units (overhead wall mounted) and associated pipe work, electrical, lighting units.
- Suspended ceilings/lining boards.
- Sanitary ware.
- Door glazed screens.
- Internal partitioning.
- Carpet/moisture.
- Floor tiles.
- Glazing.
- Timer fuses and.
- Wastes, etc.

3. **ENVIRONMENTAL MONITORING**

- Carry out throughout the duration of the soft strip work.
- Monitor dust.
- Monitor disturbance.
- Ensure minimum noise, dust and disturbance.
- Spill kit.

4. **INSPECTION OF EXPOSED STRUCTURE**

Supervisors and machine operators carry out the inspection of exposed structure, to determine presence of changes to know structural elements ensure safe demolition of structure.

**ASSOCIATED RISK ASSESSMENT No’s**

**ASSOCIATED LEGISLATION**
- Working at Height Regs.
- Manual Handling Regs.
- Control of Noise at Work.
- PUWER 98.
- COSHH 2002.
- PPE Regs.
### Environmental Issues

1. Prevention of Contamination & Sealing of Drains
   - Identify all drain runs on the site.
   - Carry out site survey to identify location/condition of all man-holes.
   - Insert temporary plugs into drain for manholes located adjacent to the site boundary/feeding retained areas.
   - Each drain run will be severed at the site of the manhole.
   - A permanent cement mortar plug the each manhole.
   - Each sealed manhole marked clearly on the site plan and site file.
   - Operate a permit to enter system (confined space).
   - Paint marked for identification.

2. Protection of Surface Water Courses
   - Surface water course be protected against runoff and associated particulate material or dissolved material.
   - Pollution protection guideline-PPG6.
   - Odour dust and nuisance control to be installed.
   - Monitoring dust generation from concrete crushing.

### 3. Protection of Other Site Users and Off Site Personnel
   - Special measures required to protect on-site users.
   - Avoidance of wind borne dust and noise.
   - Special precautions against inhalation or contact of site personnel with ground material.

**Associated Risk Assessment No’s**

**Associated Legislation**

- S20 of the health safety at work Act 1974.
- Control of Noise at Work.
- PUWER 98.
- COSHH2002.2
- PPE Regs 92
- Environment Act.

### Removal of MMMF Materials

1. Location of MMMF Material
   - Possible location Pipe work insulated.
   - Ceilings.
   - Behind internal plasterboard partitioning.

2. Preparation Works
   - Wash at site end, no smoking.
   - Wear RPEPPE. ½ face p3 high filtration masks, gloves, goggles, and safety footwear.

3. Removal Procedure
   - Damaged down by use of an airless spray unit.
   - Damaged material placed immediately into waste sacks and sealed with cloth adhesive tape.

**Associated Risk Assessment No’s**

**Associated Legislation**

- S2 of Health and Safety at Work Act 1974
- Working at Height Regs05
- PPE Regs 92
- CDM 2007
- COSHH2002

### Asbestos Removal

1. Specific Site Notes
   - Type 3 survey to determine itemisations of ACM’s before entry to structure.
   - Lined before open asbestos cement skid.
   - To seal the work platform using two layers of 1000 gauge polycyrene and cloth adhesive tape.
   - If unsure, must ask the health and safety officer.
   - Action level removed and replaced with one single control limit.
   - Asbestos fibre-non-licensable works.
   - Analytical & monitoring.
   - IOM survey results of sample, position in the building material name, type and remove method.
   - The Control of Asbestos at Work Rgag02.
   - The Asbestos Prohibition) Regs.
   - ACOP’s L143 & L127.

**Associated Risk Assessment No’s**

**Associated Legislation**

- S2 of the Health and Safety at Work Act 1974
- The control of Asbestos Regs (CAP) 2006
- PUWER 98.
- PPE Regs 9.2
- HSG 185-Work with Asbestos Cement.
- L143-Work with materials containing asbestos.
Chapter 6 Database of demolition process requirements

- Continued from previous page

# DEMOLITION

## 1. PREPARATION
- Photo specific the works.
- Ensure all parties agreement of the work method/work time.
- Separation point.
- Full protection of boundary fencing.
- Banksman to be positioned.

## 2. HAND SEPARATION WORKS
- Inspection of installed separation boarding adequate sealed.
- Direct line between site manager to site supervisor.
- Inspection of structure.
- Roof removal.
- Timber
- Glazing removal.
- Floor removal

## 3. MECHANICAL DEMOLITION
- Plant, equipment and attachment.
- Driver.
- Banksman.
- Work procedures.

## 4. ENVIRONMENTAL MONITORING
- Carried out duration of the demolition works.
- Monitoring the noise, dust, disturbance.
- Minimum migration the dust.

## 5. COMPLETION WORKS
- Site area graded and cleared to satisfaction of the client.
- The area cleared /protrusions removed for next phase of works.

### ASSOCIATED RISK ASSESSMENT No.’s

<table>
<thead>
<tr>
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<tbody>
<tr>
<td></td>
<td>PUWER 98.</td>
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<td>PPE Regs92.</td>
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<td>CDM 2007.</td>
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<td></td>
<td>The Control of Noise at work Regulation 05.</td>
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<td></td>
<td>BS9187:2000.</td>
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</tbody>
</table>

# OPERATING CRUSHING MACHINE

## 1. PROCEDURES
- Ensure machine is placed on firm level ground.
- Ensure the all signage is displayed and clear.
- All conveyor supports are to be checked daily for service ability.
- Grease jaw at 4 hours intervals.
- Grease conveyors daily.
- Check conveyors for clearance of snagged wire and build up of spoils as much as possible.
- Check oil and water levels daily.
- Check sprinklers to ensure spraying correctly.
- Check all the dust suppression and units.
- Run up the machine (warm up).
- Zero off bell weighed.
- Protective clothing must be worn all the time.
- Ensure the good water supple for the sprinklers.
- Keep the platform, machine and access area clear at all time.
- Instruct emergency stop.
- Keep any oil, diesel drum away from crusher.

## 2. WORK METHOD
- General conditions.
- Safety procedures for those not directly involved with the crushing operation.
- Sorters responsibilities.
- Personal hygiene.
- Operators responsibilities.

## 3. EQUIPMENT WORK PROCEDURE
- All operator use appropriate PPE.
- All mechanical equipment used and maintained as recommended by the manufacturer.
- Crusher work procedure.
- 300 excavator work procedure.
- Wheeled loading shovel.

### ASSOCIATED RISK ASSESSMENT No.’s

<table>
<thead>
<tr>
<th>ASSOCIATED LEGISLATION</th>
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<tbody>
<tr>
<td>Working at Height 2005.</td>
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<tr>
<td>PUWER 98.</td>
</tr>
<tr>
<td>LOPER98.</td>
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<tr>
<td>PPE Regs.</td>
</tr>
<tr>
<td>The Control of Noise at Work Regulations.</td>
</tr>
<tr>
<td>Control of Vibration of work Regs 2003.</td>
</tr>
<tr>
<td>BS9187:2000.</td>
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<tr>
<td>Environmental protection Act 1990.</td>
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</tbody>
</table>
6.3.7 Asbestos Removal

Asbestos is the name used for a range of natural minerals. There are three main types of asbestos which are blue (crocidolite), brown (amosite) and white (chrysotile). In buildings, asbestos has been used in one type or as a mixture of two or more types. Asbestos was a prominent cause of occupational ill health from about year 1950 onwards (HSE, 2006) and is still the greatest single work related cause of death. Past exposure is now responsible for about 4000 people dying from asbestos related cancers every year and the figure is expected to rise over the next ten years. The most common uses of asbestos in buildings were (hse/gov.uk, 2008):

- Loose packing: between floors and partition walls;
- Sprayed limpet fire insulation: on structural beams and girders;
- Lagging: on pipework, boilers, calorifiers, heat exchangers, insulating jackets for cold water tanks, around ducts;
- Asbestos insulation board (AIB): ceiling tiles, partition walls, soffits, service duct covers, fire breaks, heater cupboards and door panels;
- Asbestos cement (AC): roof sheeting, wall cladding, walls and ceilings, bath panels, boiler and incinerator flues, fire surrounds, gutters, rainwater pipes and water tanks; and
- Other products: floor tiles, mastics, sealants, textured decorative coating, rope seals, gaskets, millboards, paper products, fire doors, cloth and bituminous product.

The type of asbestos denotes how dangerous it is and how likely the material is to be disturbed. People most at risk of asbestos explosive are those who are involved with building maintenance and refurbishment work, for example, hand demolition works by demolition labours.

Planned removal of asbestos must adhere to The Control Asbestos Regulations (CAR) 2006. CAR 2006 gives guidance on asbestos removal. An outline of an asbestos removal checklist that is conformant with CAR 2006 is depicted in Fig. 6-13.
**Figure 6-13: Guideline to Address the CAR 2006 in a Demolition Project**

<table>
<thead>
<tr>
<th>MAIN REQUIREMENTS IN ASBESTOS REMOVING</th>
<th>SUGGESTED ACTIVITIES</th>
<th>CHECK LIST</th>
</tr>
</thead>
<tbody>
<tr>
<td>MANAGE THE ASBESTOS IN BUILDING (Regulation 4)</td>
<td>Types of survey</td>
<td>1. Type 1 – presumptive. This is to locate materials assumed to contain asbestos and not what condition they are in. No sampling is done; 2. Type 2 – sampling. This is the same as type 1 but samples are taken and analyzed to confirm whether asbestos is present; 3. Type 3 – full access. This involves gaining access to all parts of the building using destructive inspection if necessary. This type is usually used just before demolition or major refurbishment.</td>
</tr>
<tr>
<td>Risk assessment</td>
<td>1. If any work which will, or could disturb asbestos is planned, has the risk assessment been done by a competent person? 2. Does it relate specifically to the particular job and site? 3. Does it cover other risks (like falls from height or electricity)?</td>
<td></td>
</tr>
<tr>
<td>Record</td>
<td>1. Has any survey been done? If so, which type? 2. Does it cover all parts of the building? If not, why? 3. Is the information readily available and understandable? 4. Is it given to anyone who needs it, e.g. contractors?</td>
<td></td>
</tr>
<tr>
<td>IDENTIFY PRESENCE OF ASBESTOS (Regulation 5)</td>
<td>Survey result</td>
<td>1. Whether asbestos is or may be present. 2. What type of asbestos it is. 3. What material it is in and 4. What condition it is in or</td>
</tr>
<tr>
<td>Marks in the building</td>
<td>1. Is all this information readily available or has the employer said that they will assume asbestos is present? 2. Is the information clear and easy to understand? 3. Are there any parts of the building which have not been checked?</td>
<td></td>
</tr>
<tr>
<td>PLANNING WORK (Regulation 7)</td>
<td>Writing plan of work detailing</td>
<td>1. Is there a plan of work? 2. Does it say clearly how the work will be done? 3. How is the waste going to be removed? 4. How will the employer make sure that the work is done in the way the plan says it should be? 5. Have other risks which may be present (like falls from height and electricity) been considered as well? 6. How will employees be informed?</td>
</tr>
<tr>
<td>INFORMATION, INSTRUCTION AND TRAINING (Regulation 10)</td>
<td>Knowledge of Asbestos</td>
<td>1. The properties of asbestos, its health effects and the interaction of asbestos and smoking; 2. The type of materials likely to contain asbestos; 3. What work could cause asbestos exposure and the importance of preventing exposure; 4. How work can be done safely and what equipment is needed; 5. Emergency procedures; and 6. Hygiene facilities and decontamination.</td>
</tr>
<tr>
<td>Adequate training</td>
<td>1. Has everyone who is, or may be, exposed to asbestos been given enough information and training to enable them to safeguard their health? 2. Was the training suitable for the job? 3. Are there arrangements to train new people? 4. Are there arrangements for regular refresher training?</td>
<td></td>
</tr>
<tr>
<td>PREVENTING, Reducing of EXPOSURE (Regulation 11)</td>
<td>Good practice</td>
<td>1. Has this approach actually been taken? 2. How will the employer make sure that the workers are not exposed to more than the control limit? It is not always necessary to carry out air tests, for example when it is well known what exposure levels are activity generated – and the worst levels are assumed. Air tests may be needed to confirm that the controls are working.</td>
</tr>
<tr>
<td>Control the limitation</td>
<td>If any employee is exposed to more than the control limit, the employer must inform the employees concerned and their representatives 1. Ensure that the work does not continue until adequate action has been taken to reduce exposure to below the control limit. 2. Find out why the control limit was exceeded and take action to prevent it happening again, and take air samples to make sure this action was effective. 3. If employers need to ensure that whatever controls they put in place are properly maintained and used. This includes providing any necessary supervision. 4. Employees need to make sure they use any controls properly: a. Do the employees know how to use the controls in place? b. Do they know what to do if they suspect the controls are not working properly? c. The employer should make arrangements to deal with accidents, incidents and emergencies. These should minimize the effects of the event and restore the situation to normal. Anyone who may have been affected should be informed immediately. d. Do these arrangements exist and does everyone know about them? e. Is it clear who is responsible and what for? f. What happens when those people are absent?</td>
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6.3.8 Waste Management

Waste from construction, remodelling and repairing individual residences, commercial buildings and other civil engineering structures are classified as construction waste. Waste from razed building is normally defined as demolition waste (Wood, 1992; Gavilan and Bernold, 1994). Construction and Demolition (C&D) waste is also produced from natural disasters, such as earthquakes, hurricanes and floodwater (Tansel et al., 1994). In general, C&D waste can be classified as inert and non-inert materials (Hong Kong EPD, 2000). Inert wastes are non-organic materials that can be recycled or are suitable for land reclamation and site formation. Other organic materials such as bamboo, timber, vegetation, and packaging waste are classified as noninert waste and are mainly disposed of at landfills.

The C&D industry generates a significant quantity of waste which is shown in Table 6-8 (Howard and Partners, 1994; Symonds, 1999; Hobbs and Collins, 1997). C&D waste is reviewed more and more as a valuable source of engineering materials for the construction industry in the UK. The Environment Agency (EA) estimates that the construction industry currently produces approximately 53.5 million tonnes of construction and demolition waste annually (Bell, 1997). By using C&D wastes, it can potentially reduce reliance on primary aggregates and lowers the
environmental impact of construction and demolition. At present C&D waste is disposed of as follows:

- 27.4 million tonnes (51.2%) are disposed of in landfill sites;
- 21.2 million tonnes (39.6%) are exempt from licensed disposal and are primarily used for land modelling during the construction projects;
- 5 million tonnes (9.2%) are either crushed to produce a product or directly recovered.

Table 6-8: Quantities of Waste from Various Sources in England

<table>
<thead>
<tr>
<th>Construction waste</th>
<th>Mt/y</th>
<th>Mt/y</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concrete, bricks, blocks, aggregate</td>
<td>3.5</td>
<td></td>
</tr>
<tr>
<td>Metals</td>
<td>2.8</td>
<td></td>
</tr>
<tr>
<td>Excess mortar/concrete</td>
<td>1.2</td>
<td></td>
</tr>
<tr>
<td>Timber and products</td>
<td>0.8</td>
<td></td>
</tr>
<tr>
<td>Plastic package and plastic products</td>
<td>0.9</td>
<td></td>
</tr>
<tr>
<td>Plasterboard and plaster</td>
<td>0.3</td>
<td></td>
</tr>
<tr>
<td>Paper and cardboard</td>
<td>0.2</td>
<td></td>
</tr>
<tr>
<td>Vegetation</td>
<td>0.1</td>
<td></td>
</tr>
<tr>
<td>Soil</td>
<td>0.1</td>
<td></td>
</tr>
</tbody>
</table>

Total construction waste                        | 10.0 |      |

Demolition waste

| Concrete                                       | 12.0 |      |
| Masonry                                        | 7.2  |      |
| Paper, cardboard, plastic and other            | 5.1  |      |
| Asphalt                                        | 4.5  |      |
| Wood based                                     | 1.0  |      |

Total demolition waste                          | 30.0 |      |

Road planning                                   | 7.0  | 7.0  |

Total                                          | 47.0 |      |

(Source from Lu et al., 2006)

The question of how to dispose of C&D wastes in a cost-effective, environmentally friendly fashion presents one of the major environmental challenges for many municipalities around the world (Faniran and Caban, 1998). The landfill tax has contributed to a big increase in the number of fixed and mobile crushing and recycling sites. C&D waste has been recycled and the amount and value of recycled materials reused by the industry has been underestimated. From an estimate of less than 100 in 1994 (Howard and Partners, 1994), there are now thought to be in excess of 400 sites (BRE, 2000). Section 54 of the Clean Neighbourhoods and Environment Act 2005 provided the necessary powers for regulations to be made to require developers and contractors of construction and demolition projects to prepare site waste management plans. The purpose of Site Waste Management Plans (SWMPs) is basically to provide accurate projections...
for waste delivery and disposal at every stage of a construction project (Defra, 2008). By making predictions the hope is that the contractor will realize how expensive this will be and then adjust planning and, if necessary and possible, the design to reduce construction waste disposal cost by minimizing waste wherever possible, and then also recycling the remainder.

The SWMPs should detail the production and management of waste, including accurate details showing quantities to be disposed and recycled (Lu et al., 2006). From April 2007 in England, SWMPs have been required on almost every site and these also are requested as a part of planning permission procedures by most Local Authorities (Defra, 2008). Appendix D/D1:R8 has detailed the SWMP checklist and data sheet.

Lu et al (2006) focuses on modelling the waste handling processes in construction, with particular emphasis on mapping and simulation of on-site waste sorting processes. Shen et al (2004) provided the waste management mapping model. This model can represent the technological constraints and complex interdependent relationships between components in a typical waste-handling system (Shen et al., 2004). It is a simple, straightforward mapping technique depicting waste handling processes in construction by linking four basic elements. (Refer to Fig. 6-14).

**Figure 6-14:** The Basic Modelling Element for the Waste Management Mapping Model

(Source from Shen et al., 2004)

The waste source denotes waste generation or the location where waste originates. The waste processing denotes various waste handling activities like loading waste and sorting waste. The waste facilitator denotes the resource or tool used to facilitate waste handling activity, including
labour, tools and a mechanical plant. The waste destination denotes the final status in waste handling, reuse and recycling, or the final place that the waste is delivered to, like landfills or reclamation sites. A simple waste flow mapping connects the four elemental symbols by arrows representing precedence relationships according to the operation logic (Bell, 1997).

The mapping model for the treatment of timber waste, steel waste, timber waste handling processes was created by Lu et al (2006) and that is shown in Fig. 6-15.

**Figure 6-15: Process Mapping Model for Waste Management**

(Source from Lu et al., 2006)

In developing the process mapping model, two enhancements have been made to the original mapping technique. These were illustrated in Fig. 6-16.

1. The different wastes change over the site space of wastes and facilitating resources.
2. Interdependent relationships between concurring processes.

These enhancements are required to manage and design the site waste handling layout. It is included to situate the work platform, storage block, refuse chute and the refuse container for inert and non-inert waste in the suitable position on the site. Accessibility will be a key attribute
of the storage area for trades to collect, transport and dump the material. The position of the timer and steel storage on sites must be given special consideration, and should take into account the labour and machinery needed to move the materials to their designated storage areas.

**Figure 6-16:** Waste Handling Simulation Model for the Site Location Set and the Resource Transition

6.4 Management and Integration of Demolition Process Requirements

The demolition process study completed revealed that the demolition process comprises of the tasks and the procedures to be followed for each task. To manage these complex process requirements, a well structured information system is required. This system integrates various components of the main requirements of demolition processes in order to create an effective management system of Demolish-IT.

(Source from Lu et al., 2006)
Chapter 6 Database of demolition process requirements

The DFDs developed for the demolition processes, sub-processes and process requirements (refer to section 5-5), capture the dataflow between processes and requirements in a demolition project. In terms of systems design, this implies that the process requirements can be implemented into Demolish-IT. These include the health and safety plan, the risk assessment, the method statement, demolition technique selection, the waste management, the cost estimate and the Asbestos removal, etc. Whenever a demolition task is carried out, the requirements of the task can be found in Demolish-IT database to access and guide managers and workers to complete given tasks.

The DFDs also highlight the fact that inherent within demolition process a number of data stores (manual and/or electronic) were maintained, for example, demolition project files. The major contents of these files stored the main demolition requirements. However, within the UK demolition sector the main requirement files were separately managed from the entire demolition process. Fig. 6-17 illustrates this fact.

Figure 6-17: Stand-alone Process Requirements Used in Demolition Process Management

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A fundament difference with Demolish-IT database is that it introduces a central storage system that contains all the main requirements of the demolition process (refer to Fig. 9-18). Compared with Fig. 6-17 this central storage can manage the requirements of demolition processes better because of integrating all the requirements in the same storage. Thereby it improves the efficiency of demolition management.

Figure 6-18: A Central System that Shares Information among Various Requirements of Demolition Process

In practice these eight components of the demolition process requirements are all interrelated. Any requirements that are not fulfilled can delay or stop the project. For example, in the project planning stage, the completion of the health and safety plan and method statement are dependent upon the successful collection of the demolition project information, choosing the demolition...
techniques, assessing the risks and calculation of the demolition cost in the demolition operation stage. Asbestos removal and waste management depends on the procedures outlined in the health and safety plan and the demolition method statement. This is also illustrated in Fig. 6-19.

**Figure 6-19:** Inter-relationships and Dependencies of Demolition Process Requirements

Fig. 6-17, Fig. 6-18, and Fig. 6-19, point to the conclusion that it is necessary to manage and integrate the demolition process requirements in a central system since the components of the process requirements are closely related in all demolition projects.
6.5 Database of Demolition Process Requirements

A database is a wide information system which can store demolition process requirements and can be used as a protocol for redesigning the demolition process (Whitten et al., 2004). A physical data store of demolition process requirements represents the utilisation of one of the following: (1) a database; (2) a table in a database; (3) a computer file; (4) a backup store in another media for anything important; (5) any temporary file as needed by a program; and (6) any type of non-computerized file.

The eight main demolition requirements described in the proceedings section are stored in conventional files as standard logical data in demolition process management system. This logical data was stored in the database as a user-defined (i.e. demolition contractor) physical data store. Fig. 6-20 showed eight requirements converted from a logical data store to a physical data store in the database.

**Figure 6-20: Physical Data Store for Demolition Process Requirements**

<table>
<thead>
<tr>
<th>Logical Data Store</th>
<th>Implementation</th>
<th>Physical Data Store</th>
</tr>
</thead>
<tbody>
<tr>
<td>Information collection</td>
<td>A database (Multiple table)</td>
<td>Microsoft Word Information collection DB</td>
</tr>
<tr>
<td>Health and safety plan</td>
<td>A database (Outline compiled list)</td>
<td>Microsoft Word Health and safety file DB</td>
</tr>
<tr>
<td>Risk assessment</td>
<td>Forms in database</td>
<td>Microsoft Access Risk assessment DB</td>
</tr>
<tr>
<td>Selection of the techniques</td>
<td>Database (Table and framework)</td>
<td>Microsoft Word Selection of techniques DB</td>
</tr>
<tr>
<td>Cost estimate</td>
<td>Database (spreadsheet)</td>
<td>Microsoft Excel Cost estimate DB</td>
</tr>
<tr>
<td>Method statement</td>
<td>Database (multiple forms)</td>
<td>Microsoft Word Method statement DB</td>
</tr>
<tr>
<td>Asbestos removal</td>
<td>Forms in database</td>
<td>Microsoft Word Asbestos removal DB</td>
</tr>
<tr>
<td>Waste management</td>
<td>A file or records maps</td>
<td>Microsoft Word Waste management DB</td>
</tr>
</tbody>
</table>

In practice, these requirements were inter-related. The central database system created by this research can also display these inter-relationships as explained in Fig. 6-21.
Fig. 6-22 shows a screen shot of the database for demolition requirements. The detailed database of demolition process requirements can be found in Appendix D/D1.
6.6 Chapter Summary

The research has shown that current arrangement formats are inadequate because they do not provide a clear picture of the requirements of a demolition process. Management and integration needs for those requirements have also had been justified during the study. The eight main aspect requirements of the demolition process were studied in detail. These are: (1) information collection; (2) health and safety plan; (3) risk assessment; (4) selection of the techniques; (5) cost estimate; (6) method statement; (7) asbestos removal; and (8) waste management. In result, the research has created a unified format of these requirements using ICT tools provided, such as using forms, reports, sheets represented the eight main requirements instead of text described requirements. A database as the central information system for storing the demolition requirements was also created. It is able to store all the requirements in a flexible format and can guide the demolition engineer in planning for different projects.
7 Demolish-IT Prototype and Tools

7.1 Introduction

During this study, the issue has been raised, demolition engineers stated concerns that they were generally not given enough time to complete the project plan because it was so difficult to manage given complex requirements, especially in the project planning stage. Most contractors have no shortage of experience conducting unplanned demolition projects! Demolition projects as a business process simply involve entering the requirements into the process and delivering the profits which satisfy the client. The complexity of the process and the sheer number of parties involved in a demolition project, means that demolition contractors need efficient and effective planning and management to ensure that the process is handled expediently, therefore, improving the reputation of themselves.

Business management strategies that utilise ICT have examined and were found to have returned the greatest long-term value to the business (Whitten et al., 2004). For example, the Generic Design and Construction Process Protocol created by the School of Construction and Property Management of Salford University significantly improved process management in the construction industry (Sheath et al., 1996). Based on the work that was completed in previous chapters this research now creates Demolish-IT via the application of ICT, which this research has shown to, be the best strategy for Demolition Process Management (DPM).

The Demolish-IT system design has three steps in terms of the knowledge gained from the studies described in previous chapters. The first step applied the demolition process map and database of requirements to the Demolish-IT system. The second step applied the ICT as a tool to create the Demolish-IT. In final step, Demolish-IT gathered four tier information of demolition operation to access demolition contractors achieving better process management of demolition.

Demolition process data link to the process requirement, this means when ask to complete a demolition task within the map, the task requirements can be found in the database via the data link. Fig. 7-1 illustrates the fundamental components of the Demolish-IT architecture.
The tools for managing the requirements and editing the health and safety plan were a set of templates that gave demolition projects a head start by providing the demolition contractors with pre-structured document tables, outlines and procedures required to create project deliverables. These templates need to be filled in by the demolition contractor to apply to a specific demolition project.

### 7.2 Managing the Dynamic Engineering Process

#### 7.2.1 Application Requirements of DPM

The engineering process differs from general business processes, because it is highly technical, dynamic and collaborative, and involves a vast amount of information interchange, which current business management tools lack the ability to support (Steels and Lepape, 1992).

The demolition process is an engineering process and the design of Demolish-IT has been devised to meet desired needs. Design is a process that starts with the preparation of the requirements or the specification list, which are applied to optimally utilise resources to meet a stated objective (CDM-Execution Board, 2008). The list also included the overall function of demolition project and any sub-functions foreseen by the designer. Demolition requirements were classified according to (1) life phases of demolition project; and (2) types of requirements,
(e.g. technical, economical, ergonomical and legal) where technical requirements are deemed the most important one.

The project and its development process are required to comply with industry standards (Pahl, 1996). These standards are generic and are often applied to an engineering project in order to ensure that the required quality or safety of the project can be achieved (Galbraith, 1973). However, every application is different because of the differences in demolition project details. Standards restrict the demolition project development process, resulting in a number of demolition activities that must be included in a development process and have to be performed in the suggested sequence by qualified staff using appropriate demolition techniques and methods. In order to achieve the required quality of technical competence needed for the demolition project, a number of the industry standards or regulations have to be applied.

Kappel et al (2000) indicated that flexibility should be a key attribute of any system that is to succeed in supporting engineering processes. Workflow management are widely used in providing support for well-defined and predictable administrative processes (Stader et al., 2000). Therefore, it is important that a management system can be created to ensure a better compliance flow of demolition process.

### 7.2.2 Compliance Flow Framework

Compliance flow is a process management tool that provides a framework for integration of existing tools, and it is particularly important in highly technical fields where the use of specialist third-party software, such as simulation and analysis tools is essential (Stader et al., 2000).

In the demolition project three types of stakeholders are involved: (1) the people who manage the project, such as demolition project managers and team leaders; (2) the people who perform the tasks in the project, such as demolition technical engineers; and (3) the people who are responsible for quality assurance, such as demolition quality assessors (Wysocki, 2003). Compliance flow can be used by all stakeholders of a demolition project where the tasks are performed under the control of the workflow according to the demolition specified process. It should be also updated quickly after an individual task has been performed, so that the latest progress of the demolition project can be shown instantly at any time on request. The framework developed by research to support the proposed compliance flow is depicted in Fig. 7-2.
Chapter 7 “Demolish-IT” prototype and tools

In Fig. 7-2, a set of ontologies that contains the demolition processes, capabilities, applications, techniques, artefacts, and demolition documents are adopted to enable communication, and allow the users of Demolish-IT to add, change, remove or extend them depending on where the specific demolition project is running. In Fig. 7-2 that ontology server includes:

- **Process ontology**: which describes the demolition process and related activities in the context of the development process, including demolition tasks, the tasks pre-conditions and post-conditions.
- **Capability ontology**: which describes the specific skills required to perform particular demolition tasks and where the selected demolition contractors possess these skills.
- **Application ontology**: which describes the application areas of the specific demolition skills defined in capability ontology.
- **Technique ontology**: which describes the demolition techniques or methods used to carry out the tasks.
- **Artefact ontology**: which describes the demolition physical equipments or tools used in performing particular demolition tasks.
- **Document ontology**: which describes the information required to perform a demolition task or the information created during a demolition task, which is normally stored in a document.

In Fig. 7-2, the checking server records the demolition rationale of process planning and execution by logging the transactions of the objects in a workspace and capturing the cause of abnormal decisions. The task manager is the layer of a workflow through which the users of Demolish-IT model and manage their tasks. The model of standard demolition process comes with the system that is capable of providing information on a number of standards, and acts as a knowledge database for demolition process management. The standard modeller provides a visual interface for the Demolish-IT user to model a new standard or amend an existing standard in the model. The compliance agent is responsible for ensuring that the demolition tasks planning and execution are compliant with selected standards.
Figure 7-2: Framework of Compliance Flow for Demolish-IT

(Source from Chung, 2007)

The organisation server provides support for handling resource conflict. For example, if a method for carrying out a demolition task requires a particular capability but currently there are no available demolition workers with that capability, then an alternative method for achieving the task is sought. Therefore, Demolish-IT integrates elements of decision support and knowledge management.

The plan library maintains a database of the demolition plans. A hierarchical folder structure is implemented, with each folder containing solution plans for a demolition task at a specific level. Automatic plan selection to meet the requirements of a given demolition task is also possible.

Each task in the demolition task hierarchy is associated with a task workspace. Task workspaces are linked to the task related information, such as the designed task requirements and specifications. When a demolition contractor is assigned to a task, the contractor will become the owner of the associated task workspace. The contractor is able to manipulate all the objects in the task workspace. Fig. 7-3 illustrates shown the key concept of workspace.
The concept of workspace also contributes towards information transmission between demolition tasks within a project. In a demolition project, an output of a demolition task will usually be an input to one or more demolition subsequent tasks. The workflow links the output from previous tasks to the workspace where it is used as an input to the subsequent task. Fig. 7-4 provides an example of information transmission across the workspace.

**Figure 7-3:** Tasks and their Workspaces

![Tasks and their Workspaces](Source from WfMC, 2001)

**Figure 7-4:** Information Transmission across Workspaces

![Information Transmission across Workspaces](Source from WfMC, 2001)

In Figs. 7-3 and 7-4, the rounded rectangles with the letter T represent the demolition tasks of a process. The rectangles with identifiers beginning with the letters WT represent the tasks’ workspace. Documents are represented by the document icon.
In Fig. 7-3, the level N workflow represents a higher level of abstraction of a demolition process than level N+1. Demolition contractor 1 is appointed as responsible for demolition task T4 and becomes the owner of the associated workspace for demolition task T4. The contractor 1 subdivided T4 into sub-tasks T4.1 and T4.2 and assigned them to demolition contractor 2 and 3. Hence, the contractor 2 and 3 become the owners of the workspaces WT4.1 and WT4.2 of demolition task T4.1 and T4.2.

In Fig. 7-4, document B is the output of demolition task T1. Document B is required to perform demolition task T2 and T3. It is defined as a post-condition of the task T1 and a pre-condition of tasks T2 and T3. When task T1 is completed and document B is uploaded to the workspace WT1, a link to the document will appear in the workspaces WT2 and WT3. Therefore the pre-conditions of task T2 and T3 will be fulfilled. Similarly documents C and D will appear in workspace WT4 after completion of demolition tasks T3 and T4.

7.2.3 Modelling the Standard Task in the Process

The model of a standard demolition task is a process model which acts like a knowledge database providing information about a standard in terms of demolition process management (Karsh, 1990). In compliance flow, such information will be performed to assess the degree of compliance of the user-defined demolition process with a standard. The meta-model of standard modelling using Object Modelling Techniques (OMT) is shown in Fig. 7-5.

Figure 7-5: Meta-model of Standard Modelling

(Source from Cheung, 2003)
The information represented by the model should match with the user-defined demolition process. The advantage of an ontology server in compliance flow tasks is that it can enable a matching process. All terms in the context of demolition process management, such as demolition task, tasks pre-conditions and post-conditions, have to be selected from the ontology server. The modelling of a standard task consists of three sections which are (1) modelling of task framework, (2) modelling of task recommendation and (3) modelling of task capability. This is explained in Table 7-1.

Table 7-1: Contents of the Modelling of Standard Task in the Demolition Process

<table>
<thead>
<tr>
<th>Contents</th>
<th>By conception</th>
</tr>
</thead>
</table>
| Modelling of task framework | • The task framework is modelled as Hierarchical Task Network (HTN).  
• A task is a basic unit of work which can be hierarchically decomposed into sub-tasks.  
• Each task is associated with two sets of conditions pre-conditions and post-conditions. The post-conditions of a task are sometimes the pre-conditions of its subsequent tasks.  
• Performing a task requires the fulfillment of its pre-conditions, the preceding tasks that can satisfy those conditions must have their post-conditions must be completed in advance successfully.  
• The order of execution of tasks is constrained by their dependencies. |
| Modelling of task recommendation | • The recommended techniques, measures, tools or methods that have to be used for performing specific tasks to achieve a specified objectives are modelled by four parameters; the task for which the technique is applied, the requirements for applying the technique, the technique itself and the level of recommendation.  
• There are four level of recommendation namely highly recommended (HR), recommended (R), no recommendation (NR) and not recommended (NR). |
| Modelling of task capability | • A task capability refers to the required capabilities of an agent who is going to perform a specific task  
• The modelling of task capability has the same approach as modelling agent capability.  
• A capability consists of two parts: the technique capability and its application area.  
• The task capabilities have to be defined by users according to their understanding of these factors and the particular environment where the system is running.  
• The required capability for the same process in different projects may vary because of different situations. |

7.3 Requirements of Developing Demolish-IT

In order to develop a useful management system for the demolition industry, the research identified the requirements for creating a Demolish-IT from both the demolition industry and management system aspects.

7.3.1 Requirements from the Industry

For the better management and performance of a project process, the research identified four main areas of shortcomings in demolition process management which could be improved. These were: information, economic, control and efficiency, which are listed in table 7-2. Table 7-2 also suggested how the management system was designed to improve those areas.
Table 7-2: Guideline for Creating Tools to DPM

<table>
<thead>
<tr>
<th>Identified Shortcoming in the Demolition Process Management</th>
<th>Suggested Improvement in Demolish-IT</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Information:</strong></td>
<td>✓ The system has a clear outline of the information needed for the demolition process;</td>
</tr>
<tr>
<td>- Lack of necessary and relevant information;</td>
<td>✓ The system has the function to guide the information collection; and</td>
</tr>
<tr>
<td>- Information is not provided punctually for use in the project;</td>
<td>✓ The system has able to save time and effort when collecting information.</td>
</tr>
<tr>
<td>- Information that is difficult to produce; and</td>
<td>✓ Use Microsoft Excel to produce a cost estimate calculation sheet;</td>
</tr>
<tr>
<td>- Information that is not in a useful format.</td>
<td>✓ The framework of cost estimate items;</td>
</tr>
<tr>
<td></td>
<td>✓ The division of cost estimate; and</td>
</tr>
<tr>
<td></td>
<td>✓ The system can clarify costs to demolition contractors.</td>
</tr>
<tr>
<td><strong>Economics:</strong></td>
<td>✓ The system has adequate control of the project process;</td>
</tr>
<tr>
<td>A. Costs</td>
<td>✓ The system is flexible; and</td>
</tr>
<tr>
<td>- costs are unclear and unknown; and</td>
<td>✓ The system has the functionality of tracing every step of the process during the project operation.</td>
</tr>
<tr>
<td>- costs are untraceable.</td>
<td>✓ The system can clarify costs to demolition contractors.</td>
</tr>
<tr>
<td>B. Profits</td>
<td>✓ Use Microsoft Excel to produce a cost estimate calculation sheet;</td>
</tr>
<tr>
<td>- Profit not predictable; and</td>
<td>✓ The framework of cost estimate items;</td>
</tr>
<tr>
<td>- Profit can be lower due to unplanned work.</td>
<td>✓ The division of cost estimate; and</td>
</tr>
<tr>
<td></td>
<td>✓ The system can clarify costs to demolition contractors.</td>
</tr>
<tr>
<td><strong>Control:</strong></td>
<td>✓ The system will save the time and effort for the project inputs;</td>
</tr>
<tr>
<td>- Information input is not adequately edited;</td>
<td>✓ The system is useful for better planning of the project conduction; and</td>
</tr>
<tr>
<td>- Processing errors are occurring (either by people, machines or documents); and</td>
<td>✓ The system is better organized for the project resources.</td>
</tr>
<tr>
<td>- Excessive controls cause processing delays.</td>
<td>✓ The system has adequate control of the project process;</td>
</tr>
<tr>
<td></td>
<td>✓ The system is flexible; and</td>
</tr>
<tr>
<td></td>
<td>✓ The system has the functionality of tracing every step of the process during the project operation.</td>
</tr>
<tr>
<td><strong>Efficiency:</strong></td>
<td>✓ The system will save the time and effort for the project inputs;</td>
</tr>
<tr>
<td>- People, machines waste time because it takes time to generate useful information; and</td>
<td>✓ The system is useful for better planning of the project conduction; and</td>
</tr>
<tr>
<td>- People, machines waste materials and supplies; and</td>
<td>✓ The system is better organized for the project resources.</td>
</tr>
<tr>
<td>- Effort and equipment required for tasks may exceed the capability of the inputs.</td>
<td>✓ The system has adequate control of the project process;</td>
</tr>
</tbody>
</table>

7.3.2 Requirements from the System of Process Management

Requirements of an ideal support system for Demolish-IT must be addressed if it is to succeed in supporting complex, dynamic, collaborative and unpredictable engineering processes (Cheung, 2003). These requirements include seven aspects: (1) compliance management; (2) traceability; (3) selection of agent; (4) flexibility; (5) common process; (6) management at different levels; and (7) process and information management. Table 7-3 explained in detail of these requirements.
### Table 7-3: Requirements of An Ideal Support System

<table>
<thead>
<tr>
<th>Requirements</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Compliance management</td>
<td>An intelligent support system Demolish-IT should be able to provide support for managing demolition project compliance at process level. And it should ensured the best practice of project compliance takes place at documentation level, where the processes in the project have been done and their results have been documented.</td>
</tr>
<tr>
<td>Traceability</td>
<td>The demolition process information used to make the decisions during the process should be recorded so that the members of an engineering team can review the decision path to understand how the demolition requirements are implemented at any time during the development process as required.</td>
</tr>
<tr>
<td>Selection of agent</td>
<td>An demolition project usually spans multiple departments. The Demolish-IT needs to have access to knowledge about the capabilities required by the process and those possessed by the agents. The Demolish-IT must ensure that all persons involved in any activity of the project lifecycle should have the appropriate training, technical knowledge, experience and qualification relevant to the specific duties they have to perform.</td>
</tr>
<tr>
<td>Flexibility</td>
<td>The Demolish-IT should allow the models to be expressed at an appropriate level in the beginning, and details added when they become available.</td>
</tr>
<tr>
<td>Common process</td>
<td>Most demolition activities have very similar structures at high level with consistent breakdown into several design stages, particularly among similar type of demolition projects. Those common demolition process structures should be maintained as a resource to assist the set up of a specific demolition process. The task of process planning is therefore accelerated by selecting the template process that best matches the current situation and customising it as required.</td>
</tr>
<tr>
<td>Management at different levels</td>
<td>The Demolish-IT must manage responsibilities at different levels of detail for both demolition task specifications and executions.</td>
</tr>
<tr>
<td>Process and information management</td>
<td>Different technical disciplines are involved in different parts of the activities in an demolition project. These disciplines have to communicate effectively with one another since task of one discipline may impact on another. Thus, there is a need for a flexible approach where information is mapped to the interested parties so that they can obtain the required information in the first instance.</td>
</tr>
</tbody>
</table>

(Source from Cheung, 2003)

To ensure the management tools created by the research underpinning Demolish-IT and Demolish-IT serving the user well, these management tools and Demolish-IT should be comprehensive, flexible, easy-to-use and compatible. These attributes are elaborated upon in Fig. 7-6.

**Figure 7-6: The Features of a Good Management Tool**

- **Comprehensive**
  - clear structure
  - adequate description
  - accurate output

- **Flexible**
  - adaptable to new or exceptional situations
  - can be followed for the duration of the lifecycle

- **Easy-to-use**
  - customisable according to the needs of the users
  - user friendliness and reliability

- **Compatible**
  - compatible with other tools
  - produces consistent results
From these requirements, the research has illustrated some desirable features of management tools and designed the technology platform for developing Demolish-IT as illustrated in Fig. 7-7.

**Figure 7-7:** Features of the Technology Platform for Developing the Demolish-IT

7.4 Prototype of Demolish-IT Design

Managing the demolition process and its requirements are the key tasks for the demolition industry when undertaking the demolition project. In order to demonstrate and evaluate the proposed workflow framework for supporting the management of dynamic demolition processes, the prototype includes three features: (1) demolition process modelling; (2) demolition process management; and (3) compliance management.

7.4.1 Contents of Demolish-IT

Combining the demolition process requirements with the demolition process, this research reached a conclusion about the contents of Demolish-IT, which is illustrated in Figs. 7-8, 7-9, 7-10 and 7-11.
### Chapter 7 “Demolish-IT” prototype and tools

#### Figure 7-8: Major Components of Demolish-IT (Tendering Stage)

<table>
<thead>
<tr>
<th>Main components of Demolish-IT</th>
<th>Contents of Sub-components</th>
<th>Contents of Second level sub-components</th>
<th>Demolish-IT features</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bid invitation</td>
<td>- Invitation letter</td>
<td>- Health &amp; safety plan</td>
<td>- Letter and general information of demolition project from planning and creating the building.</td>
</tr>
<tr>
<td>- Contract</td>
<td>- Details of the structure</td>
<td>- Construction drawings</td>
<td>- Written contract documentation.</td>
</tr>
<tr>
<td>- Pre-tendering plan</td>
<td>- Details of Site environment and utilities</td>
<td>- Details of the building environment data.</td>
<td>- Design and construction drawings.</td>
</tr>
<tr>
<td>- Site information</td>
<td>- Details of the building</td>
<td>- Description of the building</td>
<td>- Existing service and utilities and usage of the building.</td>
</tr>
<tr>
<td>On site survey</td>
<td>- Inspection of the site environment</td>
<td>- Inspection of the site</td>
<td>- Detail of the structure;</td>
</tr>
<tr>
<td>Risk assessment</td>
<td>- Premature collapse of part or all of structure</td>
<td>- Debris falling onto machine operators</td>
<td>- Scaffolding and protection.</td>
</tr>
<tr>
<td>- Debris falling onto others adjacent to the site</td>
<td>- Debris falling on other operatives on site</td>
<td>- Edge protection</td>
<td>- Scaffolding of the site.</td>
</tr>
<tr>
<td>- Debris falling on other operatives on site</td>
<td>- Control dust and noise in the vicinity</td>
<td>- Edge protection (exposed leading edges)</td>
<td>- Historical conditions at each level.</td>
</tr>
<tr>
<td>- Debris falling in public area</td>
<td>- Control dust and noise in the vicinity</td>
<td>- Edge protection (exposed leading edges)</td>
<td>- Exclusion zones and Debris netting.</td>
</tr>
<tr>
<td>- Debris falling in public area</td>
<td>- Control dust and noise in the vicinity</td>
<td>- Edge protection (exposed leading edges)</td>
<td>- Debris netting.</td>
</tr>
<tr>
<td>- Debris falling in public area</td>
<td>- Control dust and noise in the vicinity</td>
<td>- Edge protection (exposed leading edges)</td>
<td>- Debris netting.</td>
</tr>
<tr>
<td>Health and safety</td>
<td>- Workforce</td>
<td>- General public</td>
<td>- Health and safety;</td>
</tr>
<tr>
<td>Client specification</td>
<td>- Financial considerations</td>
<td>- Time available</td>
<td>- Cost;</td>
</tr>
<tr>
<td>Physical criteria</td>
<td>- Stability of structure</td>
<td>- Time available</td>
<td>- Structural form;</td>
</tr>
<tr>
<td>- Shape and size of the structure</td>
<td>- Location and accessibility</td>
<td>- Extent of demolition</td>
<td>- Scale of construction;</td>
</tr>
<tr>
<td>Environmental criteria</td>
<td>- Environmental concerns</td>
<td>- Transport considerations</td>
<td>- Location of the building;</td>
</tr>
<tr>
<td>- Recycling</td>
<td>- Environmental concerns</td>
<td>- Transport considerations</td>
<td>- Scope of building;</td>
</tr>
<tr>
<td>Method statement</td>
<td>- Progressive demolition</td>
<td>- Previous usage</td>
<td>- Previous usage and nuisance tolerance.</td>
</tr>
<tr>
<td>Deliberation collapse mechanism</td>
<td>- Long reach machine</td>
<td>- Demolition ball</td>
<td>- Selection and use of cranes or lift.</td>
</tr>
<tr>
<td>Deliberate removal of element or deconstruction</td>
<td>- Explosive and</td>
<td>- Demolition by hand and machine.</td>
<td>- Demolition operation procedures and plant capability and suitability.</td>
</tr>
<tr>
<td>Deliberate removal of element or deconstruction</td>
<td>- Wire rope pulling.</td>
<td>- Demolition by hand and machine.</td>
<td>- Demolition operation procedures and plant capability and suitability.</td>
</tr>
<tr>
<td>Cost estimate</td>
<td>- Site overhead cost</td>
<td>- Temporary structures, facilities, and services</td>
<td>- Labour cost; labour site supervisor, manager and explosives engineer.</td>
</tr>
<tr>
<td>- Asbestos removal</td>
<td>- Site clearing and clear up</td>
<td>- Cost of demolition and</td>
<td>- Equipment cost, site removal and clearing, hand tools and scaffolding, excavator crane and equipment.</td>
</tr>
<tr>
<td>- Contaminated substance remove</td>
<td>- Disconnecting services</td>
<td>- Cost of demolition and</td>
<td>- Implosion cost, site protection cost.</td>
</tr>
<tr>
<td>- Soft stripping cost</td>
<td>Toilets, sinks, roof tiles, ceiling, doors, windows,</td>
<td>- Cost of demolition and</td>
<td>- Implosion cost, site protection cost.</td>
</tr>
<tr>
<td>Waste disposal cost</td>
<td>- Crushing on site</td>
<td>- Cost of demolition and</td>
<td>- Implosion cost, site protection cost.</td>
</tr>
<tr>
<td>- Structural demolition</td>
<td>- Trucking cost</td>
<td>- Cost of demolition and</td>
<td>- Implosion cost, site protection cost.</td>
</tr>
<tr>
<td>General overhead cost</td>
<td>- Insurance, Building permit, Study bond and office administration</td>
<td>- Cost of demolition and</td>
<td>- Implosion cost, site protection cost.</td>
</tr>
<tr>
<td>Bid submittal</td>
<td>- Contractors pre-qualification and competence</td>
<td>- Track record in successful planning and execution of work on the site</td>
<td>- Track record</td>
</tr>
<tr>
<td>- Experience and competence of contractors</td>
<td>- Experience and competence of contractors</td>
<td>- Experience and competence of contractors</td>
<td>- Track record and training of management team.</td>
</tr>
<tr>
<td>- Accident record statistics and enforcement history</td>
<td>- Accident record statistics and enforcement history</td>
<td>- Accident record statistics and enforcement history</td>
<td>- Accident record.</td>
</tr>
<tr>
<td>- Commitment to and extent of management and operative training and maintenance</td>
<td>- Commitment to and extent of management and operative training and maintenance</td>
<td>- Commitment to and extent of management and operative training and maintenance</td>
<td>- Procedures of monitoring and reviewing to health and safety policy and training record.</td>
</tr>
<tr>
<td>- Full specific demolition, public and employers liability insurance cover is in place at all times</td>
<td>- Full specific demolition, public and employers liability insurance cover is in place at all times</td>
<td>- Full specific demolition, public and employers liability insurance cover is in place at all times</td>
<td>- Procedures of monitoring and reviewing to health and safety policy and training record.</td>
</tr>
</tbody>
</table>
### Chapter 7 “Demolish-IT” prototype and tools

Figure 7-9: Major Components of Demolish-IT (Pre-demolition Stage)

<table>
<thead>
<tr>
<th>Main components of DemolishIT</th>
<th>Contents of sub-components</th>
<th>Contents of second level sub-components</th>
<th>DemolishIT features</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Documentation and notification</strong></td>
<td>CDM regulation 2007</td>
<td>Obtain section 6042 notification;</td>
<td>Notification section 6042 forms from local council;</td>
</tr>
<tr>
<td></td>
<td>Building Act 1964 section 80-82</td>
<td>Posting of courtesy notices advising to all properties situated to the boundary of the site and those adjacent to the site;</td>
<td>Demolition method statement issues;</td>
</tr>
<tr>
<td></td>
<td>BSI 1872:2000</td>
<td>Obtain service termination confirmation;</td>
<td>Sub-contracts documentation;</td>
</tr>
<tr>
<td></td>
<td>Control of substances Hazardous for Health (COSHh) Regulation 2002</td>
<td>Compilation of H&amp;S plans;</td>
<td>H&amp;S plan issues;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Prepare method statement;</td>
<td>Services disconnection confirmation documents;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Prepare site file;</td>
<td>Electricity and water;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Obtain sub-contractor’s method statement;</td>
<td>Regulation’s documentation;</td>
</tr>
<tr>
<td><strong>Health and safety plan</strong></td>
<td>Project in general</td>
<td>BGS for site location, general works list.</td>
<td>General information of the site;</td>
</tr>
<tr>
<td></td>
<td>Programme of works</td>
<td>Documentation and notification;</td>
<td>Works list and Retaining Items list;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Site set up;</td>
<td>General programme of works list;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Service/hazardous area investigation protection;</td>
<td>Written confirmation for services disconnection/drainage;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Removal of contaminated hazardous substances;</td>
<td>Scan result (location of underground service feeding running through the site);</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Demolition;</td>
<td>Portable &amp; hand held electric tools check list user check weekly, visual inspection monthly pat testing annually and</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Access/egress route and site contact phone and banksman point;</td>
</tr>
<tr>
<td></td>
<td>Access and egress</td>
<td>M&amp;E isolation disconnection;</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>CAT/GRPR Scan by specialist contractor and</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Electric tools inspection and maintenance systems;</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Safety procedures &amp; arrangement</td>
<td>Existing traffic use &amp; restrictions;</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Internal traffic system and</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Controls at access/egress point.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Identified hazards (mechanical and physical)</td>
<td>Operative awareness;</td>
<td>Danger demolition signs,</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Dangerous demolition site and exclusion zones;</td>
<td>informed any restricted areas;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Site clean maintenance; and</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Special care/fire, hot and cold cutting work;</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Operatives and training</td>
<td>Fully trained site supervisors;</td>
<td>Hazardous materials training record (for insulators and N18/D10G training);</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Safety awareness course and BSI 1872:200Q</td>
<td>Site induction list and</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Site induction;</td>
<td>Tool box talk;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Tool box talks; and</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Specialist training course.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Personal protective equipment</td>
<td>All site personnel</td>
<td>All PPE check forms for daily,</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Hot cutting operatives;</td>
<td>weekly, monthly, six monthly;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Operatives working at height</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>and asbestos removal maintenance</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Welfare arrangement</td>
<td>Site offices and</td>
<td>Site office layout;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Welfare facilities.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Project management team</td>
<td>Clerk;</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>CDM co-ordinator;</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Principal contractor teams;</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Demolition contractor teams and</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Appointed sub-contractor.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Public/other employees safety</td>
<td>Site fencing;</td>
<td>Occupied dwellings/put into protective property;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Adjacent properties protected;</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Project resources</td>
<td>Mechanical &amp; loading operations;</td>
<td>Machines and tools list and</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Access equipment;</td>
<td>Monthly six monthly and annually check forms,</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Flaming cutting equipment;</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Electric tools;</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Hand tools and</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Misc.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Special works</td>
<td>Fire;</td>
<td>Procedures to carry out these work and</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Crushing station;</td>
<td>Arising materials accounting.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Hazardous substances;</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Noise work and</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Waste removal work.</td>
<td></td>
</tr>
<tr>
<td><strong>Method statement</strong></td>
<td>Site set up</td>
<td>Site supervisor duties;</td>
<td>The supervisor duties;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Site compound; and</td>
<td>Design the site compound positions;</td>
</tr>
<tr>
<td></td>
<td>Service investigation/inspection</td>
<td>TDR investigation of existing services within site;</td>
<td>Written confirmation of isolation;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Isolate/diversion of M&amp;E supplies by service providers;</td>
<td>diversion of M&amp;E supplies;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Disconnection/tapping off of services; and</td>
<td>Written confirmation of disconnection;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Instalment of central and task lighting.</td>
<td>Competent electrical contractor and</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Records in the files.</td>
</tr>
</tbody>
</table>

---

**Continue to next page**
<table>
<thead>
<tr>
<th>Method statement</th>
<th>Site supervisor to designate:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Welfare/storage facilities</td>
<td>- Sitting zone, banksmen, locks and keys, toilet, adequate cleaning/rubbish bins/drinking and cooking facilities, site notices/rules.</td>
</tr>
<tr>
<td>Emergency procedures</td>
<td>- Identify the any possible situation to evacuation;</td>
</tr>
<tr>
<td>Erection of heras type fencing</td>
<td>- Rescue procedures;</td>
</tr>
<tr>
<td>Soft strip</td>
<td>- Control and communication for emergency services;</td>
</tr>
<tr>
<td>Environmental issues</td>
<td>- Assembly point; and</td>
</tr>
<tr>
<td>Removal of M.M.M.F. materials</td>
<td>- Action on fire, explosion, confined space accidents.</td>
</tr>
<tr>
<td>Asbestos removal (non-licensed)</td>
<td>- Method and procedures for removal of all those items.</td>
</tr>
<tr>
<td>Demolition</td>
<td>- Identify all drain runs on site;</td>
</tr>
<tr>
<td>Operating crush machine</td>
<td>- Mark on site drawing;</td>
</tr>
<tr>
<td>Site preparation</td>
<td>- Handled damping down procedures for dust generation from the demolition.</td>
</tr>
<tr>
<td>Plant and equipment preparation</td>
<td>- Form of Sample, location, material type from IOM survey;</td>
</tr>
<tr>
<td>Waste management</td>
<td>- Indicate to the building location of licensed and non-licensed asbestos; and</td>
</tr>
<tr>
<td></td>
<td>- Detailed method to non-licensed asbestos removal.</td>
</tr>
</tbody>
</table>

**To be continued from previous page**

<table>
<thead>
<tr>
<th>Method statement</th>
<th>Site supervisor to designate:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Welfare/storage facilities</td>
<td>- Sitting zone, banksmen, locks and keys, toilet, adequate cleaning/rubbish bins/drinking and cooking facilities, site notices/rules.</td>
</tr>
<tr>
<td>Emergency procedures</td>
<td>- Identify the any possible situation to evacuation;</td>
</tr>
<tr>
<td>Erection of heras type fencing</td>
<td>- Rescue procedures;</td>
</tr>
<tr>
<td>Soft strip</td>
<td>- Control and communication for emergency services;</td>
</tr>
<tr>
<td>Environmental issues</td>
<td>- Assembly point; and</td>
</tr>
<tr>
<td>Removal of M.M.M.F. materials</td>
<td>- Action on fire, explosion, confined space accidents.</td>
</tr>
<tr>
<td>Asbestos removal (non-licensed)</td>
<td>- Method and procedures for removal of all those items.</td>
</tr>
<tr>
<td>Demolition</td>
<td>- Identify all drain runs on site;</td>
</tr>
<tr>
<td>Operating crush machine</td>
<td>- Mark on site drawing;</td>
</tr>
<tr>
<td>Site preparation</td>
<td>- Handled damping down procedures for dust generation from the demolition.</td>
</tr>
<tr>
<td>Plant and equipment preparation</td>
<td>- Form of Sample, location, material type from IOM survey;</td>
</tr>
<tr>
<td>Waste management</td>
<td>- Indicate to the building location of licensed and non-licensed asbestos; and</td>
</tr>
<tr>
<td></td>
<td>- Detailed method to non-licensed asbestos removal.</td>
</tr>
</tbody>
</table>
### Chapter 7 “Demolish-IT” prototype and tools

#### Figure 7-10: Major Components of Demolish-IT (Actual Demolition Stage)

<table>
<thead>
<tr>
<th>Main components of “Demolish-IT”</th>
<th>Contents of sub-components</th>
<th>Contents of second level sub-components</th>
<th>“Demolish-IT” features</th>
</tr>
</thead>
<tbody>
<tr>
<td>Service/hazardous investigation and protection</td>
<td>Carry out CAT scan; Layout of drain; Public sewers; Animals and plants; Protection</td>
<td>Mark all findings; Protection of public sewers run across site and; Layout make the adjacent occupied dwellings.</td>
<td>Competent contractor to carry out CAT scan; Layout of drains; Road plate; and Protection of public sewers.</td>
</tr>
<tr>
<td>Site and plant set up</td>
<td>Welfare facilities delivery to site; Internal traffic routes; Access/egress point; Site fence; Vehicle plant turning point; Scaffolding and cranes; Fuel/oil/equipment/plant storage.</td>
<td>Installation the welfare facilities; Installation segregation signing of internal traffic routes; Erection of site fences; All the specific zones; Scaffolding and crane set up; Washing/Water specified water facilities; and Inspect electric supply by competent contractors.</td>
<td>Liaise with any adjoining properties awareness of work; Liaise with main office/local authority all license in specific work area; and Site file (F10 H&amp;S Plan, Method statement, site rule risk assessment first aid kit, section 80, etc.);</td>
</tr>
<tr>
<td>Removal of contaminants/hazardous substances</td>
<td>Licensed</td>
<td>Licensed asbestos removal.</td>
<td>Appropriated licensed competent contractor;</td>
</tr>
<tr>
<td></td>
<td>Non-licensed</td>
<td>ACM’s; MMMF’s; and Glazing.</td>
<td>Location and marks of those materials; and Procedures for removal of those materials.</td>
</tr>
<tr>
<td>Soft stripping</td>
<td>Kinds of elements and materials Hot cutting Combustible material Prevent fire Prevent damage of structure</td>
<td>Loose fixtures and fittings; Redundant heating units and pipework; Electrical cabling and lighting units; Suspended ceiling/living boards; Removal of sanitary ware; Removal of floor/glassed areas; Internal partitioning; Carpet/finish; Foot floors; Glazing; Timber floors; Waste; Environmental monitoring; and Inspection of exposed structure.</td>
<td>Soft stripping notes for site induction and tool box talks; Work carry out according the procedures and methods; Escape route of fire; PPE provided and Material and items removal from site plan.</td>
</tr>
<tr>
<td>Reuse and recycling</td>
<td>Material</td>
<td>Concrete; Timber; and Glazing panel.</td>
<td>Preparatory works; Concrete crushing procedure; Timber and glazing removal method and procedure.</td>
</tr>
<tr>
<td></td>
<td>Structural element</td>
<td>Typical steel</td>
<td>Method procedure.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Wooden frames; Steel and Plastic.</td>
<td>Method procedure.</td>
</tr>
<tr>
<td></td>
<td>Doors, windows, sanitary wares</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Structural demolition in predetermined sequences</td>
<td>Structural demolition</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Environmental demolition</td>
<td>Mechanical demolition</td>
<td>Breaking up concrete slabs and Grubbing up the floor foundations.</td>
<td>Safe use plant procedure; an Driver competence documents.</td>
</tr>
<tr>
<td>Environmental monitoring</td>
<td>Noise, dust disturbance</td>
<td>Noise, dust, monitoring form; Dictate damping down procedures and Vibration.</td>
<td></td>
</tr>
<tr>
<td>Completion works</td>
<td>Removal the remaining item from soft stripping Shifting material from removal of site and Crushing of inert material.</td>
<td>Procedures for completion works.</td>
<td></td>
</tr>
</tbody>
</table>

#### Figure 7-11: Major Components of Demolish-IT (Post-demolition Stage)

<table>
<thead>
<tr>
<th>Main components of “Demolish-IT”</th>
<th>Contents of sub-components</th>
<th>Contents of second level sub-components</th>
<th>“Demolish-IT” features</th>
</tr>
</thead>
<tbody>
<tr>
<td>Site clearance</td>
<td>Clean site to suitable standard.</td>
<td>Hand over the certificate.</td>
<td>Standard clearance plan.</td>
</tr>
<tr>
<td>Final account</td>
<td>Finance work out (percentage of profit).</td>
<td>Certificate of completion of the work.</td>
<td>Finance report; and Sign off form.</td>
</tr>
<tr>
<td>Post contract review</td>
<td></td>
<td></td>
<td>Review report.</td>
</tr>
</tbody>
</table>
These major components of the demolition process were stored in the database that can be found in Appendix C - Demolition process events list (tasks details). Fig. 7-12 is a screen shot for the demolition process tasks list.

**Figure 7-12: Screen Shot of the Demolition Process Tasks List**

7.4.2 Demolition Process Modelling

To facilitate Demolish-IT, an enhanced task-based model was developed. The task model not only modelled the task structure of a demolition project, but also captured the capabilities that were required of demolition tasks and possessed by the demolition contractors. It also linked the information that were required or created during demolition tasks execution to the related tasks. (Refer to Fig. 7-13).
In Fig. 7-13, the demolition project is represented by a series of tasks. The tasks performed by the demolition task agent, which included the capabilities, techniques, constraints and workplaces, with demolition contractors. These tasks should obey the demolition process flow carried out by the demolition contractors. A demolition task list was shown in Fig. 7-14 via a penetration view. The penetration function allows a user to view a hierarchical demolition process model, starting at any level, and move upwards or downwards level by the tasks flow, with the ability to add or remove any task attributes, such as contractor information in the visual interface at any time (WfMC, 2001). Fig. 7-14 also showed the penetrative view of the demolition task flow between two levels in a demolition project.

In the tasks of a demolition project, AT1, AT2, AT3 and AT4 represents tasks for four stages of demolition processes at the highest level N. The T1-1, T1-2, ..., T1-7 represent the sub-tasks at the second level N-1 of AT1; T2-1, T2-2, .., T2-6 represent the sub-tasks of AT2; the T3-1, T3-2, ..., T3-6 represent the sub-tasks of AT3 and the T4-1, ..., T4-4 represent the sub-tasks of AT4.
7.4.3 Four-tier Prototype of Demolish-IT

The prototype of Demolish-IT was designed and developed as a four-tier information system. The contents of this system are represented in Fig. 7-15.

**Figure 7-15: Four-tier Prototype of Demolish-IT**
In Fig. 7-15 tier 1, the standard demolition process, is represented by a tree map or DFD four stage demolition maps (Refer to Figs. 5-15, 5-16, 5-17 and 5-18). Fig. 7-16 illustrates a screenshot of the tree map of a standard demolition process.

**Figure 7-16: Screenshot of Standard Demolition Tree Map**

Tier 2 is the user-defined process, which specifically applied to a certain demolition project. The demolition contractor responsible for the project can design a suitable process for the project based on the standard demolition process map. This content was represented by a Microsoft Project document. Fig. 7-17 shows such a user-defined demolition project process map.

To run compliance checks on Tier 1 and Tier 2, the standard specification, demolition user-defined specification and task specification needed to be defined. The defined specification refers to a designed specification, which is modelled as a post-condition of a demolition task is represented by a document icon. The demolition task specification relates to a standard specification and is included in a user-defined process. The standard specification is included in the standard model. A user-defined specification is defined by the demolition user, but its
context is not included in the standard process model. If a demolition task specification has similar features to a standard task specification, they are corresponding and have the same name, and use the same ontology. Fig. 7-18 describes the terms of compliance check mechanisms.

**Figure 7-17:** An Example of User-defined the Project Process Map of Demolition

![User-defined Project Process Map](image1)

**Figure 7-18:** The Concept of Compliance Check Mechanisms

![Compliance Check Mechanisms](image2)
In Fig. 7-18, SA1 is the corresponding standard process to user-defined demolition process A1. S1 and UA1 produce corresponding output specifications of demolition process A1. Therefore, all the specified constraints in standard demolition process SA1 that apply to the standard demolition tasks, including pre-condition and post-conditions of the standard demolition task, the task capability, the task recommendations and the task information. These must be applied to its corresponding demolition task in the user-defined process in order to comply with standards.

The Demolish-IT task flow objects in the second tier are a user-defined process. It comprises of a number of demolition contractors defined tasks, links, pre- and post-conditions, task capabilities, agent capabilities, task agents and their workspaces. Task flow object links were used to capture the flow of demolition tasks at the same level of standard demolition task flow. The relationships among the demolition contractor defined task flow objects, together with their key attributes, major operations and operation descriptions, are illustrated in Fig. 7-19.

**Figure 7-19: Class Diagram of the Task Manager In a User-defined Process**

In the demolition standard process, a standard demolition task is represented as a Hierarchical Task Network (HTN) with the details of each task included and described in Fig. 7-20. This will be stored in the third tier of Demolish-IT – Task manager.
In the fourth tier of Demolish-IT the ontology comprises of five frameworks. These are: (1) the demolition requirements; (2) the contractors’ Pre-Qualification Questionnaire (PQQ); (3) the demolition method statement; (4) equipment capability; and (5) their usage. Each framework provides a number of specific services to the demolition processes. For example, PPQs are used to perform the capability checking services of the demolition contractors. The information from tier four can support a specific demolition task from tier three. Tier two defined demolition project process and the demolition compliance task flow. The relationship between these tiers can be shown in Fig. 7-21.
Demolition contractors require a single webpage that can contain all parts of Demolish-IT. Fig. 7-22 presents a system function chart of Demolish-IT, where all functions are shown in the screen on the single webpage. All basic functions required for Demolish-IT are integrated inside the task manager. Therefore, the task manager is the most useful interface for managing most demolition processes.

**Figure 7-22:** Function structure chart for Demolish-IT
The system functions of Demolish-IT shown in Fig. 7-22 are integrated into a user-interface webpage. This is shown in Fig. 7-23. (1) on the left hand side are the outlook bar items which include Demolish-IT ontology, task manager, task standard model, checking system and plan library; (2) an object tree of Demolish-IT is used to represent the hierarchical structure of the standard demolition process, task and ontology; (3) the Demolish-IT information area shows the particular information of selected processes in an object tree; (4) function tabs can be selected by the demolition user, and they will represent the Demolish-IT information in different functional perspectives; (5) on the right hand side is a set of command buttons which Demolish-IT applied to select the demolition project. A front page of Demolish-IT also represented by screen-shot in Fig. 7-24.

Figure 7-23: Demolish-IT Webpage Layout

7.5 Design Management tools of Demolition Process Management

The prototype of Demolish-IT was created due to demand by the demolition industry but the system design is too large to be summarised in one research project. From the overview of the requirements used by the demolition contractor, this research focused on targeting two specific tools. One is the management tool for key requirements of demolition process and another is the documentation tool for the health and safety plan within Demolish-IT. These are described and demonstrated in this section.
Figure 7-24: Screen-shot the front page of Demolish-IT

7.5.1 Tool for Managing Demolition Process Requirements

Table 7-4 lists the contents of the management tool of demolition requirements as a part of Demolish-IT.

<table>
<thead>
<tr>
<th><strong>Main components</strong></th>
<th><strong>Contents</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Collection of project information.</td>
<td>Outline of information collection.</td>
</tr>
<tr>
<td>Health and safety plan.</td>
<td>Written health and safety plan checklist.</td>
</tr>
<tr>
<td>Risk assessment</td>
<td>Risk assessment assessor and forms.</td>
</tr>
<tr>
<td>Selection of techniques.</td>
<td>Demolition techniques and criteria with factors for selection techniques.</td>
</tr>
<tr>
<td>Cost estimate</td>
<td>Detailed cost estimate sheet.</td>
</tr>
<tr>
<td>Method statement</td>
<td>Method statement outline.</td>
</tr>
<tr>
<td>Removing asbestos</td>
<td>Guideline to removing the Asbestos.</td>
</tr>
<tr>
<td>Waste management</td>
<td>Model of waste management and arrangement.</td>
</tr>
</tbody>
</table>
In order to make the tool straightforward and accessible to the demolition engineer, this research chose Microsoft Word as a platform linking the main contents of demolition requirements together. The following design steps were used to create the tool for integrating and managing demolition requirements:

1. **Insert bookmarks:** the contents of eight key requirements shown in Table 7-4 were bookmarked, these are: (1) outline of information collection; (2) health and safety plan written checklist; (3) risk assessment assessor and forms; (4) demolition techniques and selection criteria; (5) detailed cost estimate sheet; (6) method statement outline; (7) guideline to removing the asbestos; and (8) model of waste management and arrangement. Fig. 7-25 provides a screen shot of these bookmarks.

2. **Link to main requirements:** on the template in Fig. 7-24, the key requirements are illustrated. They are: (1) collection of project information; (2) health and safety plan; (3) risk assessment; (4) selection of suitable techniques; (5) cost estimate; (6) method statement; (7) asbestos removing; and (8) waste management. These were connected to the bookmarks created in the first stage by hyperlinks, so that when a main requirement is selected, the tool will direct the engineer straight to a desired section to acquire relative information.

3. **Integration of steps 1 and 2:** every key requirement was linked to their contents in Demolish-IT.

In operating the tool, the user needs to press down “**Ctrl**” on the keyboard, then “**Click**” on the requirements to be viewed, and the contents of the requirement appeared in the window. The user can easily use them to guide the demolition project management and activities.

**Figure 7-25:** Template of Demolition Process Key Requirement Tool

---

**Demolition Process Key Requirements**

- Collection of project information (R1)
- Health and safety plan (R2)
- Risk assessment (R3)
- Selection of techniques (R4)
- Cost estimate (R5)
- Method statement (R6)
- Asbestos removing (R7)
- Waste management (R8)
The detailed contents of demolition requirement tool are shown in Appendix D: D1. It includes (1) an outline created by this research for collecting information for the demolition project and shown in Table 6-1 and Table 6-2; (2) a demolition health and safety plan and a process map of the health and safety plan framework; (3) demolition risk assessment forms and protocols; (4) a demolition cost estimate of the key components and cost estimate sheets; (5) a framework of demolition techniques and the selection criteria for a suitable demolition technique; (6) an outline of the framework of various demolition method statements which are detailed in Fig. 6-12; (7) an asbestos removing guideline to address the Control Asbestos Regulation of 2006 shown in Fig. 6-13; and (8) a waste management programme comprising of a basic elements model and a demolition waste handling model.

### 7.5.2 Tool for Editing the Health and Safety Plan

Before any demolition project commences on site, the health and safety plan is the essential document to be provided by the demolition contractor (Managing Health and Safety in construction, 2007). For documentation of the health and safety plan, each demolition contractor has their own method of compilation. But the contents of the health and safety plan must fulfil the requirements of the CDM 2007 Regulation. This states that the demolition project health and safety plan must have unified contents according to the regulation. This research gathered samples of demolition projects’ health and safety plans of three demolition contractors, and summarized the outline form of the health and safety plan. Having verified these with the demolition engineers, documentation of the demolition health and safety plan was finalised.
Based on the created outline form of the Demolish-IT health and safety plan, the research organized them in a format protocol as following:

INDEX

H2: PROJECT PARTICULARS
H3: MANAGEMENT STRUCTURE
H4: NOTIFICATION
H5: SITE INFORMATION SOURCE
H6: DESIGN INFORMATION
H7: HEALTH AND SAFETY PRINCIPAL & OBJECTIVES
H8: SCOPE OF THE WORK
H9: NATURE OF THE WORK
H10: PROJECT TIME TABLE
H11: PROJECT RESOURCE
H12: FUEL OIL & GAS STORAGE
H13: FIRE EQUIPMENT
H14: SAFETY PROCEDURES
H15: PROJECT PERSONNEL
H16: INFORMATION INSTRUCTION & TRAINING
H17: ARRANGEMENTS
H18: SITE RULES
H19: METHOD STATEMENT
H20: IDENTIFIED HAZARDS 1
H21: IDENTIFIED HAZARDS 2
H22: WELFARE FACILITIES
H23: SERVICES
H24: PERSONAL PROTECTION
H25: PRE-START CHECK LIST FOR SITE MANAGEMENT
H26: WASTE DISPOSAL
H27: SAFETY ADVISOR
H28: JOINT CONSULTATION
H29: PROHIBITION/IMPROVEMENT NOTICES
H30: MONITORING & REVIEW OF SITE SAFETY PLAN
H31: INFORMATION SOURCES (HEALTH & SAFETY FILE)

The whole contents of this format protocol have been edited in Appendix D: D2.

The operation of the health and safety plan documentation tool is displayed below:
Example 1: to select “H2: PROJECT PARTICULARS”, then press “Ctrl + Click” the window will show the following link to the contents of this outline as follows, then the user can enter the information into a particular area.

### H2: PROJECT PARTICULARS

1. **Project**

<table>
<thead>
<tr>
<th>Name</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Address</td>
<td></td>
</tr>
<tr>
<td>Site map reference</td>
<td></td>
</tr>
</tbody>
</table>

2. **Client**

<table>
<thead>
<tr>
<th>Name</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Address</td>
<td></td>
</tr>
<tr>
<td>Contact</td>
<td>Telephone/Fax</td>
</tr>
<tr>
<td></td>
<td>E-mail</td>
</tr>
</tbody>
</table>

3. **CDM Coordinator**

<table>
<thead>
<tr>
<th>Name</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Address</td>
<td></td>
</tr>
<tr>
<td>Contact</td>
<td>Telephone/Fax</td>
</tr>
<tr>
<td></td>
<td>E-mail</td>
</tr>
</tbody>
</table>

4. **Principal Contractor**

<table>
<thead>
<tr>
<th>Name</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Address</td>
<td></td>
</tr>
<tr>
<td>Contact</td>
<td>Telephone/Fax</td>
</tr>
<tr>
<td></td>
<td>E-mail</td>
</tr>
</tbody>
</table>

5. **Appointed sub-contractors**
- Asbestos removal (licensed) contractor;
• Scaffold contractor;
• Asbestos disposal contractor;
• General waste disposal contractor;
• Service investigation (CAT Scan) contractor;

<table>
<thead>
<tr>
<th>Name</th>
<th>Address</th>
<th>Contact</th>
<th>Telephone/Fax</th>
<th>E-mail</th>
</tr>
</thead>
</table>

Fig. 7-27 provides a screen-shot the part **H2: PROJECT PARTICULARS**.

Figure 7-27: The screen shot of part of the template of H2: project particulars

*Example 2:* When “**H11: PROJECT RESOURCE**” is selected, then the following contents will be shown. The user can edit the contents according to their requirements.
H11: PROJECT RESOURCE

Mechanical removal and loading operations:

- Tipper transport (skips and bulkers).
- 360° demolition rigs.
- Loaders.
- Cranes.

Access equipment:

- Approved tower scaffold (to BS. Design).
- Access ladders and youngerman boards.
- Powered access platforms.

Health and Safety

- Fully compliant with the safe system of work intended for the project.
- Introduction on site to any commencement of the works and ensure that it’s fully understood.
- Monitoring of all such systems is to be carried out on a regular basis.
- Must be fully trained and in possession of an area operatives certificate of training attendance or equivalent to oversee all asbestos removal work.

Equipment

- Hand tools.

PPE/RPE

- All site personnel: gloves, goggles, respiratory protection, safety boots, hard hats.
- Operatives working at height: safety harness, lines.
- Operatives working with asbestos: respiratory protection, disposable coveralls, rubber boots.

Example 3: When you “Ctrl+ Click” on “H18: SITE RULES”, the following contents appear below. This is an outline for the user to provide particular project site rules under the same standard requirement.
H18: SITE RULES

Site layout

✓ The works are situated within the environs of grounds purchased and controlled by the client and are adjacent to inhabited buildings.
✓ The following structures should be within the scope for demolition/strip out/removal:
  o Brick bungalows and associated outbuildings; and
  o Slabs and foundations (excluding areas immediately adjacent to retained walls or fencing).

Access/egress

✓ The access and egress points for work should be clearly identified.
✓ Contractors’ vehicles should use the established road for removal of materials or the supply of machinery.
✓ The utmost caution should be adopted when entering and leaving the site compound, due to consideration to other road users, residents, pedestrians, visitors, children and occupants of adjacent units etc.
✓ A banksman should be employed for movement of construction machinery/vehicles across the site.
✓ All drivers of construction traffic should adhere to the existing area speed restrictions.
✓ Traffic management should be put in place during particular phases of the demolition if necessary.

Site security

✓ Erecting the heras fencing to eradicate unauthorized access to working areas.
✓ Existing walls and fences forming boundaries to the site will be maintained as instructed by the client’s engineer.
✓ Temporary heras fencing will cordon off all internal entry points to the works.
✓ Block off the access to the site with an easily collapsible barrier to prevent vehicle access.
✓ Access to and egress from the site should be strictly controlled so that only authorized personnel are allowed on site during operations.
✓ Visitors to the site must first report to the site manager.
✓ Location of offices and welfare facilities to be determined and agreed with the client and will be noted in the developing health and safety plan.
A register of all operatives/plant/machines on site will be kept and any operatives leaving the site during the working shift will book out with the site manager so s/he is aware of the numbers present on site at any time.

A copy of any site safety report will be retained in the site office.

Visitors to the site

All visitors to the site should be logged by the full time site supervisor to enable easy identification of any trespassers.

Site daily checklist

Site fencing checked for security so that unauthorized access is prevented.

All mechanical equipment employed on this project will be secured and immobilized at the end of each working shift.

No road transport left on site overnight unless broken down.

Any scaffolding towers/ladders to be dismantled or secured overnight to prevent illegal access to the structures.

All soft strips (combustible material) to be removed from site progressively so as to prevent a build-up of flammable waste.

Asbestos products to be properly contained and secured and be removed from site in strict accordance to the current, licensing stipulations.

Example 4: The content below will appear when you “Ctrl + Click” on “H25: PRO-START CHECKLIST FOR SITE”. The outline is the same for every demolition project. Therefore, the user does not have to write it out or edit it continuously.

H25: PRE-START CHECK LIST FOR SITE MANAGEMENT

Ensure that the environmental impact of the site and its effect on the local community has been considered.

Make personal contact with persons working in adjoining areas.

Make arrangements to exclude trespassers use of by the appropriate fencing and barriers.

Erect all necessary warning signs in positions agreed with the safety advisor ensuring extra signs for areas of special risk.
✓ Arrange the display of all statutory notices and ensure the company’s safety policy; accident book and statutory inspection registers are available for inspection on the site.
✓ Prepare suitable first aid facilities and display necessary signs indicating who is responsible as the appointed person or trained first aider on site.
✓ Display the employers’ liability insurance certificate and sub-contractors certificates so that all contractors can see them.
✓ Make sure that the company COSHH and risk assessment forms are available on site.
✓ Make arrangements to provide adequate protective equipment sufficient for the number of persons engaged. Ensure that additional hard hats are available for visitors.

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Fig.7-28 is a screen shot of the Demolish-IT health and safety plan documentation tool.

**Figure 7-28:** Screen-shot of Demolish-IT for Compiling the Health and Safety Plan
Chapter 7 “Demolish-IT” prototype and tools

7.6 Chapter Summary

This chapter has reviewed the characterisation of management system for engineering process management, so that the system complies within the industry standard. Then research created the prototype of Demolish-IT for the industry. At first, the research identified the needs of a demolition process management system from the industry, due to the complexity of the demolition process; Demolish-IT tools created by the research have the ability to manage the dynamic engineering process. Secondly, based on studies in previous chapters, the research created a four tier prototype of Demolish-IT and two demolition management tools for Demolish-IT. These are the tool for outlining key process requirements and the tool for the documentation of the health and safety plan.

To ensure the Demolish-IT is compliant with the industry standard, the research applied the knowledge of the process standard model and modelling demolition processes within the standard process in Demolish-IT. Demolish-IT prototype also has a task manager to manage the demolition tasks and a checking system to ensure that the demolition tasks comply within the standard process model.
8 Validation

8.1 Introduction

Over time, demolition organizations find themselves guessing a lot about what would constitute a good performance on a project, and demolition contractors rely on their own instincts to decide what their clients really need and they carry out the demolition accordingly. The lack of clear communication between demolition engineers and clients means that problems invariably appear. Demolish-IT offers the potential to reduce the incidence of these problems occurring.

Validation can help to understand, verify or increase the benefits of a product or service by customers or clients. It also can identify the strengths and improve the weaknesses in the program (Management Library, 2008). Validation produces valid comparisons between the research done to decide which should be retained and fully examined, and describes how the research is effective and can be applied to the industry. Hence, this chapter provides an evaluation of the research work, which includes validation of demolition process mapping, the key requirements of demolition process, the documentation tool for editing the demolition health and safety plan and the prototype of Demolish-IT. An interview, a workshop survey and a real life project testing are all methods used in this section of the research work. This is illustrated in Fig. 8-1.

Figure 8-1: Flowchart of Validation process
8.2 Validation Aim and Objective

The aim of the validation is to determine the usability and functionality of Demolish-IT for industry professionals. The validation process focuses on identifying the benefits and shortcomings on Demolish-IT components which includes the generic demolition process map, demolition process requirements and the prototype of Demolish-IT. It also considers whether the Demolish-IT prototype and management tools actually meet the demands of the demolition industry.

To achieve this aim, the specific objectives of the evaluation are:

- To assess the accuracy of the output of generic demolition process map;
- To identify how Demolish-IT will be applied to the industry;
- To verify that the key process requirements and the tool for compiling the health and safety plan comply with the demolition contractor’s demands and satisfies the original design goals;
- To determine the usability and applicability of the tools to the demolition industry; and
- To obtain user feedback for further improvement of the tools and point out any recommendations to guide further development.

8.3 The Validation Methodology

The overall goal of selecting a validation methods is to obtain the most useful information to prove that the research work has achieved its targets in the most user-effective and realistic fashion. Consider the following questions (Riley and Rosanske, 1996):

- What information is needed to make current decisions about the management of a demolition process?
- Of this information, how much can be collected and analyzed in a cost effective and practical manner of demolition process management, e.g. using questionnaires, surveys and checklists?
- How accurate is the information from the demolition industry, and just how accurate will the system is realistically to the industry? Will such a degree of accuracy be sufficient to improve the efficiency of the industry?
Chapter 8 Validation

- Is the validation methodology feasible and does it get all of the required information?
- What additional methods could be used if additional information is needed for the validation?
- Will the information collected appear to the user, i.e. to demolition contractors or to management on contractor?
- Will the nature of the audience conform to the validation methods, e.g. will they fill out questionnaires carefully, engage in interviews or focus groups, and let you examine their documentation, etc?
- How can the information gathered be analyzed to get accurate results?

Note that, ideally, the evaluator uses a combination of methods, for example, a questionnaire to quickly collect a great deal of information from a lot of people, then interviews to get more in-depth information from certain respondents to the questionnaires, and case studies then be used for an even more extensive analysis.

Table 8-1 provides an overview of the major methods used for validation.

According to the description of the validation method below, this research formative evaluation has been undertaken during the development of the generic demolition process map. In chapter five, a series of face-to-face interviews with demolition experts was conducted at the map development and result stages. The validation was then carried out again during the final stage of the research. This validation carried out on the demolition process map, the key requirements and the protocols of Demolish-IT, as to what degree they possess an acceptable level of accuracy. It also verifies whether the tools can be effectively implemented in accordance with demolition specifications. The tools went through several iterations and appropriate refinements with demolition experts. The validation process continued with a workshop survey after the tools were ready for a demonstration. A group of randomly selected demolition experts were invited, which the workshop conducted after their committee meeting of IDE, to give their opinions on the tools that were demonstrated. The summary of the workshop findings were useful for further research. Finally, the validation process conducted a trial case study of a real demolition project; the demolition engineer compared the conventional method to the newly created tools method, giving feedback on differences and highlighting how the management of demolition can be improved by using the management documentation tools.
Table 8-1: Description of General Validation Methods

<table>
<thead>
<tr>
<th>Method</th>
<th>Purpose</th>
<th>Advantages</th>
<th>Challenges</th>
</tr>
</thead>
<tbody>
<tr>
<td>Questionnaires, Surveys, Checklists</td>
<td>To get a lot of information from people quickly and easily.</td>
<td>☐ Can be complete anonymously. ☐ Inexpensive to administer. ☐ Easy to compare and analyze. ☐ Can get lots of data. ☐ Many sample questionnaires already exist.</td>
<td>☐ Might not get careful feedback. ☐ In surveys, may need a sampling expert. ☐ Doesn't get the full story.</td>
</tr>
<tr>
<td>Interviews</td>
<td>To fully understand someone's impressions or experiences, or learn more about their answers to questionnaires.</td>
<td>☐ Gets full range and depth of information. ☐ Develops relationship with Client. ☐ Can be flexible with client.</td>
<td>☐ Can take much time. ☐ Can be hard to analyze and compare. ☐ can be costly. ☐ interviewer can bias client's responses.</td>
</tr>
<tr>
<td>Documentation review</td>
<td>To gain an impression of how the program operates without interrupting the program; from review of applications, finances, memos, minutes, etc.</td>
<td>☐ Get comprehensive and historical information-doesn't interrupt program or client’. ☐ Information already exists. ☐ Few biases about information.</td>
<td>☐ Often takes much time. ☐ Information may be incomplete. ☐ Needs to be quite clear about what to look for. ☐ Not flexible enough will to get new data; restricted to data that already exists.</td>
</tr>
<tr>
<td>Observation</td>
<td>To gather accurate information about how a program actually operates, particularly about processes.</td>
<td>☐ View operations of a program as they are actually occurring. ☐ Can adapt to events as they occur.</td>
<td>☐ Can be difficult to interpret seen behaviours. ☐ Can be complex to categorize observations. ☐ Can influence behaviour of program participants. ☐ Can be expensive.</td>
</tr>
<tr>
<td>Focus groups</td>
<td>To explore a topic in depth through group discussion, e.g. about reactions to an experience or suggestion, understanding common complaints, etc.</td>
<td>☐ Quick and reliable in obtaining common impressions. ☐ Can be an efficient way to get much range and depth of information in short time.</td>
<td>☐ Can be hard to analyze Responses. ☐ Need good facilitator for safety and closure. ☐ Difficult to schedule 6-8 people together.</td>
</tr>
<tr>
<td>Case studies</td>
<td>To fully understand or depict a client's experiences in a program, and conduct comprehensive examination through cross comparison of cases.</td>
<td>☐ Fully depicts client's experience in program input, process and results. ☐ Powerful means of to portraying a program to outsiders.</td>
<td>☐ Usually quite time consuming to collect, organize and describe. ☐ Represents depth of information, rather than breadth.</td>
</tr>
</tbody>
</table>

(Source from Carter, 2008)

8.3.1 Validation Approach

The validation involved five individual experts’ interviews and a focus group workshop of twelve demolition experts. The validation approach adopted to help test all aspects of the research work has been able to identify the validation objectives. The approach was capable of generating positive feedback, limitations and further improvements for practical purposes. Also
all the evaluators were demolition experts who have considerable amount of experience working within the demolition sector. This ensured that the research work was practical.

The first part of the validation was the interview. The interviews involved a face-to-face questionnaire to selected individual demolition expert. The five interviewees were selected from the Institute of Demolition Engineer (IDE) member list. They have been directly involved in the demolition process management for over 20 years. The semi-structured interview questionnaire was created for the purpose of obtaining the opinions of experts on the reliability and applicability of the demolition process map, process mapping, process requirements and the prototype of Demolish-IT.

The second part of the validation consists mainly of a workshop with a group of twelve demolition experts, who have been selected from members of the IDE committee. The workshop was carried out after their committee meeting. It started with a presentation on the background of the research objectives and the research completed. Following a description of the prototype and a demonstration of the documentation tools, the demolition experts were encouraged to give their comments on the research work. Finally, to obtain a structured feedback and to generalize user perception of the tools, the demolition experts were asked to complete a questionnaire on the validation of the Demolish-IT, such as the effectiveness, practicality and usability of the system prototype and tools.

The third part of the validation is a trial case study. This case study used a comparison to prove that the documentation tools have the anticipated advantages by comparing them to currently used methods. An experienced demolition engineer who has completed a number of demolition projects was selected to complete the trial case study. The trial study conducted used both the documentation tools created by the research and the traditional method for editing the demolition health and safety plan for the same demolition project. From the feedback the differences between the two methods can be found.

**8.3.2 Questionnaire Design for Interview and Workshop Survey**

The questionnaire for the interview and workshop survey were based upon the aim and objectives of the validation stated in section 8.2 and covered all the major aspects of the research work that needed to be validated and was useful for obtaining essential feedback from the evaluators. The questionnaire contained twenty questions, shown in Table 8-3.
The workshop questionnaire was divided into five sections as follows:

- Request personal and company details and information about the participants.
- Tools effectiveness.
- Tools usability.
- Tools practicability.
- General comments.

Each section includes several questions that ask for a rating ranging from “poor” to “excellent”. The validation results show the percentage of people that chose each option. The trial project case study conducted checks of the documentation tool for compliance with the real project requirements, and whether it is fulfilling the industry and information system requirements discussed in the sections 7.2 and 7.3. The checklist for the case study is summarized in Table 8-2.

Table 8-2: Checklist of the Case Study

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Checklist</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Is Demolish IT detailed enough for both process specification and execution?</td>
</tr>
<tr>
<td>2</td>
<td>Can the tool ensure the best project compliance at documentation level, where the processes in the project have been completed and their results have been documented?</td>
</tr>
<tr>
<td>3</td>
<td>Can the tool review the decision path to understand how the requirements are implemented at any time during the development process as required?</td>
</tr>
<tr>
<td>4</td>
<td>Does the person using the tool have appropriate training, technical knowledge, experience and qualification relevant to the specific duties they have to perform?</td>
</tr>
<tr>
<td>5</td>
<td>Does the tool allow the models to be expressed with appropriate detail in the beginning, and added when they become available?</td>
</tr>
<tr>
<td>6</td>
<td>Can the tool be maintained as a resource for a specific process? Therefore, the task of process planning is accelerated by using the templates that can best match current situations as required.</td>
</tr>
<tr>
<td>7</td>
<td>Is the tool a flexible approach where information is mapped to the parties so that they can obtain required information when they need it?</td>
</tr>
<tr>
<td>8</td>
<td>Do the tools have a clear outline of the information needed for the demolition process?</td>
</tr>
<tr>
<td>9</td>
<td>Are the tools able to save on time and effort invested in the project?</td>
</tr>
<tr>
<td>10</td>
<td>Are the tools useful for better planning of the project conduct?</td>
</tr>
<tr>
<td>11</td>
<td>Are the tools well organized for storing project resources?</td>
</tr>
<tr>
<td>12</td>
<td>Do the tools have the functionality of tracing every step of the process during the project operation?</td>
</tr>
</tbody>
</table>
8.4 Validation Results

This section reports feedback from the validation participants and their responses to the questions posed in the interview and workshop, and the opinions from the trial case study. Further comments will be given after the assessment of the research work.

8.4.1 Results from the Interviews

Table 8-3 shows the results from the interview with five demolition experts. The percentage (%) of responses from experts presents a quantitative assessment result. The assessment scale gives a general idea of how good the research work was perceived to be by leading practitioners.

8.4.2 Results from the Workshop

The validation was conducted in a workshop with group of twelve demolition engineers, who have worked in the demolition sector for more than 20 years, and have completed numerous demolition projects and were selected from the IDE. The workshop started with a 20 minute presentation to introduce the demolition process map, demolition requirements, the prototype of Demolish-IT and documentation tools for editing the health and safety plan. Then the engineers’ group were asked to answer the pre-designed questionnaires. The question form is provided in Appendix E. The results are shown in Table 8-4.

8.4.3 Results from the Trial Case Study

The trial case study has chosen the sample project 1. The engineer (Stella Wright, Total Reclaim Demolition, Ltd.) had worked on this project before and now used the documentation tool created from the research to document the project health and safety plan. Comprising both the conventional method and the new tool assisted method, opinions of the documentation tool were given. Questions contained within Table 8-5 were subsequently posed to Ms. Wright.
### Table 8-3: Results of the questionnaire completed by demolition experts

<table>
<thead>
<tr>
<th>Interview questions with experts</th>
<th>Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1 (poor)</td>
</tr>
<tr>
<td><strong>The Performance</strong></td>
<td></td>
</tr>
<tr>
<td>How good is the map in helping you understand the demolition process?</td>
<td></td>
</tr>
<tr>
<td>How clear is the structure of the demolition process map?</td>
<td></td>
</tr>
<tr>
<td>How well are the demolition processes explained?</td>
<td></td>
</tr>
<tr>
<td>How accurate is the knowledge of the demolition process?</td>
<td></td>
</tr>
<tr>
<td>How useful will the map and mapping system be in supporting demolition process management?</td>
<td></td>
</tr>
<tr>
<td>How well does the map reflect the real demolition process?</td>
<td></td>
</tr>
<tr>
<td>How useful do you find the documentation tool in assessing with the compilation of the health and safety plan?</td>
<td></td>
</tr>
<tr>
<td>How accurately does the protocol system of demolition process management presents reflect the real demolition practices?</td>
<td></td>
</tr>
<tr>
<td>How useful are the database of demolition requirements?</td>
<td></td>
</tr>
<tr>
<td>To what degree can the research result improve the demolition management?</td>
<td></td>
</tr>
<tr>
<td><strong>Applicability to demolition industry</strong></td>
<td></td>
</tr>
<tr>
<td>How effective/accurate are the tools in demolition process management?</td>
<td></td>
</tr>
<tr>
<td>How convinced are you that demolition industry professionals will use the tools?</td>
<td></td>
</tr>
<tr>
<td>How effectively will the tools be in increasing the speed of the documentation process?</td>
<td></td>
</tr>
<tr>
<td>To what extent does it represent an improvement in the documentation process?</td>
<td></td>
</tr>
<tr>
<td>To what extent are the tools flexible in documenting the Health and Safety Plan?</td>
<td></td>
</tr>
<tr>
<td><strong>General comments</strong></td>
<td></td>
</tr>
<tr>
<td>How well designed is the DPMT template?</td>
<td></td>
</tr>
<tr>
<td>How user friendly are the Health and Safety Plan documentation tools?</td>
<td></td>
</tr>
<tr>
<td>How well integrated are the key process requirements?</td>
<td></td>
</tr>
<tr>
<td>What is your view of the demolition process mapping?</td>
<td></td>
</tr>
<tr>
<td>What is your overall rating of the research achievements?</td>
<td></td>
</tr>
</tbody>
</table>
Table 8-4: Results of the Workshop Validation

<table>
<thead>
<tr>
<th>Ref No.</th>
<th>Tools’ effectiveness</th>
<th>Level of Agreement(%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.1</td>
<td>Is the documentation tool for the health and safety plan a useful application</td>
<td>66.7 25.0 8.3</td>
</tr>
<tr>
<td>1.2</td>
<td>Will it help to save the time and effort in process management?</td>
<td>33.3 58.3 8.3</td>
</tr>
<tr>
<td>1.3</td>
<td>Will it help project management?</td>
<td>75.0 25.0</td>
</tr>
<tr>
<td>1.4</td>
<td>Is it relevant for industry needs?</td>
<td>16.7 83.3</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Ref No.</th>
<th>Tools’ usability</th>
<th>Level of Agreement(%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.1</td>
<td>Is the tool easy to use?</td>
<td>83.3 16.7</td>
</tr>
<tr>
<td>2.2</td>
<td>Does the tool deliver reliable information for industry?</td>
<td>8.3 16.7 75.0</td>
</tr>
<tr>
<td>2.3</td>
<td>Is the tool a user friendly system?</td>
<td>41.3 50.0 8.3</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Ref No.</th>
<th>Tools’ practicality</th>
<th>Level of Agreement(%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.1</td>
<td>Are the tools a practical solution?</td>
<td>33.3 58.3 8.3</td>
</tr>
<tr>
<td>3.2</td>
<td>Will the engineers use the tools to document the health and safety plan?</td>
<td>16.7 50.0 33.3</td>
</tr>
<tr>
<td>3.3</td>
<td>Do the tools have clear structure for engineers?</td>
<td>33.3 66.7</td>
</tr>
<tr>
<td>3.4</td>
<td>Do the tools have adequate output of the demolition process needs?</td>
<td>8.3 58.3 25.0 8.3</td>
</tr>
<tr>
<td>3.5</td>
<td>Are the tools compatible to the other tools in demolition process management?</td>
<td>41.7 58.3</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Ref No.</th>
<th>General comments of the research work</th>
<th>Level of Agreement(%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.1</td>
<td>How useful is the research to the industry?</td>
<td>75.0 25.0</td>
</tr>
<tr>
<td>4.2</td>
<td>How adequate is the knowledge of the output?</td>
<td>8.3 33.3 50.0 8.3</td>
</tr>
<tr>
<td>4.3</td>
<td>How does the knowledge cover the general practical requirements?</td>
<td>66.7 33.3</td>
</tr>
<tr>
<td>4.4</td>
<td>How much improved is the demolition process management?</td>
<td>16.7 66.7 8.3</td>
</tr>
</tbody>
</table>
When asked to provide any further comment Stella Wright said: “This tool saved a lot of time and energy on the documentation process in the planning stage. This efficiency would provide more time to focus on the project information collection and think deliberately on the project method statement.”

8.5 Analysis and Discussion of the Output of Validation

The outcome from the validation of the research is discussed under four headings below. Namely: (1) results analysis; (2) advantages and benefits of Demolish-IT and the tools; (3) limitations; and (4) suggestions for improvement.

8.5.1 Results Analysis

Through the interview survey it was established that demolition experts were generally satisfied with the performance of the research work undertaken. The results of the performances of the

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Checklist</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Is the documentation tool detailed for both process specification and execution?</td>
<td>YES</td>
</tr>
<tr>
<td>2</td>
<td>Can the tool ensure the best practice of project compliance check takes place at documentation level where the processes in the project have been done and their results have been documented?</td>
<td>YES</td>
</tr>
<tr>
<td>3</td>
<td>Can the tool review the decision path to understand how the requirements are implemented at any time during the development process as required?</td>
<td>YES</td>
</tr>
<tr>
<td>4</td>
<td>Does the person using it need the appropriate training, technical knowledge, experience and qualification relevant to the specific duties they have to perform?</td>
<td>Partially</td>
</tr>
<tr>
<td>5</td>
<td>Does the tool allow the models to be expressed at an appropriate level in the beginning, and details added when they become available?</td>
<td>YES</td>
</tr>
<tr>
<td>6</td>
<td>Is the tool a resource for setting up the system to a specific process? The task of process planning is therefore accelerated by selecting the template process that best matches the current situation and customising it as required.</td>
<td>YES</td>
</tr>
<tr>
<td>7</td>
<td>Is the tool a flexible approach where information is mapped to the parties so that they can obtain the required information in the first instance?</td>
<td>YES</td>
</tr>
<tr>
<td>8</td>
<td>Do the tools have a clear outline of the information needed for the demolition process?</td>
<td>YES</td>
</tr>
<tr>
<td>9</td>
<td>Are the tools able to save time and effort input for the project?</td>
<td>YES</td>
</tr>
<tr>
<td>10</td>
<td>Are the tools useful for better planning of the project?</td>
<td>YES</td>
</tr>
<tr>
<td>11</td>
<td>Are the tools better tailored to the project’s resources?</td>
<td>YES</td>
</tr>
<tr>
<td>12</td>
<td>Do the tools have the ability to trace the process steps during the project operation?</td>
<td>YES</td>
</tr>
</tbody>
</table>
generic demolition process map and the documentation tool for the health and safety plan can be established from replies to question 1 to 10. From the experts’ point of view, these can be reflected as “excellent”, “good” and “satisfactory” shown in Fig. 8-2.

**Figure 8-2: Interview Results Analysis on the Tools’ Performance**

![Interview result on tools performance chart](image)

Fig. 8-2 indicates that performance of tools created by the research was above satisfactory and that the majority of responses gave a positive view of the tools performance output. In Fig. 8-2, the area of ‘excellent’ is about 12%. The area of ‘good’ is about 72% and the area of ‘satisfactory’ is about 16%.

The applicability of the tools to the demolition industry can be inferred from question 11 to 15. The results are shown in Fig. 8-3 in the chart area.

**Figure 8-3: Results on the Tools’ Applicability to the Industry**

![Applicability of the tools chart](image)
The general comments on the research work overall was also good from the majority of respondents. In Fig. 8-3, the area of ‘excellent’ is about 15%, the area of ‘good’ is about 62.5%, the area covered ‘satisfactory’ is about 17.5% and the area covered ‘fair’ answer is about 5%.

The results from question 16 to 20 about the general comments on the research work are shown in the Fig. 8-4. Again, the answer is very positive. Ninety percent of respondents agreed that the research work is good and excellent.

**Figure 8-4**: Results on General Comments of the Research Work

The validation results from the interview were verified by the workshop and trial case study. The results of workshop and trial case study have proved again that the demolition process map, Demolish-IT and the documentation tool for the health and safety plan compilation was positively by industrial practitioners.

### 8.5.2 Advantages and Benefits of Demolish-IT and the Tools

Through the evaluation, the respondents identified several practical benefits of the research work. This gave the research work strong credibility from the industry experts’ view. These include:

- Integration: the research work effectively integrates and manages the demolition process. It complies with all the requirements required by the industry.
• Identification of the best method: the sampling strategy of this research aimed to trace back the real project documents, make comparisons of more than three projects documents to extract the best processes.

• Suitability for the entire industry: this tool provides an engineering aid to give rational and structured guidance in demolition process management. Moreover, information gathered by research can be used as a training outline for young professionals.

• Suitability for any size of project: demolition projects of any size have similar outlines of the operational process and requirements.

• Saving time and effort: examples are provided along with every template, to show how to complete it quickly and easily.

• Boosting the quality of the projects’ documents: structured unified format forms, sheets and templates in demolition documentation, can improve the documents’ quality.

• Delivering projects faster: structured demolition processes can eliminate unnecessary time spending and other inefficiencies.

• Improving the success of the project: structured demolition workflow as guidance to access the demolition contractors carrying out the projects precisely.

8.5.3 Limitations

The comments regarding the limitations of the research work were made during the discussion with experienced demolition experts and the workshop in the evaluation phase. One demolition expert found that the research work could extend to partial demolition and refurbishment projects. Another one also said that explosion demolition processes are different in nature from current study. There may be some merit in these comments but future work should aim to investigate them more fully and/or expand the use of Demolish-IT to cover these aspects.

8.5.4 Suggestions for Improvement

The demolition experts all made their suggestions for improvements to the research work in the interview, which suggestion can be summarised in the following points:

• It should allow demolition contractors to efficiently control virtually any demolition process by structuring the steps taken to complete it and automatically notify participants when they are performing certain tasks.
Demolition contractors should be able to develop schedules, track progress and effectively communicate with those directly and indirectly involved with processes.

Demolition processes that were once manual can be structured to ensure information is disseminated to the individuals who need it most, accurately and on time.

The entire team of demolition contractors should have real-time insight into project processes at every step, which will all be completed more efficiently and lead to greater overall demolition organizational efficiency.

Suggestions for improvement to the research work can be divided into two aspects:

1. Technical problems, which are the process map, process mapping, method statement, and health and safety plan – which were corrected through the research process;

2. Suggestions accrued in the final validation stage that gave recommendations for future work. This aspect is addressed in chapter 9, section 9.5 “Future work”.

8.6 Chapter Summary

This chapter has described the result of the validation process carried out and the overall feedback on the research work done is positive.

The validation approach adopted helped to test all aspects of the research work identified in the validation objectives and was considerably successful. All the evaluators came from the demolition industry and were either company directors or demolition engineers who have good experience in demolition. The questionnaire covered all the major aspects of the research work that needed to be evaluated and was useful for obtaining feedback from the evaluators. This chapter also drew conclusions on the limitations of the research and suggested improvements.
9 Research Conclusions, Limitations and Recommendations

9.1 Introduction

In managing a complex demolition process, demolition processes and process requirements, and the need of management tools in demolition process management must be clarified. This research set out clear objectives to design a prototype entitled Demolish-IT and associated documentation tools to support the management of the demolition process.

This chapter concludes the research project, which resulted in the production of a prototype of Demolish-IT and documentation tools for editing the demolition health and safety plan, based on demolition process mapping and demolition process requirements. The summary of the overall findings of the research was reported following a brief review of the research. The benefits and limitations of the Demolish-IT prototype were also established. This chapter also presents a summary of the research achievements and points to direction for future work.

9.2 Research Review

The aim for this research has chosen to explore the question:

*How is it possible to provide intelligent support for the management of dynamic demolition engineering processes, while ensuring that demolition specification and performance are compliant with a particular industry standard?*

Currently, demolition engineers, site managers and quality assurance teams spend a large amount of time tracking other parties involved in the demolition project, and managing the demolition project documentations in order to ensure that the project plan is acceptable, and that safety matters are clear and can be fully implemented during the project operation. In this context, the intelligent tool for supporting the management of the demolition process means that there is a clear description of the demolition processes in general, and at each stage the inputs are fully and unambiguously defined, so that all the objectives and requirements are met. Thus the research work gives the solution to this problem and benefits the industry.
Chapter 9 Research conclusions, limitations and recommendations

The research work has defined its objectives as follows:

1. To gain a more detailed understanding of the nature of the demolition industry and the characteristics of the demolition process.
2. To explore the potential for using ICT to improve demolition process management.
3. To identify the current demolition processes used by demolition contractors, then create and verify a demolition process map that contains the entire demolition processes and subprocesses.
4. To generate a process requirements framework and store them in a database with a unified format that aims to help the industry, improving their awareness of needs.
5. To provide step-by-step guidance on documentation of the demolition process requirements.
6. To develop a prototype of the process management system, and introduce the new system to the industry, in order to improve the management of demolition processes.

The research work has been carried out to fulfil each objective, summarized as follows:

**Objective 1: To gain a more detailed understanding of the nature of the demolition industry and the characteristics of demolition process.**

The research work began with the detailed understanding of the nature of the demolition industry and the characteristics of current demolition processes in use. This was presented in chapters two and five.

Based on the literature review in chapter two, this research summarized the general facts that currently underpin demolition projects in the UK. The study has also revealed that demolition engineers do not have a unified systematic management tool for management of the demolition process. Although the demolition processes and the process requirements are similar, each demolition contractor has used their own bespoke systems to manage their projects.

The multiple case studies in chapter five, which reviewed the three selected projects, pointed out currently used demolition processes and the lack of management tools in supporting operations in the industry.
Furthermore, demolition today is more complex and dynamic. There are many requirements with many parties and various constraints, both physical and human, involved in the project. It is important that all these factors be thoroughly managed in order to have a successful demolition project. With current practice, the demolition engineers may mistakenly leave out important factors, as there is no written or structured management tool that can be followed.

The appraisal of these problems indicated that there is a requirement to complete demolition process mapping and to develop a comprehensive management system (Demolish-IT). This integrates the currently used simple, standalone paperwork to a well structured map and management system for demolition process management.

**Objective 2:** *To explore the potential for using ICT to improve demolition process management.*

In order to find a way of solving the problems in accordance with objective 1, research work reviewed the knowledge of process mapping, process management and the feasibility of using ICT to manage the demolition process. The review was carried out and elaborated in chapter four. The review helped to gain process management knowledge such as information systems analysis and method, and to understand process mapping successfully applied in businesses and construction process management. Also it emerged that incorporating ICT into the design of the tools has significantly benefited the performance of construction industry.

After obtaining knowledge of the demolition industry in the UK, various research methodologies and strategies were adopted to achieve the defined objectives of the research. This was reviewed in detailed in chapter three. In the initial stages, an intensive literature review was conducted. Also a multiple case study was completed which comprised of three types of case study methods including: (1) semi-structured interview; (2) project document review; and (3) direct site observation. This was essential in creating the generic demolition process map for the industry. Furthermore, Data Flow Diagrams (DFD) was used as a modelling tool to map the processes for all four stages of the demolition process. And database solutions have been used to store the demolition process requirements.

**Objective 3:** *To identify the current demolition processes used by demolition contractors, then create and verify a generic demolition process map that contains the entire demolition processes and sub-processes.*
The research has achieved this objective by reviewing three samples of demolition project documents. Samples of project documents were selected from three demolition companies from different regions in the UK. The three projects (one large and two mediums) from these three companies have had their ‘method statement’ and the ‘health and safety plan’ deeply reviewed. The review has highlighted all currently used demolition processes and sub-processes, and created a first draft of the generic demolition process map. This map was then sent to demolition experts to check twice to be reassured, so that increased technical and practical accuracy can help achieve the best practical generic demolition process map.

Objective 4: To generate a process requirements framework and store them in a database with a unified format that aims to help the industry, and improve their awareness of needs.

To achieve this objective, research identified the physical and legal requirements of the demolition process, which includes eight main aspects (1) project information; (2) health and safety plan; (3) risk assessment; (4) cost estimate; (5) method statement; (6) selection of suitable techniques; (7) asbestos removal; and (8) waste management. This research studied and unified these eight aspects into a structured format, where forms and reports have been used to document process requirements. The database solutions this research offers has made necessary the creation of a central system that stores these requirements, in order to fulfil the needs of integration and better management of the demolition process.

Objective 5: To provide step-by-step guidance on documentation of the demolition process requirements.

From reviewing the projects document, research revealed that all demolition health and safety plans and method statements have similar features but are not unified in writing. Editing these documents is time consuming. Consequently, research created a step by step management tool for editing health and safety documents, whilst maintaining the documents in a unified format and a good structure. Certainly the documents’ quality is ameliorated and can be used for any demolition projects.

Objective 6: To develop a prototype of the process management system, and introduce the new system to the industry, in order to improve management of demolition processes.
Chapter 9 Research conclusions, limitations and recommendations

This objective was achieved by designing and developing a four tier prototype of Demolish-IT and a task compliance flow with the pre-condition and workplace in the process. In the system, the four tiers were: (1) the standard demolition process map; (2) combining the standard map with user-defined process; (3) the task compliance flow showing pre-conditions and generating post-conditions essential to the continuation of the next task; and (4) process requirements that can be extracted from the database whenever they are needed.

9.3 Summary of Research Findings and Benefits

The research has contributed to the industry in the following six ways:

1. Unifying Demolition Processes with a Standard Generic Demolition Process Map

All demolition processes have similar features. But before now there has been no standardised process with a well structured map. This research has adopted ideas from construction process maps and process mapping technology into demolition process management. This has benefited demolition contractors whilst undertaking projects since:

- Using the map not only saves time and eliminates other inefficiencies, and is also more accurate;
- Mapping the complex demolition process gives projects a clear picture of how all the participants are involved in the process, and thus better coordination can be achieved during the demolition operation;
- The structured demolition map automates transferring the information between demolition process stakeholders and ensures that all participants in demolition processes are aware of their responsibilities at all times;
- Structured schedules will aid monitoring of the status of processes that underpin the entire operation to achieve greater efficiency and team effectiveness;
- Using the map ensures that processes proceed according to defined policy by linking the process to demolition rules; and
- Using the map informs the user of demolition decisions based on a comprehensive view of the status of all related business processes.
2. Visualizing the Workflow

Standard process maps have commonly framed the process, but cannot measure the performance of the process whilst in motion. This research has adopted DFDs to mapping the demolition process in all stages.

- These DFDs illustrate and understand how a given process impacts another process downstream;
- The DFD states each demolition process’ pre-condition, including documents and worker capacities. This is essential knowledge that must be gathered before the start of any process.
- The DFD indicates each party involved in the process and procedures, as well as documents needed in each process; and
- The DFD sets measures that can help the entire organization to optimise its operations in overview of the real process time.

3. Creating a Database Solution to Manage Demolition Processes

The research completed a detailed review of demolition process requirements and the contents have been displayed in various formats, such as frameworks of the demolition health and safety plan, tables of information, outlines of the demolition method statement etc. Since a database has the ability to share the same data across multiple applications and store data in flexible formats, this research chose to apply the database repository technology to store these key requirements in a structured way. This database has benefits to the industry such as:

- Summarising the fundamentals needed to operate the demolition project, it can be the framework to guide the demolition projects undertaken;
- Applying to any demolition project throughout the demolition processes;
- Providing a training program of demolition processes; and
- Providing an outline of demolition documentation.

4. Documenting Tools Using the ICT

By applying ICT, this research created the documentation tools for generating the most indispensable demolition documents. The tool for demolition process requirements and the tool for editing the health and safety plan can:
• Enhance the documents’ quality and can be used for any demolition project;
• Save time and effort spent on demolition documentation; and
• Be simple and very easy to use.

5. Introducing a New Management System Demolish-IT to Demolition Industry

This research focused on developing the prototype of Demolish-IT. Demolish-IT was based on
the demolition process map and the database of demolition process requirements in chapters five
and six. This system applies ICT to help the demolition industry to manage demolition processes.
Demolish-IT comprises of four tiers of information: the standard demolition process map, the
user-defined demolition process map, the demolition requirements and the task manager. This
system will support the demolition industry on process management. The benefits can be listed
as:

• Being a fresh idea in the industry: Demolish-IT sets a milestone within demolition
management research by applying advanced ICT techniques to improve process
management;
• Integrating the whole demolition process using the ICT techniques provided, thereby
improving the effectiveness of management; and
• Managing the dynamic engineering process because it is capable of checking each process
and even task during the process operation.

6. Managing demolition tasks with a compliance flow

Demolish-IT manages the demolition tasks by adopting compliance flow technology. It has
created a task manager which contains the task definition, task workplace, task pre-condition,
task post-condition and task agent capability to manage the demolition tasks within each process.
The task manager benefits the industry because:

• Controlling each task becomes easier by defining the task’s pre-conditions and post-
conditions. The task post-conditions can be the next task’s pre-conditions, and tasks
completed can show compliance with the task’s specification. Demolition task flow from
one to another can be penetrative;
• It can verify the contractors’ capability of carrying out the particular demolition tasks; and
It clarifies all factors that need to be avoided before carrying out the tasks by specifying the tasks constraints.

9.4 Limitations of the Research

The research undertaken has the following limitations:

- The prototype of Demolish-IT is still in its initial stage. Each demolition project is unique, due to the sheer number of parameters that govern the demolition processes. Such wide ranging pre-conditions make the demolition of a structure or building a highly complex task that requires several considerations from various parties involved in the demolition process. So Demolish-IT could not include all contents of the demolition processes. A fully detailed system could be developed in the future;
- The contents of Demolish-IT did not include partial demolition and refurbishment work;
- The explosion demolition process has differences in nature from the general demolition project. Demolish-IT is not able to consider it although the research gave a brief introduction of explosion demolition technique in chapter two; and
- Demolition work still cannot be counted as an exact science. Most demolition contractors are used to completing projects in their usual and accustomed ways, so there is a need to push through the Demolish-IT to demolition contractors, encouraging them to accept the new technology of process management, shun their old practices and adopt new ideas and more efficient procedures.

9.5 Future Work

Based on the limitations of the research and the validation from the industry, some issues have required further research that is outlined below.

1. Further extension of the contents of Demolish-IT

Increasing the system’s applicability to demolition, Demolish-IT can be further extended in two areas:

- To partial demolition and refurbishment work; and
- Explosion demolition contents can be included within same outline of Demolish-IT.
2. The future of Demolish-IT as an electronic system can be explored

The webpage of Demolish-IT can be operated by applying a graphic user-interface. This can be done by programming using Visual Basic or other software packages that can carry out a user-interface design.

3. Implementation of the system and documentation of editing tools in the industry

It is essential that research work completed is useful and acceptable to the user. This requires input from industry participants via:

- Workshops to introduce the system and management knowledge with companies’ managers and engineers;
- Further work to identify the benefits of the system on real projects;
- Introducing to the industry that ICT can be an efficient and effective way to improve demolition process management;
- Ensuring better management of the demolition industry’s process operation to survive intensive competition; and
- Innovation which leads to improvement.

4. Further improvements to the Demolish-IT prototype

The prototype of Demolish-IT can be improved by:

- Adding some more information into the system with various types of demolished structures;
- Regularly updating the system with the latest regulations and techniques as well as changing the requirements of the demolition process; and
- Improving the user interface webpage, developing a better layout for the user.

5. More research and development needed in the demolition industry

The study found that the demolition industry is behind in terms of research and process management compared to the construction industry. The literature available on demolition is limited. Academic papers are few and far between. Most of the demolition companies stand
alone with their own ways of managing and doing their projects. Therefore, more research work should be done to integrate them to an industry standard.

9.6 Closing Remarks

The research has revealed that, the current process management of the demolition industry in the UK use traditional ways of managing their work. There is shortage of advanced ICT usage in management. So most decision-making by demolition engineers based on their experiences without any systemic procedures that can be followed to corroborate them.

Based on these statements and by applying advanced ICT, the research aimed to produce a management system entitled Demolish-IT that provides intelligent support to manage the dynamic demolition process in accordance with industry standards. This research first created a standard demolition process map and mapped the processes with DFDs. Secondly with the detailed study of demolition process requirements; the research applied a database with repository technology to store the demolition process requirements. Finally, the research developed a prototype of the Demolish-IT that comprised of four tiers of demolition process information.

Furthermore, the research undertaken validation of the work already done with industry experts in interviews, an experts’ group workshop and real project testing. The validation proved that the research has significantly guided the industry towards a more accurate and scientific direction. The validation also established that the work done is compliant with industry practice. It presents many benefits in terms of the efficient and effective management of the demolition process.
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APPENDIX

Appendix A: Multiple Case Study

A1: Sample Projects for Multiple Case Study

PROJECT 1:

Name: Asbestos removal, Demolition and Site Clearance
Location: Blocks A, B and C British Geological Society,
          Platt Lane,
          Keyworth, Nottingham,
          NG12 5GG
Contractor: Total Reclaims Demolition Ltd
           Melvyn Robert House
           Bakerbrook Industrial Estate
           Wigwam Lane
           Hacknall
           Nottingham
           NG15 7SZ

PROJECT 2

Name: Asbestos Removal, Demolition, Dismantling, Strip out and Site Clearance
Location: “The Granary” 74 Canterbury road
          Whitstable
          Kent
          CT5 4HE
Contractor: Dorton Demolition and Ecavation Limited
           Station Goods Yard
           Station
           Burgess Hill
           West Sussex
           RH15 9DG

PROJECT 3

Name: Demolition and Site Clearance
Location: Cargate water tower
          Cargate water reservoir
          Cargate terrace
          Aldershot
          Hants
          GU11 3EL
Contractor: C. G. Comley & Sons Ltd
           Southern Way
           Rye Common
           Odiham
           Hants, RG29 1HU
A2: Semi-structured Interview Form

Name of interviewee:
Position:
Company name and address:
Contact No:
Date:

Introduction:
Briefly talk about the research and the interview purpose to the interviewee.

Objective:
1. Identify the current used demolition processes in UK industry.
2. Verify the generic demolition process map created by the research.
3. Indicate the constraints of each process.

Questionnaire:
1. Could you draw a demolition operation processes map step by step?
2. Could ask your opinions on the GDPM generated by the research? If anywhere wrong, do correct it. Please?
3. May I ask you to point out the constraints at each process in the GDPM?
4. What do you think the GDPM is based on the best practice observed? Any problems anywhere? How to adjust them to the demolition project?
Appendix B: Generic Demolition Process Map

B1: Protocol of the GDPM

B2: Map of Demolition Processes and Sub-processes
Appendix B: Generic demolition process map

B3: Tree Map of Demolition Main Processes

- Tendering stage (1)
  - Bid invitation (1.1)
  - Knowledge of site (1.2)
  - Risk assessment (1.3)
  - Selection of demolition techniques (1.4)
  - Method statement (1.5)
  - Cost estimate (1.6)
  - Bid submission (1.7)

- Pre-demolition stage (2)
  - Document and notification (2.1)
  - Health and Safety plan (2.2)
  - Demolition method statement (2.3)
  - Site preparation (2.4)
  - Plant and equipment preparation (2.5)
  - Waste management (2.6)

- Actual demolition stage (3)
  - Services/hazardous investigation and protection (3.1)
  - Site and Plant set up (3.2)
  - Removal of contaminants/hazardous substances (3.3)
  - Soft shipping (3.4)
  - Recycle and reuse (3.5)
  - Structural demolition (3.6)

- Post-demolition stage (4)
  - Clearance of site to suit standards (4.1)
  - Final sign off (4.2)
  - Contract documentation filed (4.3)
  - Post contract review (4.4)

B4: GDPM Using Microsoft Project

[Image of Microsoft Project screenshot showing the generic demolition process map]
Appendix C: Demolition Process Events Lists and Details

C1: Events lists

<table>
<thead>
<tr>
<th>Event</th>
<th>Start Time</th>
<th>End Time</th>
<th>Location</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>A1-1</td>
<td></td>
<td></td>
<td></td>
<td>Bid invitation letter, Contract, Health and safety plan</td>
</tr>
<tr>
<td>A1-2</td>
<td></td>
<td></td>
<td></td>
<td>Knowledge on site Desk study and on site survey (Asbestos and Geotechnical)</td>
</tr>
</tbody>
</table>

C2: Event Details

**Event: A1-1 Bid invitation**

**Start Time**

**End Time**

**Location**

A1-1

**Description**

Invitation letter, Contract, Health and safety plan

**Event: A1-2 Knowledge on site**

**Start Time**

**End Time**

**Location**

A1-2

**Description**

Desk study and on site survey (Asbestos and Geotechnical)
### Event: A1-3 Risk assessment

<table>
<thead>
<tr>
<th>Start Time</th>
<th>End Time</th>
<th>Location</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>A1-3</td>
<td>Manual handling, Asbestos, services, mechanical, deconstruction</td>
</tr>
</tbody>
</table>

### Event: A1-4 Selection of demolition techniques

<table>
<thead>
<tr>
<th>Start Time</th>
<th>End Time</th>
<th>Location</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>A1-4</td>
<td>Criteria and sub-criteria</td>
</tr>
</tbody>
</table>

### Event: A1-5 Demolition method statement

<table>
<thead>
<tr>
<th>Start Time</th>
<th>End Time</th>
<th>Location</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>A1-5</td>
<td>Outline of method statement,</td>
</tr>
</tbody>
</table>

### Event: A1-6 Cost estimate

<table>
<thead>
<tr>
<th>Start Time</th>
<th>End Time</th>
<th>Location</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>A1-6</td>
<td>Detailed estimate sheets</td>
</tr>
</tbody>
</table>

### Event: A1-7 Bid submittal

<table>
<thead>
<tr>
<th>Start Time</th>
<th>End Time</th>
<th>Location</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>A1-7</td>
<td>Contractor pre-qualification questionnaires</td>
</tr>
</tbody>
</table>

### Event: A2-1 Documentation and notification

<table>
<thead>
<tr>
<th>Start Time</th>
<th>End Time</th>
<th>Location</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>A2-1</td>
<td>Building regulation section 80-82, notice letters</td>
</tr>
</tbody>
</table>
Appendix C Demolition process events lists and details

Event: A2-2 Health & safety plan

Start Time
End Time
Location A2-2
Description
Outline of health and safety plan

Event: A2-3 Demolition method statement

Start Time
End Time
Location A2-3
Description
All works safe methods, procedures and plans

Event: A2-4 Site preparation

Start Time
End Time
Location A2-4
Description
Welfare facilities, site layout design

Event: A2-5 Plant preparation

Start Time
End Time
Location A2-5
Description
Plant capability and suitability, safe use method

Event: A2-6 Waste management

Start Time
End Time
Location A2-6
Description
Waste estimating sheets of recycle, reuse and landfill

Event: A3-1 Service disconnection & hazardous protection

Start Time
End Time
Location A3-1
Description
Sheets of kind of services and protection, gas, electricity...
**Event: A3-2 Site & plant set up**

Start Time
End Time
Location A3-2
Description Method statement, site layout

**Event: A3-3 Removal of contaminants & hazardous**

Start Time
End Time
Location A3-3
Description Safe working procedures, risk assessment

**Event: A3-4 Soft stripping**

Start Time
End Time
Location A3-4
Description Safe working procedures, working procedures, recycle and reuse plan

**Event: A3-5 Recycle & reuse**

Start Time
End Time
Location A3-5
Description Material, structural element, doors, windows, sanitary wares

**Event: A3-6 Structure demolition**

Start Time
End Time
Location A3-6
Description Info from on site survey of structure

**Event: A4-1 Site clearance**

Start Time
## Appendix C Demolition process events lists and details

<table>
<thead>
<tr>
<th>Time</th>
<th>Location</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>A4-1</td>
<td>Client’s satisfactory, suitable standard</td>
</tr>
</tbody>
</table>

**Event: A4-2 Finance sig off**

<table>
<thead>
<tr>
<th>Time</th>
<th>Location</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>A4-2</td>
<td>Certificate of completion the work, percentage of profit,</td>
</tr>
</tbody>
</table>

**Event: A4-3 Contract document filed**

<table>
<thead>
<tr>
<th>Time</th>
<th>Location</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>A4-3</td>
<td>Contract, health and safety file, method statement, finance report</td>
</tr>
</tbody>
</table>

**Event: A4-4 Post contract review**

<table>
<thead>
<tr>
<th>Time</th>
<th>Location</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>A4-4</td>
<td>Review report</td>
</tr>
</tbody>
</table>
Appendix D: Demolition Process Management Tool

D1: Tool for Outline of Demolition Requirements

Demolition Process Key Requirements

- Collection of project information (R1)
- Health and safety plan (R2)
- Risk assessment (R3)
- Selection of the techniques (R4)
- Cost estimate (R5)
- Method statement (R6)
- Asbestos removing (R7)
- Waste management (R8)
## R1: Information gathering

1. Information gathering at pre-tendering planning stage

<table>
<thead>
<tr>
<th>Main contents of information</th>
<th>Details of the information collection</th>
</tr>
</thead>
</table>
| Contractors Pre-Qualification and Competence (Contractor selection) | - Track record in successful planning and execution of work on the size and type of structure being considered.  
- Experience and competence of contractors design/management/site team.  
- Accident record statistics and enforcement history.  
- Commitment to and extent of management and operative training and maintenance.  
- That full specific demolition, public and employers liability insurance cover is in place at all times.  
- Health and safety policy, its monitoring and reviewing of procedures |
| Details of structure to be demolished (Access to choose suitable demolition method) | - Identifying the structural form of the building (including of Large panel system, Reinforced concrete beam and column frame with in situ r.c. slabs, Steel frame concrete or brick cladding).  
- Identifying how overall structural stability is maintained (including of Shear walls, Braced bays and Shear cores).  
- Identifying any pre-stressed elements (including of Pre-tensioned and Post-tensioned).  
- Identifying any gross structural defects in the building or known major alterations made since construction (including of Strengthening installed following the structural defect). |
| Construction drawings (Original drawing from client) | - Relating to the structural design and checked for consistency.  
- Other alterations. |
| Details of existing services and utilities (Entering the building and crossing the site) | - Electricity and underground cables, overhead lines, building supply, equipment and transformer rooms.  
- Gas mains.  
- Oil and other fuel lines.  
- Hydraulic pressure mains.  
- Services and drainage.  
- Telecommunications and optic fibre cables.  
- Radio and TV cables. |
| Details of previous use of the building and site (Informing the risk) | - Identify any previous use of the building, which may indicate the presence of hidden hazards (including of Laboratories handling hazardous substances, where pockets of contamination may remain).  
- Identify any previous use of the site, which may cause a physical or health hazard or influence selection of demolition method or plant (including of contamination of land, underground cellars or voids, tunnels or under passes).  
- Identify the extent to which the facility has been decommissioned and request a copy of any decommissioning plan, which should itself be checked against the current state of the facility. |
| Details of Asbestos and other hazardous Materials (Survey and Properties' test) | - Asbestos:  
  - Logging to pipes and boilers.  
  - Fire insulation.  
  - Insulation under winder sills.  
  - Linings to ducts and airing cupboards.  
  - In room heaters.  
  - Floor and ceiling tiles  
  - ‘Dry riser’ water pipes.  
  - Insulation within curtain wall cladding.  
- Hazardous materials:  
  - Chlorofluorocarbon (CFC).  
  - Polychlorinated Biphenyls (PCB).  
  - Manmade Mineral Fibre (MMMF).  
- Other:  
  - Used syringes and hypodermic needles.  
  - Pigeon droppings.  
  - Rodent infestation.  
  - Human excrement.  
  - Contamination of air conditioning tanks—Legionnaires disease. |
| Details of site environment (to assist contractor selection of demolition method) | - Proximity and type of nearby property (including of Residential, Commercial, Industrial, Schools, Retirement/Nursing homes, Hospitals).  
- Existence of flora and fauna and weather or not these are to be protected.  
- Highways, transportation systems, watercourses and waterways.  
- Crime and vandalism rates in the area, with instructions on minimum levels of security (Hoardings, watchmen, etc.) to be provided to ensure site security. |
2. Information gathering at post-contract award stage

<table>
<thead>
<tr>
<th>Main contents of information</th>
<th>Details of the information collection</th>
</tr>
</thead>
</table>
| **Asbestos and other hazardous materials** | ➢ Confirm the information given in the Pre-tender Stage Health and Safety Plan  
➢ Undertake further checks. |
| **Structural survey**  
(direct observation, testing and examination of existing drawing) | ➢ Confirm the form of construction.  
➢ Confirm the existing condition of the structure, including identification of vandal damage or local corrosion of reinforcement and pre-stressing tendons.  
➢ Provide information on the loading, which may safely carried by the existing structure so that any propping arrangements may be designed.  
➢ Confirm the size of all elements to determine craneage requirements.  
➢ Provide sufficient information to ensure that the structural integrity of all parts are maintained in order to prevent unplanned collapse. |
| **Temporary propping and shoring design information** | ➢ Plants loads on floors.  
➢ Debris loads on floors or against any wall, including perimeter.  
➢ Arrangement of the structure and its safe load capacity.  
➢ Changing structural form affected the safe loading capacity of floors. |
| **Design programme consideration:** | ➢ The form and condition of the structure.  
➢ That due care is taken to ensure that no components are unsupported during or in advance of demolition/dismantling or deconstruction.  
➢ The possible presence of post-tensioned concrete and the possible structural effects of cutting the stressing tendons. |
| **Services and utilities** | ➢ Verify the information given in the Pre-tendering stage health and safety plan.  
➢ Physically check and locate the routes of all notified incoming services to the site.  
➢ Physically, check that no unidentified services remain in the building or cross the site. |
| **Scaffolding/sheeting for protection** | ➢ Intended method of deconstruction.  
➢ Whether or not external access is required at each working level to demolish external brick wall panels.  
➢ The risk presented by falling debris to site personnel and the general public.  
➢ Measures which can be put in place to control dust and noise.  
➢ Provision of protection to exposed leading edges during partial demolition of sections to the building/structure.  
➢ Provision of boarding up external openings in order to contain dust and debris.  
➢ Design of exclusion zone.  
➢ Edge protection around openings created during demolition. |
| **Environmental consideration** | ➢ Proximity and type of nearby property (including of Residential, Commercial, Industries, Schools, Retirement/Nursing homes, Hospital).  
➢ Existence of flora and fauna and weather or not these are to be protected.  
➢ Highways, transportation systems, watercourses and waterways.  
➢ Crime and vandalism rates in the area, with instructions on minimum levels of security (Hoardings, watchmen, etc) to be provided to ensure site security. |
| **Selection and use of cranes** | ➢ Cutting and lifting during demolition the centre of gravity must be correct.  
➢ Weight of the item to be lifted has to be within the capacity of the crane.  
➢ Spare capacity 10% at least.  
➢ Position of cranes to ensure safe working loads are not exceeded. |
| **Schedule of conditions/dilapidation survey** | ➢ Client, with the appointed demolition contractor and relevant third parties, carry out pre-contract and post-contract conditions/dilapidation surveys of immediate adjacent properties, roads, pavements and haul routes in conjunction with the local authority highway officers. |
| **Protection of public from nuisance** | ➢ Attention to adjacent/adjoining building and their uses, provide protection against nuisance and damage to those buildings during demolition and dismantling. |

To be continued to next page
Appendix D/D1 Tool for outline of demolition requirements

<table>
<thead>
<tr>
<th>Post Contract Award Stage</th>
<th>Perimeter security</th>
<th>Site security</th>
<th>Exclusion zone</th>
<th>Access and egress</th>
<th>Dust control</th>
<th>Noise control</th>
<th>Fire precautions</th>
<th>Safety method statement</th>
<th>Training</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>✓ Boundary walls, fencing/hoarding.</td>
<td>✓ Security of building/structure out of working hours.</td>
<td>✓ Space encompassing the demolition/dismantling activity from which all persons.</td>
<td>✓ Using the existing facilities whenever possible maintain good safe access.</td>
<td>✓ Provision for an adequate supply of water and/or other appropriate measures for suppression of dust arising from the works.</td>
<td>✓ Time limits on plant and equipment (imposed by Local Authorities).</td>
<td>✓ Prevention to prevent the risk of fire and explosion caused by gas, combustible dust or vapour.</td>
<td>✓ Prepared following risk and COSHH assessments.</td>
<td>✓ CITB/NFDC Certificates of competence – demolition operatives/supervisors.</td>
</tr>
</tbody>
</table>

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R2: Health and Safety plan

Health and safety plan contents checklist and DFDs for management of health and safety process:
- Scope of works: location of works, extents of works and special works;
- Description of existing structures with existing draws;
- Site welfare arrangements;
- Sequence of works;
- Setting up sites and site security;
- External scaffolding and calculations;
- Details of cranes, plant and equipment;
- Asbestos and other hazardous material survey and removal;
- Storage of gases for hot work;
- Safety requirements, including risk and COSHH assessments and resultant Safety Method Statement to cover:
  i. Removal of non-load bearing elements and fixtures and fittings;
  ii. Removal of roof structures;
  iii. Removal of existing lift cars;
  iv. Removal of partition walls;
v. Temporary lateral propping of wall panels and columns;
vi. Removal of external walls;
vii. Removal of floors and propping requirements for plant and debris loads;
viii. Dismantling of stair/lift core;

- Disposal of materials off-site;
- Personnel assess to work area;
- Personal protective equipment;
- Safe means of exit in emergency;
- Management structure;
- Induction training;
- Programme of works;
- Monitoring of health and safety.

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R3: Risk assessment

1. Assessor for demolition risk assessment framework
2. Risk assessment form

<table>
<thead>
<tr>
<th>Degree of likelihood</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Degree of severity</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>2</td>
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</tr>
<tr>
<td>4</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

3. Risk assessment form

**PROJECT DETAILS**

Project Name: Name of the project to which the risk relates

Project Manager: Name of the project manager responsible for mitigating the risk

**RISK DETAILS**

Risk ID: Unique identifier assigned to this risk

Raised By: Name of person who is raising the risk

Date Raised: Date on which this form is completed

Risk Description:

Add a brief description of the risk identified and its likely impact on the project (e.g. scope, resources, deliverable timescales and/or budgets)

Risk Likelihood: Describe and rate the likelihood of the risk eventuating (i.e. Low, Medium or High)

Risk Impact: Describe and rate the impact on the project if the risk eventuates (i.e. Low, Medium or High)

**RISK MITIGATION**

Recommended Preventative Actions:

Add a brief description of any actions that should be taken to prevent the risk from eventuating

Recommended Contingent Actions:

Add a brief description of any actions that should be taken, in the event that the risk happens, to minimize its impact on the project

**APPROVAL DETAILS**
4. Mechanical operation risk assessment form (adopted from Dorton Demolition & Excavation Limited)

<table>
<thead>
<tr>
<th>Hazard/risk assessment</th>
<th>PROJECT</th>
<th>DATE</th>
</tr>
</thead>
<tbody>
<tr>
<td>PROCESS/OPERATION</td>
<td>IDENTIFICATION</td>
<td>RISK RATING</td>
</tr>
<tr>
<td>Mechanical demolition</td>
<td>Premature collapse of part or all of structure</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>Debris falling onto machine operator</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Debris falling onto others adjacent to the site</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>Debris falling on other operative on site</td>
<td>3</td>
</tr>
</tbody>
</table>

**PROBABILITY** The likelihood of these hazards to cause harm  
H=High  M=Medium  L=Low  
**SEVERITY** The severity of the injuries from these hazards  
H=High  M=Medium  L=Low  
**HAZARD RISK RATING**  
H+H=9  H+M=8  H+L=7  M+H=6  M+M=5  M+L=4  L+H=3  L+M=2  L+L=1

**CONTROL MEASURES** Means of reducing the probability/likelihood of these hazards to cause harm

**BEFORE STARTING WORK:**
- Site supervisor and machine operator to carry out walk around survey. Ask advice if not sure of building and/or structures construction.
- Machine operator to be competent and in possession of a competence card.
- ERECT PHYSICAL BARRIERS TO PROHIBIT UNAUTHORISED PERSONS INTO THE WORKING AREA. POST WARNING SIGNS.
- SAFE WORKING:
  - Ensure that the machine is large enough to carry out the work at arms length, or that the machine is able to reach structure safely by creating a raised platform (hardcore base).
  - Establish a safe system of work (method statement) and communicate to the operatives.
  - Employ a bank man during all mechanical demolition.
- Ensure through good supervision that the work is being carried out according to the Method statement.

**PROTECTIVE MEASURES** Means of reducing the severity of injuries or ill health from these hazards

- PPE hearing protection, Safety boots, dust Mask, Gloves, Goggles, High Vis

**Communicate to operatives by**
- A. Site Induction  
- B. Tool Box talks  

**SIGNED**  
**AUTHORITY**  
**DATE**

<table>
<thead>
<tr>
<th>SITE AUDIT</th>
<th>COMMENTS</th>
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<td>Are controls effective</td>
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<td>Are operatives complying</td>
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<td>Is additional training needed</td>
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</table>

**AUDITED BY**  
**DATE**

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Appendix D/D1 Tool for outline of demolition requirements

R4: Selection of suitable demolition techniques

1. Type of demolition techniques

![Diagram of demolition techniques]

- **Progressive demolition**: This is the controlled removal of sections of the structure at the same time retaining the stability of remainder and avoiding collapse of the whole or part structure to be demolished (BS 6187:2000)

- **Demolition ball**: The demolition ball application consists of a crane equipped with a steel ball that is suspended from a lifting appliance (crawler crane) and the released to impact the structure repeatedly in same or different locations. Suitable for tumble down structure.

- **Deliberate collapse mechanism**: Demolition by deliberate collapse is the removal of the key structural members to cause complete collapse of the whole or part of the building structures of the whole or part of the structure to be demolished (BS 6187:2000)

- **Deliberate removal of elements or deconstruction**: Deconstruction or topdown technique is those techniques that proceed from the roof to ground in general trend. On a floor-by-floor downward sequence, depending on site conditions and structural elements to be demolished (BS 6187:2000)

- **Long reach machine with various hydraulic attachments**: The excavator attached with boom and hydraulic attachments such as crushers, impact hammers, shears, etc. The crusher attachment breaks the concrete and the reinforcement by the hydraulic thrust through the long boom arm system. The hydraulic crusher could be operated from the ground outside the building. This technique is also suitable for dangerous buildings, silos and other industrial facilities.

- **Explosive**: Use of explosive
- Restrictive entry to work areas
- Adequate clear space of 2.5 times building height
- Qualified blaster
- Notification and evacuation
- Could shorten the work period and reduce labour
- Risk assessment required to be continued

- **Wire rope pulling**: Involves the use of an earth mover machine or mechanical Which device equipped with heavy steel wire for pulling down structure members.
- Restrictive to work area
- Adequate clear space of 2.5 times building height
- Qualified blaster
- Notification and evacuation of neighbourhood
- Risk assessment required to be continued

2. Key factors with importance for demolition techniques selection

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<th>Ranking</th>
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<td>Structure form</td>
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<td>Scale of construction</td>
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<td>Location</td>
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<td>6</td>
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<td>Nuisance tolerances</td>
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<td>11</td>
<td>Proposed fate of building</td>
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<td>Profit</td>
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3. Criteria for selection of demolition techniques

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<tr>
<th>Criteria</th>
<th>Justification</th>
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<tr>
<td>Health and safety</td>
<td>• H&amp;S is the most important consideration and should be considered throughout the demolition process.</td>
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<tr>
<td></td>
<td>• H&amp;S aspects for the person on and off site need to be considered before selecting a demolition technique.</td>
</tr>
<tr>
<td>Stability of the structure</td>
<td>• Different types of techniques need to be considered depending on whether a structure is stable or unstable.</td>
</tr>
<tr>
<td></td>
<td>• Avoid having the workers working inside a structure that is unstable.</td>
</tr>
<tr>
<td></td>
<td>• If the structure is unstable, this become the top criteria in the selection of a demolition technique.</td>
</tr>
<tr>
<td>Location and accessibility</td>
<td>• Different locations have an effect in selecting demolition techniques.</td>
</tr>
<tr>
<td></td>
<td>• The deconstruction technique is probably the best choice for structures that located in a town centre.</td>
</tr>
<tr>
<td></td>
<td>• All the demolition techniques available should be considered if the structure is located in a remote area.</td>
</tr>
<tr>
<td>Presence of hazardous material</td>
<td>• The material should be removed before the structure demolition is carried out.</td>
</tr>
<tr>
<td></td>
<td>• Not much effect on the selection of demolition techniques since it was done in the decommissioning stage.</td>
</tr>
<tr>
<td>Environmental consideration</td>
<td>• Certain level of nuisance imposed by Local Authorities or based on specified regulation.</td>
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<tr>
<td></td>
<td>• The choice depends on the permitted level of noise, dust and vibration.</td>
</tr>
<tr>
<td></td>
<td>• Minimize the size of demolition debris. The smaller the debris the easier it is to crush or to transport to a landfill site.</td>
</tr>
<tr>
<td>Shape and size of the structure</td>
<td>• A single demolition technique or a combination of techniques is selected depending on the shape and size of the structure.</td>
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<tr>
<td></td>
<td>• A high rise building probably needs a combination of techniques. Deconstruction should be used for the top part of the building that can be reached by demolition excavator.</td>
</tr>
<tr>
<td></td>
<td>• The demolition engineer might only use a demolition excavator to demolish a single storey house.</td>
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<tr>
<td>Client specification</td>
<td>Clients forbid some types of demolition techniques.</td>
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<tr>
<td>Structural engineer approval</td>
<td>• Did not need any approval from the structural engineer.</td>
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<tr>
<td></td>
<td>• Their opinions are a guide on determining the stability of the structure.</td>
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<tr>
<td>Time constrain</td>
<td>Duration of the job important.</td>
</tr>
<tr>
<td>Extent of demolition</td>
<td>• Partial demolition used in conjunction with building refurbishments.</td>
</tr>
<tr>
<td></td>
<td>• Complete demolition used to make way for new structure.</td>
</tr>
<tr>
<td>Financial constrains</td>
<td>• Economical consideration for different technique selection.</td>
</tr>
<tr>
<td></td>
<td>• The costs considered include machinery and manpower.</td>
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<tr>
<td>Recycling and reuse</td>
<td>The amount of reusable and recyclable materials affects the techniques selection. The less reusable materials there are, the wider the choice of demolition techniques.</td>
</tr>
<tr>
<td>Transportation consideration</td>
<td>The condition of the site may restrict the accessibility of heavy machinery.</td>
</tr>
<tr>
<td>Availability of plant or equipment</td>
<td>• Plant and equipment can be purchase or rented</td>
</tr>
<tr>
<td></td>
<td>• Capability of the plant and equipment must be considered.</td>
</tr>
<tr>
<td></td>
<td>• The easily available plant and equipment, which offers the best value for money and should be selected.</td>
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</table>
R5: Cost estimate

1. Sheet for demolition cost estimate

![Cost Estimate Sheet](image1)

<table>
<thead>
<tr>
<th>Item</th>
<th>Quantity</th>
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<th>Price/Unit</th>
<th>Total Cost (£)</th>
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<tr>
<td>Site overhead cost (£1)</td>
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<td>Temporary structures, facilities and services</td>
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<tr>
<td>Enclosure, fencing and protective structure</td>
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<tr>
<td>Temporary water, light, power, heat</td>
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<tr>
<td>Restroom facilities/toilets</td>
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<tr>
<td>Office/ritable cabins</td>
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<tr>
<td>Others (Please specify)</td>
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<tr>
<td>Personal protective Equipment</td>
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<tr>
<td>Head protection</td>
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<td>Foot protection</td>
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<tr>
<td>Eye and face protection</td>
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<td>Respiratory protection</td>
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<td>Fall prevention and protection</td>
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![Cost Estimate Sheet](image2)

<table>
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<th>Item</th>
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<th>Labour &amp; Equipment cost</th>
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<tr>
<td>Soft stripping (Removal of non-structural items) (£2)</td>
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<td>Toilets</td>
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<td>Rest tiles</td>
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<td>Interior Wall/partition</td>
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<td>Decks</td>
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<td>Windows</td>
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<tr>
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<td>TOTAL</td>
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Appendix D/D1 Tool for outline of demolition requirements

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<th>D</th>
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<th>I</th>
<th>J</th>
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<td>Crushing on site (mobile crushing plant)</td>
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273
# Appendix D/D1 Tool for outline of demolition requirements

## Structural demolition cost (C5)

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<th>Item</th>
<th>Description</th>
<th>No. of item</th>
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<th>Price/Unit</th>
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<td></td>
<td>site manager</td>
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<tr>
<td></td>
<td>others</td>
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<td>TOTAL LABOUR</td>
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<tr>
<td></td>
<td>tracked mounted crane with demolition ball</td>
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<tr>
<td></td>
<td>backhoe loaders</td>
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<td>teletruck</td>
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<td>telescopic handlers</td>
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<tr>
<td></td>
<td>mobile crane</td>
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<td></td>
<td>access platform</td>
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<td></td>
<td>TOTAL</td>
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</tr>
</tbody>
</table>

## Optional excavator or backhoe attachment:

- Attachment 1: Concrete crusher
- Attachment 2: Pulverizers
- Attachment 3: Hydraulic breaker/hammer
- Attachment 4: Shears/cutters
- Attachment 5: Demolition processor
- Attachment 6: Cradle
- Attachment 7: Bucket
- Attachment 8: Ripper
- Attachment 9: Others

## Various hand tools:

- hand held breakers
- hand held drills
- power saw
-便携式锯
- sledge hammer
- polo axe
- pipe axe
- crane bar
- shovel
- flame cutting equipment
- others

## TOTAL EQUIPMENT

## Implosion

- Drilling cost
- Drill cost including handheld cost
- Nitroglycerin (NG) or gel-based stick
- Line shaped charge (steel)
- Nitrostrella trinitramine (RDX)
- Other explosives
### Appendix D/D1 Tool for outline of demolition requirements

#### Cost Estimate Sheet

<table>
<thead>
<tr>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>F</th>
<th>G</th>
<th>H</th>
<th>I</th>
<th>J</th>
<th>K</th>
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<tr>
<td>1</td>
<td>Summary of detailed estimate cost</td>
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<td>Site overhead cost</td>
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<td>3</td>
<td>Decommissioning cost</td>
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<td>General overhead cost</td>
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</tr>
</tbody>
</table>

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R6: Method statement

1. Detailed outline of method statement framework

<table>
<thead>
<tr>
<th>SITE SET UP</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1. SITE SUPERVISOR DUTIES</strong></td>
</tr>
<tr>
<td>✓ Liaise with any adjoining properties to ensure that all are aware of the work.</td>
</tr>
<tr>
<td>✓ Collate all applicable information relating to requirements of adjoining properties regarding access, movement etc.</td>
</tr>
<tr>
<td>✓ Liaise with main offical Authority to ensure all applicable licenses are in place for the specific work area.</td>
</tr>
<tr>
<td>✓ Site all applicable signs (all visitors report to site office/ danger demolition/ hard hat signs) including main contract sign as depicted within tender documentation</td>
</tr>
<tr>
<td>✓ Erect additional fencing as required</td>
</tr>
<tr>
<td>✓ Carry out inspection of all fencing etc to ensure security is maintained and put in appropriate additional measures where required</td>
</tr>
</tbody>
</table>

| SITE COMPOUND |
| 2. SITE COMPOUND |
| **Designate and position the following** |
| ✓ Site welfare facilities |
| ✓ Fuel storage area |
| ✓ Oxypropene storage area (vented, cage showing empty and full) |
| ✓ Equipment/plant storage area |

| WELFARE FACILITIES |
| 3. WELFARE FACILITIES |
| Site supervisor/designated person |
| ✓ To post F10, H&S poster, Site rules, Method statement, Risk assessment, First aid requirements section 80 building control etc within site cabin. |
| ✓ Inspect washing/toilet facilities and provide additional materials (cleaning, soap, towels) |
| ✓ Set up hot water facilities |
| ✓ Arrange for competent contractor to inspect electric supply and issue certificate of same |

| SERVICE INVESTIGATION/ INSTAMENT |
| 1. INVESTIGATION |
| ✓ Information concerning existing services within the site and surrounding area has been obtained by TRD. |
| ✓ All isolation/diversion of M&E supplies are to be carried out by the service providers therefore written confirmation will be received by the site supervisor before commencement of structural demolition works. |
| ✓ Any retained services will be marked with suitable high visibility materials and road plates positioned at all require points. |

| 2. DISCONNECTION/CAPPING OFF OF SERVICES |
| Ensure written confirmation that all necessary documents are contained within this file. |

| 3. INSTATEMENT OF CENTRAL AND TASK LIGHTING |
| Where necessary central task lighting will be installed by a competent electrical contractor. Particular attention will be paid to all emergency exit routes and hazardous areas. |

| RECORDS |
| The site supervisor will ensure that all information relating to location of all capped services is relayed to the CDM Co-Coordinator for inclusion in the file |

| ASSOCIATED RISK ASSESSMENT No.'s |
| ASSOCIATED LEGISLATION |
| ✓ SL2 of the health & safety at work Act 1974 |
| ✓ The electricity at work regulations 1989 |
| ✓ Institution of electrical engineers wiring regulations |
| ✓ Road & street works act 1991 |
| ✓ CDM 2007 |

| WELFARE/STORAGE FACILITIES |
| 2. Task list |
| ✓ Site supervisor to designate sitting zone |
| ✓ Bankmen to be allocated and made aware of exact zone and engaged to ensure safe manoeuvring of vehicles/positioning of units |
| ✓ Site supervisor make sure locks available for both units |
| ✓ Welfare unit to be "hooked" up to services/ plumbar to be engaged to connect to water supply for washing |
| ✓ Electrician to be engaged to connect to suitable supply and test Certificate to be issued |
| ✓ Toilet to be positioned as instructed by the site supervisor |
| ✓ Nominated operative to set up welfare facilities within cabin and ensure adequate cleaning/fishbowl drinking and cooking facilities are available |
| ✓ Operative to be assigned to ensure cabin is cleaned regularly |
| ✓ Site supervisor to post notifications and site notice rules etc within unit |

| ASSOCIATED RISK ASSESSMENT No.'s |
| ASSOCIATED LEGISLATION |
| The Electricity at work Regulations 1989 CDM 2007 |
Continued from previous page:

EMERGENCY PROCEDURES

1. SET UP OF EMERGENCY PROCEDURES
- Site supervisor:
  - Position First Aid equipment within site cabin
  - Designate Fire Marshal, including
    - Pre-planning and positioning of fire extinguishers and fire hose
    - Reinstate same at start of day prior to works commencing
    - Inspection of stairwell lighting daily
    - Inspection of emergency exit route daily (particular stairwell) to ensure clear
    - Overseen any ‘hot’ works via permit system
    - Direct emergency vehicles into the site.
- Designate muster point.
- Organise instatement of fire extinguishers with site supervisor.
- Post emergency exit signs and emergency layout fire plan to all floors.
- Post emergency procedures within site welfare unit.

Note:
Following site and emergency procedures supply the site supervisor or company safety advisor will carry out the site specific induction talk. This include interaction with other trades/site restrictions/site rules/emergency procedures/site communication etc.

EMERGENCY PROCEDURES TASK
- First Aid: i) the requirement for first aid provision, i i) the first-aid box, i ii) set the site’s responsibilities for first-aid on site.
- Medical assistance: i) phone number of nearest hospital and route, i) a copie of the A-Z map for the area with the route to the nearest hospital.
- Emergency plan: the management of health and safety at work regulations require every employer to prepare a plan which sets out the action to be taken in the event of any emergency.
- Introduction: i) to highlight any situation which require evacuation and outline the procedures, i) Rescue procedures; i i) Possible hazardous situations
- Communications: representative from the company will site mobile telephone throughout the emergency and responsible for alerting the emergency services.
- Assembly point needed.
- Action on fire.
- Action on explosion or LPG escape.
- Action on confined space accidents.
- First aid kit.

ERECUTION OF FENCE

1. SCOPE OF WORK
- Erection of fencing to define site boundary line
- Internal fencing to designate zone.
- Protection operatives from hazardous areas
- (openings to floors, segregate further contractors from demolition zones)

2. TASK LIST
- Site layout plan showing exact layout of fencing and access points.
- Calculate required number of panels blocks and design drop off area at each elevation.
- Place amount at each designated point to reduce manual handling risk.
- Phase works to ensure unimpeded access for further deliveries.
- PPE protection applied to workers.
- Two operators needed and use correct lifting procedures.
- Affix warning notice to all elevations.
- Ensure the boundary fencing at start and end of shift all panels/rips in place etc.

ASSOCIATED RISK ASSESSMENT No.5
ASSOCIATED LEGISLATION

75
- CDM2007
- The Manual Handling Regs

SOFT STRIPPING

1. PRIOR WORK NOTES
- Ensure known all locations of asbestos.
- Stop work if any suspected material.
- Risk assessment needed of work area.
- Materials remove progressively and safely manner.
- No smoke
- Adequate escape.
- Prevent damage the structure.
- All hazardous removal by appointed specialist before.

ASSOCIATED RISK ASSESSMENT No.5
ASSOCIATED LEGISLATION

S-2 of the Health and Safety at Work Act 1974
Working at Height Regs
CDM2007
Manual Handling Regs
Control of Noise at Work
PUWER 98
COSSH 2002
PPE Regs

2. SOFT STRIP INTERNAL FITTINGS LIST
- Loose fixtures and fittings (cupboards, shelving)
- Redundant heating units (overhead dwell mounted) and associated pipework, electrical cables & lighting units;
- Suspended ceiling removing boards;
- Sanitary ware;
- Door glazed screen;
- Internal partitioning;
- Carpenters
- Floor tiles
- Glazing
- Timber floors
- Wastes

3. ENVIRONMENTAL MONITORING
- Carry out throughout the duration of the soft strip works. Monitoring Noise, Monitoring dust, Monitoring disturbance.
- Ensure minimum noise, dust and disturbance.
- Spill kit.

4. INSPECTION OF EXPOSED STRUCTURE
- Supervisor and machine operator carry out the inspection of exposed structure, ensure safe demolition of structure.
- Continued from previous page

### ENVIRONMENTAL ISSUES

1. **PREVENTION OF CONTAMINATION & SEALING OF DRAINS**
   - Identify all drain runs on the site.
   - Carry out site survey to identify location/condition of all manholes.
   - Insert temporary plugs into drain for manholes located adjacent to the site boundary/feeding retained areas.
   - Each drain run will be severed at the site of the manhole.
   - A permanent cement mortar plug the each manhole.
   - Each sealed manhole marked clearly on the site plan and site file.
   - Operate a permit to enter system (confined space).
   - Paint marked for identification.

2. **PROTECTION OF SURFACE WATER COURSES**
   - Surface water course be protected against runoff and associated particulate material or dissolved material.
   - Pollution protection guideline-PPG.
   - Odd dust and nuisance controls be installed.
   - Monitoring dust generation from concrete crushing.

3. **PROTECTION OF OTHER SITE USERS AND OFF SITE PERSONNEL**
   - Special measures required to protect on-site users.
   - Avoidance of wind borne dust and noise.
   - Special precautions against inhalation or contact of site personnel with ground material.

#### ASSOCIATED RISK ASSESSMENT No's

#### ASSOCIATED LEGISLATION

- Control of Noise at Work.
- PUWER 98.
- COSHH 2002.
- PPE Regs 92.
- Environment Act.

### REMOVAL OF MMMF MATERIALS

1. **LOCATION OF MMMF MATERIAL**
   - Possible location Pipe work insulated.
   - Ceilings.
   - Behind internal plasterboard partitioning.

2. **PREPARATION WORKS**
   - Wash at shift end, no smoking.
   - Wear RPE/PPE, 1/3 face p3 (High filtration) masks, gloves, goggles, and safety footwear.

3. **REMOVAL PROCEDURE**
   - Dampened down by use of an airless spray unit.
   - Damped material placed immediately into waste sacks and sealed with cloth adhesive tape.

#### ASSOCIATED RISK ASSESSMENT No's

#### ASSOCIATED LEGISLATION

- S.2 of Health and Safety at Work Act 1974
- Working at Height Regs 05
- PPE Regs 92
- COM 2007
- COSHH 2002

### ASBESTOS REMOVAL

1. **SPECIFIC SITE NOTES**
   - Type 3 survey to determine item specifications of ACM’s before entry to structure.
   - Lined before open asbestos cement skip.
   - To seal the work platform using two layers of 1000 gauge polyethylene and cloth adhesive tape.
   - If unsure, must ask the health and safety officer.
   - Action level removed and replaced with one single control limit.
   - Asbestos fibre - non-licensable works.
   - Analytical & monitoring.
   - IOM survey results of sample, position in the building material name, type and remove method.
   - The Control of Asbestos at Work Reg 02.
   - The Asbestos (prohibition) Regs.
   - ACOP’s L143+L127.

#### ASSOCIATED RISK ASSESSMENT No’s

#### ASSOCIATED LEGISLATION

- The control of Asbestos Regulations (CAP) 2006
- PUWER 98.
- PPE Reg 92.
- L143-Work with materials containing asbestos.

- Continued from previous page

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### DEMOLITION

**1. PREPARATION**
- Photo specific the works.
- Ensure all parties agreement of the work method/work time.
- Separation point.
- Full protection of boundary fencing.
- Banksmen to be positioned.

**2. HAND SEPARATION WORKS**
- Inspection of installed separation boarding adequate sealed.
- Direct line between site manager to site supervisor.
- Inspection of structure.
- Roof removal.
- Timber
- Glazing removal.
- Floor removal

**3. MECHANICAL DEMOLITION**
- Plant, equipment and attachment.
- Driver.
- Banksmen.
- Work procedures.

**4. ENVIRONMENTAL MONITORING**
- Carried out duration of the demolition works.
- Monitoring the noise, dust, disturbance.
- Minimum migration the dust.

**5. COMPLETION WORKS**
- Site area graded and cleared to satisfaction of the client.
- The area cleared / intrusions removed for next phase of works.

<table>
<thead>
<tr>
<th>ASSOCIATED RISK ASSESSMENT No.'s</th>
<th>ASSOCIATED LEGISLATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Health and safety at Work Act 1974.</td>
<td>PUWER 98.</td>
</tr>
<tr>
<td>The Control of Noise at work Regulation 05.</td>
<td>BS5817:2000.</td>
</tr>
</tbody>
</table>

### OPERATING CRUSHING MACHINE

**1. PROCEDURES**
- Ensure machine is placed on firm level ground.
- Ensure the all signage is displayed and clear.
- All conveyor supports are to be checked daily for service ability.
- Grease jaw at 4 hours intervals.
- Grease conveyors daily.
- Check conveyors for clearance of snagged wire and build up of spoils as much as possible.
- Check oil and water levels daily.
- Check sprinklers to ensure spraying correctly.
- Check all the dust suppression and units.
- Run up the machine (warm up).
- Zero off bell weighed.
- Protective clothing must be worn all the time.
- Ensure the good water supply for the sprinklers.
- Keep the platform, machine and access area clear at all time.
- Instruct emergency stop.
- Keep any oil, diesel drum away from crusher.

**2. WORK METHOD**
- General conditions.
- Safety procedures for those not directly involved with the crushing operation.
- Sorters responsibilities.
- Personal hygiene.
- Operators responsibilities.

**3. EQUIPMENT WORK PROCEDURE**
- All operator use appropriate PPE.
- All mechanical equipment used and maintained as recommended by the manufacturer.
- Crusher work procedure.
- 360 excavator work procedure.
- Wheeled loading shovel.

<table>
<thead>
<tr>
<th>ASSOCIATED RISK ASSESSMENT No.'s</th>
<th>ASSOCIATED LEGISLATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>PUWER 98.</td>
<td>LOLER98.</td>
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<tr>
<td>The Control of Noise at Work Regulations.</td>
<td>Control of Vibration of work Regs 2005.</td>
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</table>

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### Appendix D/D1 Tool for outline of demolition requirements

**R7: Asbestos removal**

1. **Guideline to address the CAR 2006 in demolition project**

<table>
<thead>
<tr>
<th>MAIN REQUIREMENTS IN ASBESTOS REMOVING</th>
<th>SUGGESTED ACTIVITIES</th>
<th>CHECK LIST</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>MANAGE THE ASBESTOS IN BUILDING</strong> (Regulation 4)</td>
<td>Types of survey</td>
<td>1. Type 1—presumptive. This is to locate materials assumed to contain asbestos and note what condition they are in. No sampling is done. 2. Type 2—sampling. This is the same as type 1 but samples are taken and analysed to confirm whether asbestos is present. 3. Type 3—full access. This involves getting full access to all parts of the building using destructive inspection if necessary. This type is usually used just before demolition or major refurbishment.</td>
</tr>
<tr>
<td><strong>Risk assessment</strong></td>
<td>1. If any work which will, or could, disturb asbestos is planned, has the risk assessment been done by a competent person? 2. Does it relate specifically to the particular job and site? 3. Does it cover other risks like falls from height or electricity?</td>
<td></td>
</tr>
<tr>
<td><strong>Record</strong></td>
<td>1. Has any survey been done? If so, which type? 2. Does it cover all parts of the building? If not, why? 3. Is the information readily available and understandable? 4. Is it given to anyone who needs it, e.g. contractors?</td>
<td></td>
</tr>
<tr>
<td><strong>IDENTIFYING PRESENCE OF ASBESTOS</strong> (Regulation 9)</td>
<td>Survey result</td>
<td>1. whether asbestos is, or may be, present; 2. what type of asbestos it is; 3. what material it is in; 4. what condition it is in; 5. if there is any doubt about whether asbestos is present, the employer has assumed that it is present and that it is not only white asbestos</td>
</tr>
<tr>
<td><strong>PLANNING WORK</strong> (Regulation 7)</td>
<td>Marks in the building</td>
<td>1. Is all this information readily available or has the employer said that they will assume asbestos is present? 2. Is the information clear and easy to understand? 3. Are there any parts of the building which have not been checked?</td>
</tr>
<tr>
<td><strong>INFORMATION, INSTRUCTION AND TRAINING</strong> (Regulation 10)</td>
<td>Writing plan of work detailing</td>
<td>1. Is there a plan of work? 2. Does it say clearly how the work will be done? 3. How is the waste going to be removed? 4. How will the employer make sure that the work is done in the way the plan says it should be? 5. Have other risks which may be present (like falls from height and electricity) been considered as well? 6. How will employees be informed?</td>
</tr>
<tr>
<td><strong>Knowledge of Asbestos</strong></td>
<td>Adequate training</td>
<td>1. the properties of asbestos, its health effects and the interaction of asbestos and smoking; 2. the type of materials likely to contain asbestos; 3. what work could cause asbestos exposure and the importance of preventing exposure; 4. how work can be done safely and what equipment is needed; 5. emergency procedures; 6. hygiene facilities and decontamination;</td>
</tr>
<tr>
<td><strong>PREVENTING, REDUCING OF EXPOSURE</strong> (Regulation 11)</td>
<td>Good practice</td>
<td>1. Has the approach actually been taken? 2. How will the employer ensure that the workers are not exposed to more than the control limit? It is not always necessary to carry out air tests, for example when it is well known what exposure levels an activity generates—and the worst levels are assumed. Air tests may be needed to confirm that the controls are working.</td>
</tr>
<tr>
<td><strong>Control the limitation</strong></td>
<td>1. If any employee is exposed to more than the control limit, the employer must inform the employees concerned and their representatives; 2. ensure that the work does not continue until adequate action has been taken to reduce exposure to below the control limit; 3. if the control limit was exceeded and take action to prevent it happening again and take air samples to make sure this action was effective; 4. employers need to ensure that whatever controls they put in place are properly maintained and used. This includes providing any necessary supervision. 5. employees need to make sure they use any controls properly; 6. do the employees know how to use the controls in place? 7. do they know what to do if they suspect the controls are not working properly? 8. the employer should make arrangements to deal with accidents, incidents and emergencies. These should minimise the effects of the event and restore the situation to normal. Anyone who may have been affected should be informed immediately; 9. do these arrangements exist and does everybody know about them? 10. is it clear who is responsible and what for? 11. what happens when those people are absent?</td>
<td></td>
</tr>
</tbody>
</table>

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Continue to next page
Appendix D/D1 Tool for outline of demolition requirements

Checking list:
1. Is asbestos present?
2. What is the safest way to do the work?
3. Can you look at the risk assessment for the job (which should tell you what the risks are and how to control them)?
4. Is the work such that it should only be done by a licensed contractor?

1. have received adequate training first;
2. are provided with and always wear a suitable mask;
3. are provided with disposable overalls;
4. are provided with a class HEPA vacuum cleaner to vacuum up dust;
5. do not cut or drill into asbestos with power tools (unless it is unavoidable – in which case the employer must ensure that the appropriate controls are in place and used);
6. dispose of all waste properly.

www.hse.gov.uk/asbestos.

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R8: Waste management

1. The basic modelling element for waste management mapping model

![Waste Management Diagram]

- Waste source
- Waste Facilitator
- Waste processing
- Waste destination
2. Process mapping model for the waste management

- Timer WST
  - Waste
    - Collect
    - Transport
    - Dump

- Steel WST
  - Collect
  - Transport
  - Dump to store

- Refuse truck
  - Load
  - Transport
  - Dump

- Waste removed

- Collection truck
  - Load
  - Transport to recycler

- Load stored waste
  - Transport

- Recycle

- Landfill

3. Waste handling simulation model about location set for the site system and resource transit information system.
4. Site Waste management checklist

Policy:
- Has your organisation adopted a waste management policy?
- Has the client signed the site waste management plan?
- Have relevant sub-contractors producing significant waste streams been identified?
- Have the identified sub-contractors signed the site waste management plan?

Procurement:
- Has a careful evaluation of materials been made so that over-ordering and site wastage is reduced?
- Has full consideration been given to the use of secondary and recycled materials?
- Is unwanted packaging to be returned to the supplier for recycling or re-use?
- Can unused materials be returned to purchaser or used on another job?

Project planning:
- Has responsibility for waste management planning and compliance with environmental legislation been assigned to a named individual at both main contractor and identified sub-contractors?
- Has a project programme been developed to include likely waste arising (how much, when, and what type)?
- Has an area of the site been designated for waste management, including segregation of waste?
- Have targets been set for the different types of waste likely to arise from the project?
- Have measures been put in place to deal with expected (and unexpected) hazardous waste?
- Has disposal of liquid wastes such as wash-down water and lubricants been considered?
- Where relevant, has discharge consent been obtained from the Agency?
- Have opportunities been considered for re-use of material on-site?
- Have opportunities been considered for re-use of material off-site?
- Have opportunities been considered for on-site processing and re-use of material?
- Have opportunities been considered for reprocessing materials off-site?
- Have you considered what are the most appropriate sites for disposal of residual waste from the project?
- Are there opportunities for reducing disposal costs from waste materials which may have a commercial value?

Site operations:
- Has responsibility for waste management on-site and compliance with environmental legislation been assigned to a named individual?
- Have toolbox talks been planned for all site personnel about waste management on-site?
- Are selected waste materials segregated to allow best value to be obtained from good waste management practices?
- Are containers/skips clearly labelled to avoid confusion?
- Is duty of care procedures complied with, including provision of transfer notes and checking authorisation of registered carriers, registered exempt sites and licensed waste is received at the intended site?
- Are any checks made that excavation waste is received at the intended site?
- Is implementation of agreed waste management procedures monitored?
- Are reports regularly produced regarding waste quantities and treatment/disposal routes, and on costs incurred?
Appendix D/D1 Tool for outline of demolition requirements

- During site operations, are barriers to good waste management practice considered and noted for incorporation into the post-completion review?

Post completion:
- Has final report of use of recycled and secondary materials, waste reduction, segregation, recovery and disposal, with costs and savings identified, been completed?
- Has final report been signed by the relevant sub-contractors and the client?
- Have key waste management issues been considered for action at future projects?

5. Site Waste management Plan data sheet

<table>
<thead>
<tr>
<th>Project Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project address/ location</td>
</tr>
</tbody>
</table>

| Main contractor |
| Person responsible for waste management on site (name and job title) |
| Person and company completing this form, if different |

<p>| Type of waste arising (add more rows if needed): |</p>
<table>
<thead>
<tr>
<th>Material</th>
<th>Quantity</th>
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<tr>
<td>Performance score as %</td>
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</table>

SWMP Target % |
D2: Tool for Editing Health and Safety Plan

H2: PROJECT PARTICULARS
H3: MANAGEMENT STRUCTURE
H4: NOTIFICATION
H5: SITE INFORMATION SOURCE
H6: DESIGN INFORMATION
H7: HEALTH AND SAFETY PRINCIPAL & OBJECTIVES
H8: SCOPE OF THE WORK
H9: NATURE OF THE WORK
H10: PROJECT TIME TABLE
H11: PROJECT RESOURCE
H12: FUEL OIL & GAS STORAGE
H13: FIRE EQUIPMENT
H14: SAFETY PROCEDURES
H15: PROJECT PERSONNEL
H16: INFORMATION INSTRUCTION & TRAINING
H17: ARRANGEMENTS
H18: SITE RULES
H19: METHOD STATEMENT
H20: IDENTIFIED HAZARDS 1
H21: IDENTIFIED HAZARDS 2
H22: WELFARE FACILITIES
H23: SERVICES
H24: PERSONAL PROTECTION
H25: PRE-START CHECK LIST FOR SITE MANAGEMENT
H26: WASTE DISPOSAL
H27: SAFETY ADVISOR
H28: JOINT CONSULTATION
H29: PROHIBITION/IMPROVEMENT NOTICES
H30: MONITORING & REVIEW OF SITE SAFETY PLAN
H31: INFORMATION SOURCES (HEALTH & SAFETY FILE)
## H2: PROJECT PARTICULARS

1. **Project**

<table>
<thead>
<tr>
<th>Name</th>
<th>Address</th>
<th>Site map reference</th>
</tr>
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</table>

2. **Client**

<table>
<thead>
<tr>
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<th>Contact</th>
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<th>E-mail</th>
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</thead>
</table>

3. **CDM Coordinator**

<table>
<thead>
<tr>
<th>Name</th>
<th>Address</th>
<th>Contact</th>
<th>Telephone/Fax</th>
<th>E-mail</th>
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</thead>
</table>

4. **Principal Contractor**

<table>
<thead>
<tr>
<th>Name</th>
<th>Address</th>
<th>Contact</th>
<th>Telephone/Fax</th>
<th>E-mail</th>
</tr>
</thead>
</table>

5. Appointed sub-contractors

- Asbestos removal (licensed) contractor:
- Scaffold contractor:
- Asbestos disposal contractor:
- General waste disposal contractor:
- Service investigation (CAT scan) contractor:

<table>
<thead>
<tr>
<th>Name</th>
<th>Address</th>
<th>Contact</th>
<th>Telephone/Fax</th>
<th>E-mail</th>
</tr>
</thead>
</table>
H3: MANAGEMENT TEAM

- Managing Director
- Estimating Director
- Project Director
- Project co-ordinator
- Company Secretary
- Health & Safety
- Site Supervisor
- CCDO Demolition Operatives
- CPCS Plant Operatives
- Sub-contractor Site Supervisor

Emergency 24 hour call out No.:  
*Safety advisor No.:  

H4: NOTIFICATION

1. Obtain Building Act 1984-section 80-82, notification from Local Council; (Principal Contractor)
2. Notification to HSE Form ASB5; (to be displayed on site)
3. Obtain service termination confirmation notices from appropriate authorities;
4. Issue of written confirmation of services to required parties;
5. Posting of courtesy notices advising of impending demolition to all properties situated to the boundary of the site and those adjacent the site including the emergency contact No.’s.

H5: SITE INFORMATION SOURCE

1. Tendering documents list:
   - Statement of work:
     - defining the type of contractor that you wish to appoint;
     - describing the materials and equipment you need;
     - specifying the deliverables to be provided by the contractor;
     - Stating your terms and conditions for payment
   - Request for information
   - Request for proposal
   - Contractor contract:
     - deliverables to be provided by the contractor;
Appendix D/D2 Tool for editing health and safety plan

- training, documentation and support to be provided;
- Responsibilities of both parties;
- Performance criteria and review process;
- Pricing schedule and invoicing process;
- Contractual terms and conditions

2. Method statement list:
   - Site set up
   - Service investigation/instatement
   - Welfare/storage facilities
   - Emergence procedures
   - Erection of fence
   - Soft stripping
   - Environment issues
   - Removal of FFFM material
   - Asbestos removal
   - Demolition
   - Operation of crushing machine

Drawings
   - Site layout
   - Site zones
   - Fire assembly point
   - In site traffic route
   - Emergence rescue route

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H6: DESIGN INFORMATION

Compiling Health & Safety plan;
Method statement design;
Hazard identification/Risk assessment;
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H7: HEALTH AND SAFETY PRINCIPAL & OBJECTIVES

1. Relevant legislation list:
     ✓ Section 1-8 general Duties of employers and persons in control of premises;
     ✓ Section 53 (1) General Interpretation of Part I.
   - The management of Health and Safety at Work Regulations 1999.
Appendix D/D2 Tool for editing health and safety plan

- Electricity at Work Regulations 1989.
- Control of Noise at work Regulations 2005.
- COSHH Regulations 2002.
- Work at Height Regulations 2005.
- Personal Protective Equipment at Work Regulations 1992.
- The Control of Asbestos Regulations 2006.
- Control of Pollution Act 1974.
- Control of Lead at Work Regulations 2002.
- Health and Safety (First Aid) Regulations 1981.
- Ionising Radiations Regulations 1999.
- The Reporting of Injuries, Diseases and Dangerous Occurrences Regulations 1995.
- The construction (Head protection) Regulations 1989.
- Guidance Notes GS29 Parts 1-4.
- Control of Vibration at Work regulations 2005.
- Environmental Protection Act.

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**H8: SCOPE OF THE WORK**

Documents for tender stage;
Documentation and notification;
General site plan;
Method statement;
Site set-up;
Service/hazardous area Investigation and Protection;
Removal of Contaminants/ Hazardous substances;
Demolition;

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**H9: NATURE OF THE WORK**

1. Section 80-81 application to local council.
   - Note: Council require a 6week period for issue of this notice.
2. To carry out all service disconnections feeding the site, including any overhead service.
   - Note: All services are terminated outside the footprint of the site for safety purposes;
   - Written confirmation provided;
   - Start date cannot confirm until written confirmation id received.
3. Erection of protective 2.4m hears type fencing to encompass any site boundaries required and ensure prevention of unauthorized access.
4. Protection at all times of adjacent properties.
5. Protection at all times of adjacent roadways and pavements.
Appendix D/D2 Tool for editing health and safety plan

7. Provision of fully trained NFDC/NDTG site supervisor for the duration of the project.
10. Monthly external safety audits for the duration of the project with written reports issued.
11. Weekly in-house safety audits for the duration of the project with written reports issued.
12. Appointment of specialist, licensed contractor and removal of all licensed asbestos based materials, as detailed within the survey provided and (CAR) 2006.
13. Removal of all non-licensed asbestos containing products in line with HSE ACOP L143-work with material containing asbestos.
14. Arranging and paying for installation of full height scaffold/edge protection as required enabling safe execution of works.
15. Removal of above ground tanks.
18. Demolition of sensitive areas by hand working methods.
20. Grubbing up of all footings to a depth of 1.5m.
21. Grubbing up tarmac car park and roadways.
22. Grubbing up hard standings.
23. Crushing of all clean, inert materials down to 6F2 specification.
24. Stockpiling of crushed material within designated area for reuse by you.
25. Clear site of all brick, concrete rubble and waste, leaving a level and tidy site to your satisfactory.

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H10: PROJECT TIME TABLE

MS project demolition process management.mpp

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H11: PROJECT RESOURCE

1. Mechanical removal and loading operations:
   ✓ Tipper transport (skips and bulkers)
   ✓ 360° demolition rigs
   ✓ Loaders
   ✓ Cranes

2. Access equipment:
   ✓ Approved tower scaffold (to BS. Design)
   ✓ Access ladders & younger man boards
   ✓ Powered access platforms

3. Health and Safety
Appendix D/D2 Tool for editing health and safety plan

- Fully conversant with the safe system of work intended for the project
- Introduction on site to any commencement of the works and ensure fully understood
- Monitoring of all such systems is to be carried out on regular basis
- Must be fully trained and in possession of operatives certificates of training attendance or equivalent person can operating all asbestos removal work.

4. Equipments
   - Hand tools

5. PPE/RPE
   - All site personnel: gloves, goggles, respiratory protection, safety boots, hard hats
   - Operatives working at height: safety harness, lines
   - Operatives working with asbestos: respiratory protection, disposable coveralls, rubber boots

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**H12: FUEL OIL AND GASSES STORAGE**

- Requirement for storage of adequate fuel to facilitate the refuelling to mobile plant and equipment use on site for the duration of the project.
- All storage of oxy/propane gasses should be kept in upright position as for away from occupied premises as is practicable.
- Number bottles stored on site to correspond with the requirement for that day. Exchange the bottles should be arranged through the site supervisor.
- Sitting of those areas should be by arrangement with the client and be implemented on arrival to site. Locations will be fully documented and noted as part of the developing health and safety plan.

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**H13: FIRE EQUIPMENT AND ARRANGEMENTS**

- Fire fighting equipment: fire hoses/standpipe, fire extinguishers.
- Adequate fire points with minimum of two fire extinguishers at designated positions and be advised to operatives within site induction talk.
- Changes to the stated procedures will be conveyed to all personnel by way of tool box talks.
- Emergency procedures set up: management staff contact No’s, nearest accident and emergency hospital address, route, and contact No’s.
- Designated the fire and emergency assembly point.

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**H14: SAFETY PROCEDURES**

1. Site notices.
Appendix D/D2 Tool for editing health and safety plan

- Health &Safety Law poster
- F10
- Hard hat signs
- Danger asbestos removal in progress signs
- Other hazard signs applicable to risks

2. All works on the project, wherever practicable conform to the acts and regulations as set out in H7.

3. All work is carried out in clearly designated site areas.

4. Suitable and adequate liaison arrangements are in place with a structural engineer to advice on concerns regarding the partial demolition operations and or the continued integrity of the retained areas.

5. Extreme care is to be taken when Lorries are entering and leaving the site.

H15: PROJECT PERSONNEL

<table>
<thead>
<tr>
<th>Title</th>
<th>Name</th>
<th>Contact No.</th>
</tr>
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<tbody>
<tr>
<td>Project Director</td>
<td></td>
<td></td>
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<tr>
<td>Site Manager</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Safety Director</td>
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</tr>
</tbody>
</table>

H16: INFORMATION INSTRUCTION & TRAINING

- Contractor’s responsibility to ensure that all operatives on the project are fully conversant with the safe system of work intended for the project.
- A cope of all operatives training certificates should keep within the site safety manual, in the site office.
- The site manger will enter operative’s level of training and competence in the site register.
- No operatives be allowed to work on the project unless they are fully trained in the work they are being asked to do, or they under training supervision by a person competent in that task.

H17: ARRANGEMENTS

- Agreed safe system of work method statement of contractors appointed.
- A copy of the approved method statement should be holding on site.
- Site variation to the agreed method should be discussed at site management level.
- The method statement addendum completed and submitted to the project manager before any alternate method of work is implemented.

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H18: SITE RULES

1. Site layout
   ✓ The works are suited within the environs of grounds purchased and controlled by the client and are adjacent to live occupancy of buildings.
   ✓ The following structures should be within the scope for demolition/strip out/removal:
     o Brick bungalows and associated outbuildings;
     o Slab and foundations (excluding areas immediately adjacent to retained walls or fencing).

2. Access/egress
   ✓ The access and egress point for work;
   ✓ Contractors’ vehicles use the established road for removal of materials or the supply of plant and machinery;
   ✓ The utmost caution should be adopted when entering and leaving the site compound, due to consideration to other road user, residents, pedestrians, visitors, children and occupiers of adjacent units etc.
   ✓ A banksman should be employed for movement of construction plant/vehicles across.
   ✓ All drivers of construction traffic should adhere to the existing area speed restrictions
   ✓ Traffic management put in place during phases of works programme as is necessary.

3. Site security
   ✓ Erecting the “heras fencing” to eradicate unauthorized access to working areas.
   ✓ Existing walls and fences forming boundaries to the site will be maintained as instructed by the clients engineer.
   ✓ Temporary heras fencing will cordon off all internal entry points to the works.
   ✓ Block off the access to the site with an easily demountable barrier to prevent vehicle access.
   ✓ Access and egress to the site be strictly controlled only authorized personnel will be allowed on site during operations.
   ✓ Visitors to site must first report to site manager.
   ✓ Location of office & welfare facilities to be facilities to be determined and agreed with the client and in the developing health and safety plan.
   ✓ A register of all operatives/plant/machines on site will be kept and any operatives leaving site during the working shift will book out with the site manager so he is aware of the numbers present on site at all time.
   ✓ A copy of any site safety report will be retained in the site office.

4. Visitors and trespassers to the site
   ✓ All visitors to the site should be logged by the full time site supervisor

5. Site daily checklist
   ✓ Site fencing checked for security so that unauthorized access is prevented
   ✓ All mechanical equipment employed on this project will be secured and immobilized at the end of each working shift.
   ✓ No road transport will be left on site overnight unless broken down.
Appendix D/D2 Tool for editing health and safety plan

✓ Any scaffolding towers/ladders will be dismantled or secured overnight to prevent illegal access to the structures.
✓ All soft strips (combustible material) will be removed from site progressively so as to prevent a build-up of flammable waste.
✓ Asbestos products be properly contained and secured and be removed from site in strict accordance to the current, relative licensing stipulations.

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H19: METHOD STATEMENT/RISK ASSESSMENT
 Outline of Method statement
 Risk assessment form
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H20: IDENTIFIED HAZARDS (1)
1. Working near occupied private properties
   ✓ care and consideration to be paid
2. Working adjacent occupied premises
   ✓ past warning signs to make all aware
   ✓ Ensure all affected by the works are informed.
3. Damage to adjacent structures
   ✓ Adequate protection to all sections considered to be in a fragile condition to be in place prior to commencement of stripping works.
4. Services
   ✓ Services to be terminated to commencement of works.
5. Contamination of waterways
   ✓ Seal drains and ensure adequate protection is taken to prevent contamination during the works.
6. Hot cutting
   ✓ Safe work procedures to be adopted for all hot cutting works.
7. Site neighbourhood
   ✓ Roadways in 24hr use to all of works areas. Take all necessary precautions to prevent nuisance, disturbance, disruption etc.

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H21: IDENTIFIED HAZARDS (2)
1. Noise
   ✓ All mechanical equipment intended for use on this project is of the design standard required to conform to the Control of Noise at Work Regulations 2005.
2. Pollution
Appendix D/D2 Tool for editing health and safety plan

✓ Take all reasonable precautions to prevent pollution of the site. If pollution occurs inform relevant authority.

3. Nuisance
✓ Take all necessary precautions to prevent nuisance from smoke, dust, rubbish, vermin etc.

4. Fire
✓ Take all necessary precautions to prevent injury, death and damage to the works and other property from fire.

5. Manual handling
✓ The following materials/equipment handling could present problems on site
  ○ Soft strip, fixtures and fitting etc (cut and grazes when stripping and handling
  ○ Changing of machine attachments

6. Working at height
✓ Work where a fall from any height may cause injury.
✓ Access to and egress from places of work where a fall is possible.

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H22: WELFARE FACILITIES

Adequate welfare facilities are provided to meet the requirements of the CDM Regulations 2007.
1. Site office accommodation including:
   ✓ Sufficient space and seating arrangements for the number of operatives employed on site, to allow them to take meal breaks with the facility for hot water and food warming.
   ✓ Washing facilities with a sufficient supply of hot water for the number of operatives employed, including a supply of soap and towels.
   ✓ Suitable and sufficient plumbed in toilet facilities.
   ✓ Clothes drying facility.

2. Arrangements will be made for all toilets and welfare facilities to be cleaned and restocked on a regular basis.
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H23: SERVICES
✓ Prior to any works commencing, full investigation will take place to ensure there are no live services and that all pipes and cables have been isolated.
✓ Written confirmation should be received.
✓ Location of underground ducts containing services and underground fuel tank should be identified prior to commencement of works and marked and protected.
✓ All on site will be made aware of their location within a site induction talk.
✓ All work carried out to or which affects new or existing services will be in accordance with the by laws or regulations of the relevant statutory authority.

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H24: PERSONAL PROTECTION

✓ It is policy that all employees, visitors or visiting drives on site wear head protection and safety footwear at all times.
✓ During soft stripping, asbestos removal and in particular where there is risk to contaminated surfaces, operatives will be required to wear the appropriate personal protective equipment.
✓ During asbestos removal works respiratory protection will be worn
✓ Eye protection to be worn as and when necessary
✓ During any work where a fall resulting in injury is possible a safety harness will be worn.
✓ All operatives on site will be instructed in the need for a good standard of personal hygiene. In particular operations the removal of asbestos products.

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H25: PRE-START CHECK LIST FOR SITE MANAGEMENT

✓ Ensure that the environmental impact of the site and its effect on the local community has been considered.
✓ Make personal contact with persons working in adjoining areas.
✓ Make arrangements for fencing the work area to exclude trespassers, in particular other trades who may enter the work area.
✓ Erect all necessary warning signs in positions agreed with the safety advisor ensuring extra signs for areas of special risk
✓ Arrange the display of all statutory notices and ensure the companies safety policy, accident book and statutory inspection registers are available for inspection on the site.
✓ Prepare suitable first aid facilities and display necessary signs indicating who is responsible as the appointed person or trained first aider on site.
✓ Display the employer’s liability insurance certificate and sub-contractors certificates so that all contractors can see them.
✓ Make sure that the company COSHH and risk assessment forms are available on site.
✓ Make arrangements to provide adequate protective equipment sufficient for the number of persons engaged. Ensure that additional hard hats are available for visitors.

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H26: WASTE DISPOSAL

1. All waste products must be removed from site whilst adhering to relevant regulations and duty of care movement notice filled. Copies of these should be held on site.
2. Waste will be removed from site by company and other licensed waste carriers as and when required.
3. Waste skips:
   • All skips and roll-on containers will be placed so that they do not present an obstruction to means of access and egress for personnel, plant or vehicles.
   • All skips and roll-on/off containers are based on firm level ground.
   • No fire made in waste skips.
• The filling of skips should be undertaken with discretion. It is dangerous to overload them.
• Proper transportation will be provided to move waste skips and roll-on/off containers. Movement with unsuitable equipment will not be permitted on site.
• The drivers responsibility to ensure that his load is safe when being transported, the site manager will ensure that waste skips are suitably sheeted and that scrap containers are not overloaded before leaving site and that necessary waste transfer documents are available and in order for each skip.

H27: SAFETY ADVISOR
1. Advice management on the preparation of the safety plan.
   Give advice to management as requested on the following:
   ✓ Legal requirements affecting health, safety and welfare.
   ✓ Prevention of injury and damage.
   ✓ Provision, selection and use of protective clothing and equipment.
   ✓ New working methods and equipment which could reduce risks.
   ✓ Proposed changes in legislation.
   ✓ Potential hazards on site before work starts, health and safety factors effecting the selection of plant and equipment, sub-contractors and so on.
   ✓ Specialist services required in relation to substances hazardous to health, noise, asbestos removal etc.

2. Carry out regular inspections of the site, as and when necessary, to determine whether work is being carried out in accordance with company policy, safety plan and the relevant statutory provisions. Provide an inspection report to site supervision and send a copy of the director nominated responsible for health and safety within the company.
3. Assist management in notifying the health and safety executive of dangerous occurrences, major injury accidents and so on, in accordance with the appropriate regulations and the company safety policy.
4. Assist management in any dealings with the health and safety executive.
5. Carry out investigations of serious accidents in accordance with company policy and prepare statistics.
6. Check that necessary first aid equipment is on site and arrange for supply if requested.
7. Check that necessary statutory literature for use or display is on site and arrange for supply if requested.
8. Provide advice on training requirements and arrange training courses where required.

H28: JOINT CONSULTATION
1. In accordance with the safety representatives and Safety Committee Regulations 1977 and the Codes of Practice and Guidance Notes relating to these regulations, every facility will be afforded to officially appointed safety representatives and committees.
2. Procedures on site regarding the functions of safety representatives and committees shall be in accordance with the national working rule 24 of the National Joint Council for the Building
H29: PROHIBITION/IMPROVEMENT NOTICES
1. If a prohibition or improvement notice is issued by an inspector of an enforcement Authority (Health and Safety Executive, Local Authority), the person to whom it is issued must comply immediately with any instruction on the notice and contact the director responsible for safety either directly or through their appropriate manager.
2. The safety advisor will be informed by the director responsible for safety and asked to provide advice on the measures necessary to comply with the notice.
3. When remedial measures have been taken the director responsible for safety will contact the inspector who issued the notice to inform him/her of action taken. This will confirm in writing.

H30: MONITORING AND REVIEW OF SITE SAFETY PLAN
1. Site meetings:
   ✓ Site managers will be convened on the instructions of the client. Contractor Company will be given prior notice to prepare any documentation and ensure compliance with the site safety plan, safe systems of work, progress, and disposal and on site housekeeping.

2. The agenda:
   ✓ Method statement review procedure.
   ✓ Site safety record and compliance with site safety rules.
   ✓ Employee representations.
   ✓ Project variation and client instructions
   ✓ Progress.

3. All employees are encouraged to bring to the notice of the Site Management any areas where the Safety Plan appears to be inadequate. Their suggestions will be considered.
4. Arrangements will be made for the Safety Advisor will visit the site at regular intervals and will report on any hazards, defects or breaches of Regulations observed during the visit.
5. Contractor company will advise site management on any intended changes to methods of work and of the results of new risk assessments.

H31: INFORMATION SOURCES (Health and Safety File)
1. Minutes of all site safety and progress meetings will be passed to the CDM Coordinators for inclusion in the health and safety file.
2. Information on any specific contaminants identified by site management during the project, and the safe system of work employed to deal with the contaminates will be passed to the CDM Coordinator for inclusion in the Health & Safety File.
Appendix E: Questionnaire Forms

Section 1 – Personal Details

Name:

Job title/Position:

Company Name:

Company Address:

Experience in Construction Industry:

Contact Number:
Section 2 – Interview and Workshop Questionnaire

Form 1:

<table>
<thead>
<tr>
<th>Interview questions with experts</th>
<th>Rating</th>
</tr>
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<td></td>
<td>1 (poor)</td>
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<tr>
<td>The Performance</td>
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<tr>
<td>How well does the map help in understanding the demolition process?</td>
<td></td>
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<tr>
<td>How clear is the structure of the demolition process map?</td>
<td></td>
</tr>
<tr>
<td>How well are the demolition processes explained?</td>
<td></td>
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<tr>
<td>How accurate is the knowledge of the demolition process?</td>
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<tr>
<td>How useful is the map and mapping system be supporting the process management?</td>
<td></td>
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<tr>
<td>How well does the map reflect the real demolition process?</td>
<td></td>
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<tr>
<td>How useful do you find the documentation tool to compile the health and safety Plan?</td>
<td></td>
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<tr>
<td>How accurately does the protocol system of demolition process management presents the real demolition practice?</td>
<td></td>
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<tr>
<td>How useful is the database of demolition requirements?</td>
<td></td>
</tr>
<tr>
<td>To what degree can the research result improve the demolition management?</td>
<td></td>
</tr>
<tr>
<td>Applicability to demolition industry</td>
<td></td>
</tr>
<tr>
<td>How effective/accurate are the tools in the demolition process management?</td>
<td></td>
</tr>
<tr>
<td>How convinced are you that demolition industry professionals will use the tools?</td>
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<tr>
<td>How effectively will the tools increase the speed of the documentation process?</td>
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<tr>
<td>To what extent does it represent an improvement (or) help in the documentation process?</td>
<td></td>
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<tr>
<td>To what extent is the tools flexible in documentation the Health and Safety Plan?</td>
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<tr>
<td>General comment</td>
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</tr>
<tr>
<td>How well designed is the DPMT template?</td>
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</tr>
<tr>
<td>How user friendly is the Health and Safety Plan documentation tools?</td>
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<tr>
<td>How well integrated are the key process requirements?</td>
<td></td>
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<tr>
<td>What is your view of the demolition process mapping?</td>
<td></td>
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<tr>
<td>What is your overall rating of the research achievements?</td>
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</table>
Form 2:

<table>
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<th>Ref No.</th>
<th>Tools effectiveness</th>
<th>Level of Agreement(%)</th>
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</thead>
<tbody>
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</tr>
<tr>
<td>1.1</td>
<td>Is documentation tool of Health and Safety Plan a useful application?</td>
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<tr>
<td>1.2</td>
<td>Will it help to reduce the save the time and effort to process management?</td>
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</tr>
<tr>
<td>1.3</td>
<td>Will it help in project process management?</td>
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<tr>
<td>1.4</td>
<td>Is it relevant for the industry needs?</td>
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<tr>
<td>2.1</td>
<td>Tools usability</td>
<td>Level of Agreement(%)</td>
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<tr>
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<tr>
<td>2.1</td>
<td>Is the tool easy to use?</td>
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<td>2.2</td>
<td>Does the tool deliver the reliable information for the industry?</td>
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<tr>
<td>2.3</td>
<td>Is the tool a user friendly system?</td>
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<tr>
<td>3.1</td>
<td>Tools practicality</td>
<td>Level of Agreement(%)</td>
</tr>
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<tr>
<td>3.1</td>
<td>Are the tools a practical solution?</td>
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<td>3.2</td>
<td>Will the engineers use the tools to document the Health and Safety Plan?</td>
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<tr>
<td>3.3</td>
<td>Do the tools have clear structure for engineers?</td>
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<tr>
<td>3.4</td>
<td>Are the tools have adequate output of the demolition process needs?</td>
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<tr>
<td>3.5</td>
<td>Are the tools compatible to the other tools in demolition process management?</td>
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<tr>
<td>4.1</td>
<td>General comments of the research work</td>
<td>Level of Agreement(%)</td>
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<tr>
<td>4.1</td>
<td>How useful is the research to the industry practice?</td>
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<tr>
<td>4.2</td>
<td>How adequate is the knowledge of the output?</td>
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<tr>
<td>4.3</td>
<td>How does the knowledge cover the general practical requirements?</td>
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<tr>
<td>4.4</td>
<td>How well improved is the demolition process management?</td>
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