SAFE, HEALTHY
and
SUSTAINABLE DEMOLITION

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ABSTRACT

The £198M demolition industry sector is part of the construction industry, worth approximately £2.2bn in the UK p.a albeit such a small fraction it is nevertheless the largest provider of secondary building products, handles 32 million tonnes (approximately) of waste each year and is principally responsible for clearing brownfield sites in readiness for new build.

Sustainable demolition activities are at the forefront of the UK Government and many NGO's policies on waste reduction, increased recycling and reclamation of waste building products at the end of life cycle. However, there are problems in developing more sustainable demolition processes based on historical methods of working, in particular, those involving manual handling activities. Whilst the UK construction industry boasts reduced accident and incident rates the demolition sectors rates are in the ascendency, rising by 43% overall from 1996 to 2009. That said, it would appear that those working within the sector are unaware of the rise in accidents which has steadily increased by 100% since 2000. Despite the demolition sector's increased use of mechanical applications for structural demolition, the prolonged and prolific method of stripping out buildings by hand remains a major risk and causal factor for injuries.

The results of this research have identified the causation of such an increase in accident occurrence and has offered an insight into how the reduction of accident and incident may be accomplished. This research is unique in that practising exponents of the demolition sector have participated in providing exclusive evidence of methodology, accident reporting and waste handling protocols that give clear indications of a gulf in current thinking by government, NGO's and the enforcing authorities.

The research has also identified failings in product and building design that create unsustainable conditions for safe, efficient and cost effective demolition, dismantling and handling of materials at end of life. This realisation also opens up the debate on the role of designers and their contribution to a safe and sustainable demolition process.

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LIST OF ABBREVIATIONS

ACOP	Approved Code of Practice
BERR	Department for Business Enterprise and Regulatory Reform
BMRA	British Metals Recycling Association
BRE	Building Research Establishment
BREEAM	Building Research Establishment Environmental Assessment Method
BS	British Standard
CCDO	Certificate of Competence for Demolition Operatives
C & D	Construction and Demolition (waste)
CD&E	Construction Demolition and Excavation (waste)
CDM	Construction Design and Management (regulations)
CDMC	Construction Design and Management Coordinator
CEC	Commission of the European Communities
CIC	Construction Industry Council
CIRIA	Construction Industry Research and Information Association
CPA	Construction Products Association
DEFRA	Department for Environment Food and Rural Affairs
DCLG	Department for Communities and Local Government
Dfd	Design for Deconstruction
DTI	Department for Trade and Industry
EEC	European Economic Community
EEF	Engineering Employers Federation
EMAS	Employment Medical Advisory Service
EPIC	Engineered Panels In Construction
EU	European Union
HEP	Human Error Probability
HGV	Heavy Goods Vehicle
HSC	Health and Safety Commission
HSE	Health and Safety Executive
HSG	Health and Safety Guidance
HSWA	Health and Safety at Work Act
ICE	Institution of Civil Engineers

IDE	Institute of Demolition Engineers
LFS	Labour Force Survey
LU	Loughborough University
MHSW	Management of Health and Safety at Work (regulations)
MIE	Materials Information Exchange
MRF	Materials Recycling Facility
MRW	Materials Recycling Week
NDTG	National Demolition Training Group
NFDC	National Federation of Demolition Contractors
NGO	Non Governmental Organisation
ONS	Office of National Statistics
PPE	Personal Protective Equipment
RIDDOR	Reporting of Injuries, Diseases and Dangerous Occurrences Regulations
RPE	Respiratory Protective Equipment
SD	Sustainable Development
SME	Small to Medium Enterprise
UK	United Kingdom
UMIST	University of Manchester Institute of Science and Technology
WRAP	Waste and Resource Action Programme
WTS	Waste Transfer Station

You've got to go out on a limb sometimes because that's where the fruit is.

Will Rogers

PREFACE

The Demolition Industry

The definition of “Demolition”, according to the ‘Oxford Dictionary’, is the act or process of demolishing or being demolished and the definition of “Demolish” is to pull or knock down (a building). Further descriptions in online dictionaries describe the meaning of “Demolish” as to tear down completely; wreck; level: to do away with completely; put an end to. This traditional interpretation by lexicographers may need to be amended in the near future, to recognise the value that demolition operations bring to sustainability and the potential for re-use of reclaimed materials.

Trying to map the beginnings of a demolition industry is no small undertaking when one may have to go back hundreds or even thousands of years to a time when building products gathered by earlier builders were subsequently recycled at a later date by others.

The UK demolition industry has historically been linked with the construction industry. Those wishing to gather information, regarding accident, incident or even manning levels within the demolition sector, may find it extremely difficult to separate out such statistics given that there is little or no such facility in place. With the exception of RIDDOR, Office of National Statistics (ONS) and the demolition industry trade body, the National Federation of Demolition Contractors (NFDC), there remains no other way to collate relevant information or figures matching performance levels within the demolition industry.

This situation is unfortunate given that there are around 1,164 demolition companies in the UK (ONS, 2008). Amongst the 158 NFDC members there is a ground swell of opinion that the demolition industry is large enough to stand apart from construction and that legislation and guidance aimed at controlling the activities of the construction industry does not adequately reflect the needs or operations undertaken within the sector. In relation to this statement the HSE discussion document of 2002, Revitalising Health & Safety in Construction, reported that Construction workers are six times more likely to be killed at work than other workers. Fatality figures reported to NFDC by its members via a mandatory annual return form, in 2003, show that the demolition sector recorded one fatality. The Office for NS reporting for HSE 2003/04 shows that 72 deaths were recorded for the whole of the construction industry in this time. Therefore, the demolition fatalities represented a mere 1.38% of the construction fatalities for that period. However, one cannot be complacent when three years later the demolition sector recorded three fatalities and an over three day injury rate of 581 per 100,000 workers which is 18% higher than the national average (HSE, 2008).

It could be argued that the public may view the operations of a demolition contractor as being slightly nefarious, somewhat dubious and a good deal dangerous. However, to challenge this view, the demolition industry has made major advances in technology, training and the reduction of accidents and incidents. In the absence of such an industry-wide reporting regime there is clearly a need to collate, update and review the activities of the demolition industry sector to better understand its problems and needs. With the advent of sustainability and the drive towards greater recycling, reclamation and reuse of the earth's natural resources, there is a huge onus on the demolition industry to show leadership. Despite the common perception that demolition contractors discard small amounts of materials preferring to sell as much as possible, the use of large hydraulic plant in preference to manual operations has resulted in fewer instances of wholesale reclamation. This situation is by no means accidental; there has been a concerted move over a period of years to substitute mechanical plant for manual labour with the express aim of preventing accidents and incidents arising from demolition activities.

In many demolition projects and, in particular domestic type buildings, traditional 'soft strip' activities (where timber and cladding materials are removed first) are followed by structures brought to the ground and mixed materials separated by machine for processing. This type of activity produces a large amount of waste which is considered to be a cost effective and safer option than the use of large numbers of manual labour. Although the sector is not as large as many others it has been growing exponentially year on year recording £301m of work carried out up to the third quarter of 2008 with a total employment of 13,600 persons; compare this with its outputs in 2000, when these figures were £89m and 6,200 respectively (ONS, 2008). This represented a 30% rise in work undertaken and a 119% increase in labour numbers.

As the demolition industry continues to grow it has to take account of the changing commercial and societal world as well as the environment, health, safety and moral issues. This study therefore, is designed to stimulate debate and to provide a strategy from which questions and answers may be formulated, discussed and derived. The future of our society may well depend on sustainability, but the future of the demolition industry as we know it, will hinge on achieving the desires of sustainability without compromising the advances, in health & safety and demolition methodology, already made.

Chapter One contains a general introduction to the research giving the rationale, key considerations and an explanation of the types of methodologies, plant and equipment in use. This chapter also sets out the objectives of the research and the research propositions.

Chapter Two concentrates on the literature review for the four key areas of the research which are ‘Sustainability’, Waste Management’, Accident Causation’ and ‘Legislation’.

Chapter Three introduces the research methodology, the reasons for choosing those methods, the respondents of the research and the types of data collection.

Chapter Four details the data collected and analyses the data within the research questionnaire, the interview process, the regional and national accident data and compares statistics from the construction, demolition and waste sectors.

Chapter Five discusses the accident and injury frequencies, types and causation and the influence of legislation, waste management and sustainable demolition. Included in this chapter is an evaluation of the attainment and influence of the research objectives and propositions.

Chapter Six brings together the conclusions and recommendations of the research to the demolition sector, designers, the health and safety executive and other influencing bodies.

1. CHAPTER ONE: GENERAL INTRODUCTION

The chapter discusses key trends and recent developments in the UK demolition industry, setting the scene for the research and informing the reader. It relates sustainability and environmental initiatives, changes in safety culture and equipment availability to the challenges of carrying out demolition processes. The chapter concludes by identifying four key research questions that will be examined through the thesis.

1.1. Rationale for the Research

Construction has been a natural and normal activity carried out for centuries all over the world. Demolition of buildings and infrastructure has followed behind, sometimes quite soon after, on other occasions many years after. Secondary use of those materials used in the first build may have, on a number of occasions, been utilised over and over again. This re-utilisation of the products of construction has evolved over the years following people's ability to recycle, reclaim and re-use materials by segregation and processing methods. The modern day term that embraces such activities is engendered within 'Sustainable Development'. This much used phrase is thought to have been born out of the emerging environmental movement of the 1950s and 1960s. Recognition for inventing the term itself has been variously attributed to Eva Balfour, founder of the Soil Association, the International Institute for Environment and Development, and Wes Jackson, the American geneticist and biodynamic farmer (SDC, 2009). Since those early days the environmental movement has become a huge business embracing many aspects of the built environment including socio-economic principles as well as physical shaping of material usage and design.

The international community first recognised the need for strategies for sustainable development at the Rio Earth Summit in 1992. At that Summit, Heads of Government from around the world adopted Agenda 21, a blueprint for action on sustainable development for the 21st century, which included a call on all countries to develop national sustainable development strategies (UNCED, 1992). In 1994, the UK became the first country to publish such a strategy: 'Sustainable Development, the UK Strategy' (UK Government, 1994). A revised strategy – A Better Quality of Life – was published in 1999 (UK Government, 1999) whilst a later strategy to appear was in March 2005, 'In parallel to One Future – Different Paths (UK Government and the Devolved Administrations, 2005). The United Nations in 2005 expanded on Agenda 21, which provided the basis for the Millennium Development Goal Indicators (MDGI's), which while far-sighted and brilliant in its scope and balance, the action agendas that emerged around Agenda 21 were much less concrete than the policy programmes and resources allocated to achieving the MDGs (Pinter et al, 2005). The MDG indicators serve a very clear policy purpose: to measure progress towards agreed upon and widely publicized time-bound targets as a vehicle needed to translate the grand vision into political will and action (Pinter et al, 2005). However, the many faces of sustainable development have, at their core, both a distinguishing monetary and physical outlook at the heart of all agreements and disagreements across the international community. A brief summary of which can be viewed as:

> *Economic sustainability refers to the established requisite for economic growth, capital maintenance, and extends the (produced) capital concept to include non-produced natural capital.*
>
> *Ecological sustainability considers material flows from the environment, through the economy and back to the environment (as waste) as pressures on the carrying capacities of natural systems, and aims to reduce this pressure to tolerable levels by de-materializing the economy* (Pinter et al, 2005).

The World Commission on Environment and Development, in a ground breaking report, produced a definition of SD which became commonplace.

> *'Development that meets the needs of the present without compromising the ability of future generations to meet their own needs'* (Brundtland, 1987)

This is a concept that is particularly pertinent for the construction industry, as it has always played a major role in producing the built environment that society has required and has played an important part in the development of the human race. The growing consensus being that appropriate corporate social responsibility strategies and actions are needed to ensure sustainable built environments and construction activity (Sexton et al, 2009). The degree of corporate responsibility does not however appear to extend to questioning whether applying all the principals of a sustainable existence may impact on advances brought about by workplace changes. Many of those changes have resulted in better working conditions and have, in some instances no doubt, contributed to a reduction in accidents and incidents. RIDDOR and the Labour Force Survey provide some evidence that all industries are experiencing a fall in fatal, major and over 3 day injuries. Conversely, accident and incident rates recorded by RIDDOR, for the construction industry, do not show a marked downturn in the number of accidents, particularly during the early 2000's, despite the plethora of safety information and changes to legislation designed to influence people's attitudes. If the propensity for an accident or incident on site has a direct or indirect correlation with sustainable development, there are good reasons for investigating what proclivity this could have on people's attitudes or actions to work activities and each other. As a result, it is arguably very important to understand the changes taking place and to what degree they have benefited or even disenfranchised individuals or organisations. The UK construction industry is a large employer and accounted for 9.1% of the UK Gross Domestic Product in 2007 (ONS, 2009). In 2008 the construction industry consisted of 202,407 firms, employing 1.26 million people and carrying out 26,891million pounds of work (Construction Statistics Annual, 2009).

Any effect on staffing levels or productivity on a social, economic or business front from any external influences such as sustainable development warrants attention. Integration of new ideas and concepts can have reverse outcomes to those originally intended and identification of such trends should be embraced by all stakeholders, equally, those with an anachronistic view should also be identified and discarded. David Runnalls, President and Chief Executive Officer of the International Institute of Sustainable Development, has his doubts as to whether the global community have made the right improvements, he argues:

> *So, we had everything in place to move forward with sustainable development…. yet, needless to say, we have been going backward, or perhaps more generously, sideways. Until the environment is truly integrated throughout all economic policy making, real change will be stunted*. (Runnalls, 2008, p.4).

This research examines the values and emphasis placed on meeting the aspirations of sustainability and sustainable development and what impact, if any, there is on the demolition sector in applying those principles and methodology.

1.2. The Demolition Sector – Key Considerations

1.2.1. Demolition Methodology

Demolition methodology may in the past have appeared to represent more of an 'art' form as opposed to a science. The theory behind this thinking would not necessarily have been difficult to understand with the realisation that there are no text books, technical journals, manuals, detailed drawings, sketches or papers on how to demolish buildings or structures etc. The only publication available for general release in the UK that deals specifically with the UK demolition industry and its practices is BS6187:2000, the 'Code of Practice for Demolition' (BSI, 2000). This revealing document is only the third edition, which was published in September 2000 and is due to be updated in 2011. BS6187 is an informative read which attempts to provide guidance as well as indicating recommendations for demolition activities. However, it is constrained in its ability to specify exact processes and procedures regarding individual demolition methods. Nowhere is this better highlighted than in its introduction, which states: '*This code has been written on the understanding that the execution of its provisions is entrusted to appropriately qualified and competent people'* (BS6187, 2000). Whilst one could not argue with the wisdom of this statement one must also be aware that there is no academic route to qualification as there is with building and construction. Similarly, the word 'competent' is usually associated with a person having achieved the following three qualities; training, experience and knowledge. Therefore, the code of practice has to be a document that can be understood by all persons regardless of their educational acumen. In general, that means that it can only give a broad perspective on matters and in terms of scientific content it is largely unsuccessful.

One is therefore compelled to ask where the author of a demolition method statement will get the requisite information to enable them to complete the process? If not from technical journals, manuals or papers it has to come from previous knowledge and experience, either on a personal basis or from a corporate view point. Whether it is one person acting alone or there is a collective input the formulation of the methodology will be derived solely from a similar previous project or one that broadly mirrors such. The review of related literature indicates the absence of any knowledge bank that a contractor can tap into other than that which their peers have acquired through practical experience. It seems that the sharing of demolition methodology between different contractors is uncommon and that many projects which have similar structures may be demolished in a variety of ways. All of this points to a duplication of mistakes rather than learning from one mistake and passing on the knowledge for the benefit of others.

There are a number of limited routes in which knowledge can be shared, at individual and corporate level. On an individual level, the Institute of Demolition Engineers (IDE) provides a forum for members to meet and share experience via seminars and regional meetings. On a corporate level, the National Federation of Demolition Contractors (NFDC) provides an opportunity through similar events, although there is no documented evidence to prove that any formal or informal exchange of knowledge exists. However, the attendees at events of this nature tend to be the heads and senior managers of companies and not the site operatives who it can be proved account for those most at risk of injury. One further route, which can be attributed to the itinerant habits of individuals, is the movement from one contractor's employ to the next, in which they take with them the knowledge gained at each place of work. This last point is probably a much underestimated and important process in the sharing of knowledge and in particular demolition methodology, as it removes any reluctance to pass on information that may at one time have been classed as sensitive to any particular contract.

The importance of method statements as a safety tool is unquestioned. They are also legal documents that may be used as evidence in a court of law and therefore must be formulated by a competent practitioner with an eye for accuracy and best practice in mind. If the demolition sector is to consistently perpetuate the reduction of accidents and incidents the method statements must reflect all conditions, principles and processes for each and every project or task.

It is also important to reflect that all methods formulated for the successful outcome of a demolition project have to meet a strict set of criteria, whether there is a case for its scientific value or its art form. They must be able to demonstrate that the work can be carried out in a safe, efficient and cost effective manner. Efficiency and cost effectiveness run hand in hand as one without the other would tend to have a cancelling effect. Safety is capable of having a negative or positive effect on both. The negative effects of a poorly planned method may end in punitive measures taken by the client or the enforcing authorities against the company or individuals or it could result in serious injury or even fatality. Unfortunately, there does not appear to be available any records on how many accidents and incidents are derived from a poorly thought out and executed methodology.

The author's own experience indicates that, in most cases, demolition methodology is plagiaristic and that only the details of the site and players involved will be changed. In general, the person completing the document must have the ability to identify the key issues and the control measures necessary to ensure the safety of all and the successful outcome of the task. Whilst there is no standard format as to the contents of a method statement it is generally accepted that such an instrument should, as a minimum, detail how a task will be carried out. In theory, it would be possible for such information to be written on one side of A4 paper, if the task were simple enough, whilst a more complicated task may necessitate 20 pages or more. Often the quality and at times the quantity of information contained within the method statement may be questioned by the recipient who should be the end user. Where the demolition contractor is the principal contractor this is generally the case. However, there are many occasions when the demolition contractor is in the employ of a client contractor whose site team or representative is the main recipient of that methodology and will deliberate as to its suitability despite the fact that such persons may be unqualified to comment. This situation is unfortunate given that the main purpose of a method statement is to empower the end user and inform on best practice.

Regardless of who should acknowledge the suitability of the demolition method, it still falls to the company to produce a document that is accurate and specific to a given task with all hazards having been identified and engineered out. In terms of content for a demolition task, the author of a method statement need only supply information that is relevant and vital to ensure safe working. He or she must also identify the significant hazards and allocate a risk rating to those hazards. Control measures must then be formulated to reduce or eliminate the risk of harm and the monitoring and review regime that will be in place to ensure that those control measures are effective. This simple approach is, or should, be universal to all demolition projects and tasks irrespective of the type or application.

In this respect, above all others, BS6187:2000 can provide key points to be considered by the author of the document. How often the code of practice is used in this manner is unknown, but it may be very infrequent. Evidence of this statement was found during a demolition supervisor course in March 2007. Twelve weeks into the course, delegates were asked to bring along a copy of BS6187:2000, as this document would form the basis for that training session. Of the 13 supervisors who attended that session, only one had heard of the document and none had ever seen or read it (Quarmby, 2007). Whilst it may not necessarily be the remit of a site supervisor to write the original methodology, they are expected to acknowledge its content and approve the method of work, as they may be responsible for its execution. It may be questionable as to the level of understanding that a demolition supervisor may attain from reading the code of practice. Conversely, it may be argued that having read the code of practice it may stimulate the mind to pick up on previously unknown facts. The code of practice is a guidance document for best practice and is the only UK written word that exponents of the demolition industry can obtain. As such it should arguably appear in all offices and sites of UK demolition contractors.

Over a period of years, demolition methodology has changed in line with technological advances to plant and equipment. The authors of the demolition method will obviously take advantage of any new technology to enhance, speed up and improve the demolition process. Whilst this evolution is understandable it should also be accompanied by skills training for those needed to administer the new technology. Training requirements for the UK demolition industry are represented by the National Demolition Training Group (NDTG) which is administered by NFDC. Demolition operatives are required to be assessed for their competency under the Certificate of Competency for Demolition Operatives Scheme (CCDO) which has competency levels ranging from new entrant through to supervisor. However, skills training or competency assessment for administration staff and senior managers to apply or promote evidence of learning in the workplace is not readily available. This anomaly is worrying because the exchange of information between site and office is a two way process where understanding of a situation or problem has an equal importance to providing paper based systems for evidence of compliance or competency. When set against the probability that many demolition companies employ administration staff or safety officers to produce method statements the accuracy of the finished article or the process in place for its monitoring and review could readily be called into question (Quarmby, 2010).

1.2.2. Demolition Plant

Demolition methodology, despite the changing work environment, is generally designed to take a predominantly simple approach. With the introduction of heavy construction plant into the process, manual handling, for reduction of the structural shell, has been dramatically reduced and this has helped to reduce personal accidents. With the advent of sustainability (and calls for greater recovery and recycling), the usage of heavy construction plant continues but pre-weakening and strip out by hand may need to be increased, which could have a negative effect on accident and incident rates. That said, the use of mechanical aids in demolition operations is the desired option where the type of structures being demolished are predominantly steel and or concrete framed.

The demolition industry of the 1960's and 1970's was heavily reliant on manual operations assisted by crawler crane and ball and tracked loading shovel for pushing over walls and loading materials. Many of the buildings being demolished around this period were brick built structures constructed in the Victorian, Georgian and Edwardian eras. Bricks, whether handmade or mass produced, were generally laid in soft (lime-based) mortar and this facilitated reclamation for resale and re-use. It was not uncommon for whole houses to be taken down, brick by brick, with men working off the floors of the buildings. Textile mills, in this same period, were also being demolished in their hundreds and although heavy machinery in the form of crane and traxcavator were used, hand demolition played a large part in the process, particularly for strip out to reclaim materials such as timber and roofing slates etc., as illustrated in Figures 1.1 – 1.4.

Figure 1.1: Typical 1970's House Demolition Behind Southy Street, Workington. (www.users.globalnet.co.uk)

Figure 1.2: Typical 1970's House Demolition. Durham City, Silver Street demolition. (www.durham.gov.uk)

Figure 1.3: Hanbury Street, Enfield, London 1970. (Google image 1960's demolition)

Figure 1.4: George Square, Edinburgh 1960's demolition by hand. (www.flickr.com)

House demolition, in particular, was largely unregulated and considerations for health and safety generally were of low priority in preference to the production of resalable materials. Figure 1.4 highlights a typical mode of operation at that time utilising hand demolition and pushing over the walls onto a pile of hardcore. All three workers on the second floor are operating without any form of personal protective equipment, scaffolding or fall arrest.

In 1970 the UK Government commissioned the Robens Report which set out with the intention of determining failures and inadequacies in the legislation and regulation at that time. This led to the Health & Safety at Work etc Act 1974 and a new factory inspectorate in the guise of the Health & Safety Executive (HSE). The Act combined with the new powers given to the inspectorate was a major influence on how employers should address the issues of health, safety and welfare at work. This new Act replaced many of the unworkable and unregulated acts and regulations made beforehand and identified specific duties to both employer and employee in a strictly prescriptive manner leaving little scope to chance or ambiguity. The Act is a model example of simplicity and complexity working in tandem to create an all defining document that has stood the test of time and scrutiny under the UK's judicial system. For the enforcing authorities it has been a significant success and is still without precedent when prosecution of health & safety offences is required.

However, although the Act, and regulations that have cascaded down from it, spell out the duties to employer and employee, they stop short of identifying the duties and responsibilities placed on individuals within an organisation's chain of management. This is a situation that has largely been addressed by the introduction of the UK's Corporate Manslaughter and Corporate Homicide Act 2007 (National Archives, 2007). The intention of this new Act is to focus the health, safety and welfare responsibilities that a manager is tasked with and how he/she ensures that they manage that process and execute their duties in line with the statutory regulations and their company's policies. For managers engaged in the demolition process, the emergence of this Act is unlikely to trigger a change in policy. However, it could have an influence on methodology which may dictate the manner in which salvage and reclamation is carried out as this type of operation largely calls for a manual handling approach. Managers may now be inclined to take the view that overexposure to tasks of a manual handling kind are to be limited to reduce the risk rating whilst not addressing the actual or perceived hazard.

Whilst it could be argued that the Robens report of the early 1970's was the trigger for change in health and safety legislation, it has been only one of a series of similar reports to have followed. Combined with safety led initiatives the UK has endeavoured to update and modify workplace regulations to reflect the changes in working principles and new technology. In addition, European Directives (such as the Waste Framework Directive) have played a major part in influencing the route that legislators have taken, none more so than where issues regarding sustainability are concerned. However, in a dash to promote environmental initiatives and policy the basic needs of individuals to be properly and effectively protected in the workplace may have been overlooked.

A large part of the UK's workplace regulations rely heavily on the assessment of risk to determine best practice. This process of risk assessment can be transferred to all areas of workplace operations from the boardroom down to the site. Whatever the risk there has to be workable control measures that will enable that risk to be reduced or eliminated. In the case of personal harm the control measure will nearly always involve either the cessation of a particular operation or the changing of methodology to mitigate that risk. With more sustainability initiatives such as materials reclamation, it is becoming increasingly harder to accept that changes in demolition methodology, developed over a lengthy period of time to reduce manual handling, may have to be readjusted to meet public expectations. Such changes may sit uncomfortably with many demolition contractors where the trend has been to increase machine demolition. However, despite the desire to cut manual handling there are limitations to what can be achieved through a wholly machine-based approach. Even with the technological advances that have been made in engineering to bring a wide and diverse range of equipment into use, dexterity and finger tip control will surely elude the industry for some time to come, unless designers of personal protective equipment can innovate and make the necessary leap forward.

The advancement of technology in engineering has brought many benefits to the demolition industry and this is most apparent when one considers the array of operated plant and attachments specifically manufactured for use in demolition. This position is relatively new in that plant manufacturers have been slow to develop bespoke equipment for the demolition industry, although that situation has radically changed in recent years with the realisation that the market is vibrant and growing. One such plant manufacturer is David Kokurek of Ipswich who in 1992 produced his first demolition machine and has, arguably, gone on to become the leading front end producer of demolition equipment in Europe. Kokurek's approach to the development of bespoke equipment has always been to engage with his clients and take note of operational feedback to his equipment in the drive to produce better functionality. In 1997 Kokurek delivered the UK's first super high reach demolition machine for DSM Demolition Limited of Birmingham. The machine, a Leibherr 984 standard excavator was sourced by DSM from the gold fields of Australia and shipped back to the UK. With a base weight of around 85 tonnes, Kokurek adapted the machine to take a 41 metre reach, three-piece arm, capable of carrying and operating a 2 tonne shear at full height. With a modular joint at the base of the arm and hydraulically operated boom pins, it was also possible to change from super high reach to a standard arm in less than 1 hour. This radical and innovative achievement has had a major influence on demolition methodology particularly in association with the reduction of high buildings and structures that may previously only have been possible with a crawler crane and ball or alternatively by hand.

However, unlike the crawler crane and ball, demolition by super high reach machine can be said to be a more controlled process, in that selectivity of sections or even individual elements of a structure are possible. Those contractors who favour the crane and ball, and there are no doubt a number that remain, may not entirely agree. However, the greatest disadvantage to balling down a structure is that the impetus of the ball is difficult to control and where a part of a building has been weakened failure of adjacent sections to that being demolished is always a probability. Where there is a sufficient area around the structure to create a safe exclusion zone this is not insurmountable, but where operational space is constrained by live or occupied areas close by, it limits the use of this type of demolition process. Therefore prior to the introduction of high reach machines, high rise structures had to be manually reduced, floor by floor, with the assistance of mini demolition rigs where practical and possible. That same process is still very much in existence for very tall structures and those set within busy town or city centres, but with the passing of time the super high reach machine exceeds 60 metres bringing many more buildings within range.

Having identified that not all structures can be reduced by remote mechanical means, there is still the need for top down demolition requiring a degree of manual labour assisted by mechanical plant. Technology has provided solutions in the form of mini demolition rigs and none can be better highlighted than the Swedish-made Brokk demolition machine (Figure 1.5). This highly innovative and robust design is available in models ranging from 500kg to 5,000kg. They are electrically operated which makes it extremely desirable for use in confined spaces and have a break out force several times greater than a standard mini demolition machine of comparable size. The Brokk's greatest asset is that it is controlled from a joy-stick enabling the operator to stand well away from the immediate demolition area. Although this type of operation is possible with standard sit on machines, it is costly in terms of time taken to undertake the work and does not have the flexibility afforded to the Brokk. The founders of the machine produced their first model in 1976, but it is only from the mid-1990's that the true value of this type of tool has been exploited. Like all new technologies there is usually a period of adjustment by end users in which an evaluation will be made as to effectiveness and efficiency set against cost. Machines such as the Brokk are much more expensive (approximately 10 times) than standard mini demolition rigs and it is factors such as this that surely influence greater usage, which is unfortunate given that safety features, flexibility of operation, high productivity and ease of transportation make this type of tool an ideal partner for the reduction of accidents and incidents on site.

Figure 1.5: Brokk 330d Model – Remote controlled. (www.brokk.com)

1.2.3. Demolition Equipment

The demolition industry uses a wide variety of tools and equipment. The use of small tools for hand working can be dated back many years and although it is difficult to associate any one particular hand tool as being bespoke for demolition purposes, it is nevertheless apparent that some tools are used regularly and to good effect, i.e. crow bars, sledge hammers and two bladed mattocks. These kind of tools do of course have limitations of use and may be associated with such activities as soft strip and non load bearing partition/wall removal etc. ('Soft Strip' is the common name used by the demolition sector to strip out the interior of a building, usually back to the frame or shell).

Accident frequency levels caused by hand tools cannot be assessed readily or accurately, although a study undertaken by Loughborough & Manchester Universities for HSE in 2003 pointed to several factors in accident causation (Haslem et al, 2003). The study indicated that the worker or work team were the contributing cause for nearly two thirds of the accidents; more than a quarter were due to materials and more than half implicated that the equipment was at fault (Haslam et al, 2003).

Power tools such as pneumatic hammers, rotary percussion drills, chain saws and abrasive wheel cutters are all commonly used within the industry although chain saws are becoming much more difficult to hire because of insurance complications arising from work and leisure accidents. Power tools can cause significant ill health from prolonged use, ie HAVS, vibration white finger and carpal tunnel syndrome. Use of these tools must follow a risk based approach and although there appears to be a wider understanding of the risks from use of such equipment, there appears to be a low level of knowledge of the recommended action levels and trigger time constraints.

Haslam et al (2003) analysed equipment under three headings:

1. Suitability of equipment
2. Usability of equipment
3. Condition of equipment

Their report explains that all three must be considered to have a major influence on what type of tool is used and for what purpose. The demolition industry has been extremely innovative in the past when applying different tools to carry out individual tasks.

The author recalls an occasion many years ago when faced with taking out a large number of doors, for reclamation, from within a row of houses due for demolition. The shaft of the mattock had broken and there were no spare crow bars for use. The foreman picked up a telephone directory, jammed it between the door and the door frame, and slammed the door shut. The hinges pulled clean from the frame and the door was freed. A most unusual tool, but extremely effective.

There is of course a genuine, observed tendency to make do, adapt or rearrange the properties of a tool to fit the given purpose, but this should be avoided because a significant hazard may arise from doing so. Examples of this include removing the guard from an abrasive wheel cutter to fit a bigger wheel or wrapping adhesive tape around a normal screwdriver to try to insulate the handle. The human trait for innovation will always be central to finding solutions to otherwise intractable problems. Innovation in construction tools and equipment is a multi million pound business and interest in demolition activities is clearly reflected in the manner of tools available. One particular driver is the fact that employers need to ensure that they provide a safe place of work and safe equipment to meet some of the requirements of the Health & Safety at Work etc Act 1974. So, reducing noise, vibration and dust during demolition activities is a major undertaking calling for specialist equipment and best practicable environmental solutions and one of the latest innovative tools to reach the demolition sector, that can fulfil many of these aims, is the hand held demolition shear, as shown in Figure 1.6.

Figure 1.6: Hand held shear. (DEHACO B.V.)

The aluminium based shears come in a variety of sizes with interchangeable cutting jaws to enable concrete cutting and steel cutting applications. Power is supplied through petrol or electrically driven packs to create hydraulic pressure at 700 bar and can achieve breakout forces, at the head, of between 4 and 14 tonnes. Similar tools are available for pulverising and cracking concrete, all designed to be lightweight, robust, mobile, of low vibration and quiet in operation.

Manufacturers of hand held power tools are ideally placed to take advantage of the increasing desire by legislators and regulators to minimise the growing instances of ill health, accidents and incidents. Recommendations given by Bomel Limited, to HSE, in their Research Report 232 (Bomel, 2004) highlighted several key points: that equipment manufactures should be targeted to obtain reduction in the levels of vibration transmitted by their equipment, as well as increasing the efficiency, which would mean a reduction of time exposed. In addition, Bomel are keen for the HSE, manufacturers and contractors to develop and improve the availability of information and advice for such as risk control, inspection and maintenance regimes as well as what suppliers need to expect from equipment manufactures. In 2008/9 an estimated 3.04 million days, in all sectors, were lost to occupational ill health and injury at a cost to employers of between £100m and £180m for ill health and £140m for injuries (HSE, 2009). When it comes to dealing with health problems it seems the industry is less effective than when dealing with safety.

Pushing for and achieving reductions in noise, vibration, dust and manual handling could dramatically reduce the number of lost time days to all industries and in particular the construction industry. These notions are fundamental principles that should be addressed by all contractors who wish to remain compliant and promote best practice. For many demolition contractors these are pressures that are applied on a daily basis and are especially true when structures are adjacent to or connected to others that are to be retained. There is the requirement to ensure that the structural integrity of the adjoining building is measured, as well as risk assessment and the added onus on environmental aspects and impacts to be considered.

Separation from adjoining structures, using manual labour and hand held tools and equipment is a standard operating procedure. However, moving towards a mechanical solution for the greater part of the demolition process appears to be the desired route. In the 1960's, the demolition contractor's first choice to take down a building would possibly have been the ball and crane. In the hands of an experienced operator this mode of operation offered a precise and selective reduction of a structure, using the ball to impact and break individual elements as well as whole elevations. Many demolition contractors reportedly mourn the demise of this mode of operation as it is no longer looked upon as desirable by crane manufacturers, HSE and local authorities. The arguments against the use of the demolition ball centre around the high torsional and side loads imposed on the lattice jib, particularly when balling side on to the building or structure. Some within the industry may point towards many years of accident and incident free use. However, as with all work related activities there are the inevitably some recorded instances of damage and injury.

A large demolition company working at Bath Gasworks in 1978 was engaged in taking down two gas holders and the retort house. Having removed the dragline, the crane operator swung the ball into the side elevation of the brick retort house. The ball's impetus was so great that it passed through the brickwork and swung in a wide arc to land on top of the jib causing major damage to the jib section.

Machine-mounted equipment for use in demolition applications has greatly improved over the last decade. Equipment manufacturers have responded to the challenges the contractors face and have produced an array of attachments that are capable of performing multiple functions on the demolition site. These attachments have made the process seem effortless and have improved efficiency with their versatility. With such a diverse range for the contractor to choose from methodology can be designed around the tools available. It is also worth noting that with such a range of bespoke attachments readily available they are now being used by other industries such as the waste sector, mines and quarries, agriculture, construction and the scrap metals sector etc.

1.2.4. Hydraulic Attachments

a) Machine Mounted Shears

Contractors can now choose from four categories of hydraulic demolition attachments — shears, pulverisers, universal processors and grabs — to meet the requirements of a demolition job. These are described in turn below.

Steel cutting shears (Figure 1.7) are primarily used for cutting, sizing and removing steel frame structures and supports associated with the skeleton of a building. Shears are an appropriate choice when a contractor takes advantage of material recycling opportunities by readying the steel removed from a structure for a scrap yard or mill.

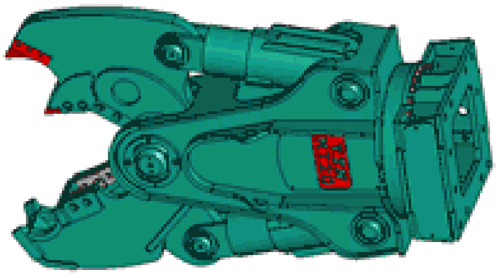

Figure 1.7: Steel Shear. (www.inmalo.co.uk)

A contractor can use shears to cut the steel into oversize lengths, typically about 6 metres; the lengths can then be easily loaded onto a truck or rail car for delivery to a scrap yard for further processing. Contractors can also use shears to complete "final processing" directly on the job site. This involves cutting the steel into a length specified by the scrap processor, thereby increasing the monetary value of the material.

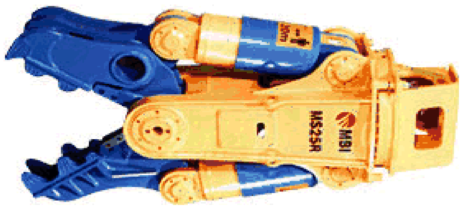

Figure 1.8: Concrete Shears. (www.inmalo.co.uk)

In addition to steel cutting shears, shears are also designed to cut through concrete structures that may include flat slab, reinforced beams and columns and pre-stressed structural elements. This application is highly effective and efficient, particularly for high and or awkward shaped structures. Concrete structures are notoriously unstable when weakened, particularly close to 'node' points or when bracing etc has been removed. With the use of shears to apply remote demolition methods, the felling of concrete frame buildings is safer and quicker, although processing of the felled materials has some limitations, mainly due to the width of the cutting jaws and their configuration, i.e. in line with the carrying arm, therefore restricting 'elbow' bend type movement.

b) Machine Mounted Pulverisers

Like shears, pulverisers can be used for both demolition and recycling applications that involve crushing concrete and separating out rebar, mesh or cable. The tool shown in Figure 1.9 is capable of reducing large pieces of concrete to smaller more manageable pieces to aid loading from the site or the supply of materials to an onsite crushing unit. The equipment can also be used to break up hardcore and concrete arisings to be used as fill material where foundations have been removed or voids have been uncovered etc. To aid separation for recycling, most pulverisers are fitted with cutting blades for rebar and smaller steel sections.

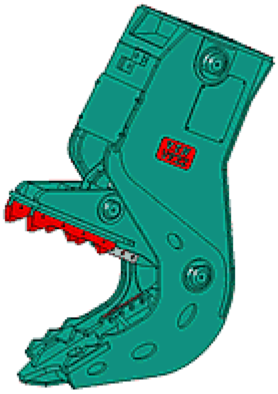

Figure 1.9: Concrete Pulveriser. (www.inmalo.co.uk)

Pulverisers can be operated fully by hydraulic pressure to open and close the jaws as well as enabling 360º rotation in both directions. They can also be used to function mechanically (as shown in Figure 1.10) where the only moving part is the front jaw which is connected to the 'bucket' ram. The rear or right hand jaw is connected via the bar to the underside of the arm, which is commonly referred to as the dipper arm. Although this type of pulveriser is less versatile in its movements it is popular with smaller contractors, as it is less costly, has fewer moving parts and requires less hydraulic circuitry.

Figure 1.10: Mechanical Pulveriser. (www.inmalo.co.uk)

c) Machine Mounted Universal Processors

Universal processors offer the combined functionality of both shears and pulverisers. Interchangeable jaws can both cut steel and crush concrete, which effectively speeds up the process of demolishing concrete structures or steel encased concrete structures. There is a wide variety of design regarding universal shears, such as that shown in Figure 1.11. Each attachment manufacturer may cater for all carrying arm capabilities or specialise in a particular machine gross weight category. A good example of this is the 'mini demolition machine' market, from one tonne up to a seven tonne gross weight machine, where universal shears are very popular for use in confined work spaces.

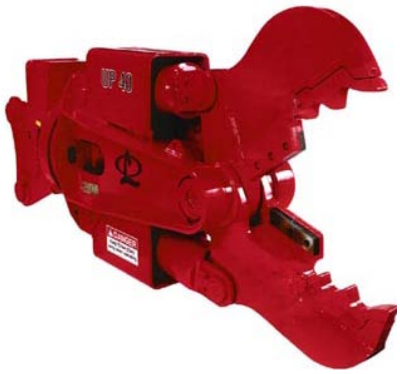

Figure 1.11: Universal Shear. (www.inmalo.co.uk)

d) Machine Mounted Selector Grab

As versatile and efficient that shears and pulverisers undoubtedly are, there is little doubt that with the advent of the selector grab (Figure 1.12), building reduction techniques and the processing of materials was greatly enhanced. Fitted directly onto the 'dipper' arm the jaws work simultaneously off a separate hydraulic circuit operated by switch or foot pedal in the cab. The grab has a 360º rotation capability and the whole attachment can be bent upwards or downwards by virtue of the connection to the bucket ram via a universal jointed frame. These attachments are available from many of the major plant and equipment manufacturers for most types and sizes of demolition rig. Experience has shown that an operator can be very precise in the removal of individual elements from a building or structure. This improves the capability for recycling and reclamation and reduces the need for manual handling. Loading of scrap or waste products is quick and safe due to the flexibility and strength of the jaws.

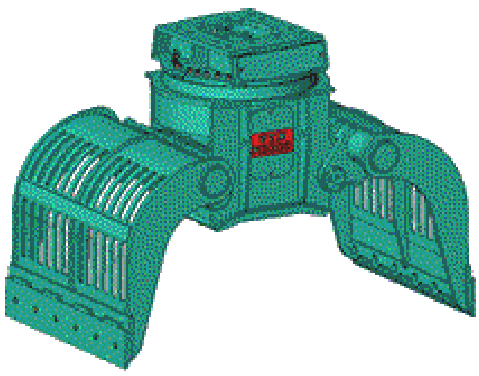

Figure 1.12: Selector Grab. (www.inmalo.co.uk)

e) Machine Mounted Grapple

The forerunner to the selector grab was the hugely successful grapple. Grapples in their original form (as illustrated in Figure 1.13) were mechanically operated but are now available fully hydraulically operated. This attachment is widely favoured by demolition contractors because of its robustness and versatility in undertaking the full range of demolition activities on all types and weights of machine. One of the first grapples closely associated with today's use was developed by Roy E La Bounty's in 1974 for mounting on a 360º excavator base (US Patent, 1974). Although his design was constructed over forty years ago it still mirrors attachments in general use today.

Figure 1.13: Mechanical Grapple. (www.tramacus.com)

The plethora of work implements has without doubt had a major effect on demolition related activities. Attachments have helped to reduce the number of manual handling operations, building reduction times, processing, separating and loading of materials and, perhaps most importantly, it has taken manual labour out of the equation for the majority of building reduction processes.

1.2.5. The future of attachment use

Attachment use is popular and seems likely to persist, at least for the foreseeable future, and whether that equipment is simple in design or complex its usefulness to the demolition contractor is unquestionable, up to a certain point. However, technology and innovation will continue to improve on present day achievements and one may conclude that there is still a way to go for attachment manufacturers to perfect and innovate towards ensuring that their equipment ticks all the relevant boxes. Sustainability promotes greater recycling, reclamation and re-use. This for the greater part requires a high degree of manual operations and those operations will have an element of risk attached. Therefore finding a middle road that addresses both issues is the desired route. However, the reliance on hand operations, particularly for most structural reduction methods, would appear to be carried out by use of mechanical plant.

Recycling aspirations have also improved as have handling and loading capabilities. It is interesting to note that of the 79% of respondents to a research questionnaire (described in more detail later in Chapter 4.1.1) who were employing attachments as well as hand working to soft strip, 60% did not think that attachment use inhibited salvage operations. This last point is particularly important as experience would suggest that hard edged removal of building components may cause undue damage to elements marked for reuse and resale. If contractors are satisfied that the minimum of damage may be realised through attachment use in removing components then the opportunity to maximise profit is greater, whilst maximising machine use and reducing manual labour operations.

1.2.6 Summary

This section of chapter one has reviewed the demolition sectors use of a wide variety of tools and equipment and how these are interacted with hand working. The following section details the research objectives and propositions.

1.3. RESEARCH QUESTIONS, PROPOSITIONS AND OBJECTIVES

1.3.1. Introduction

This section of the chapter explains the rationale behind the research questions, the emergence of the propositions and the specific objectives that are sought from the use of questioning using a quantitative and qualitative approach to data collection.

1.3.2. Research Using Questions

The main aim of using questions in research is to test out the hypothesis or more generally, the assumption or probability of the theory on which the research is based (Fellows and Liu, 2003). An initial set of pilot questions were aimed at middle to senior managers working within the demolition sector and in particular those employed directly by demolition companies, with the purpose of gauging the recipients views on recycling, sustainability and accident reporting. The responses from this review provided an insight into the development of further strategies for data collection (see Chapter 3.2 for details). The questions, posed (during the interview stage) for examining the effect that four key influences of sustainability, waste management, accident causation and legislation have on activities within the demolition sector were derived, mainly, from the literature review (see Sections 2.2 to 2.5) and a theory of the causality of increasing accident rates within this sector.

1.3.3. Propositions

In attempting to understand the relationship between the four key influences of sustainability, waste management, accident causation and legislation it is important to collect data from sources of information close to the subject matter. Because little is written or recorded, in the way of statistical data, by the demolition sector, those sources of information are invariably the practicing and individual exponents of the trade. As discussed within the methodology of the research in Chapter 3.2, the key informants were selected from two membership organisations, the Institute of Demolition Engineers and the National Federation of Demolition Contractors. The literature review identified areas for exploration and the pilot questionnaire answers provided the author with a number of assumptions that required testing. Most importantly, the impact that a dependent variable (effect) has on an independent variable (cause) is the basis for a robust research design (Bryman and Cramer, 2005). Therefore in addition to questioning one must also test the hypothesis at a higher level. This process has been initiated by use of propositions that are to be examined and discussed within Chapter 5, Discussion. The propositions, of which there are 18, were derived from the questions and the literature discussions (please refer to Appendix A).

1.3.4. Aim and Objectives of the Research

The aim of this research is to examine the values and emphasis placed on meeting the aspirations of sustainability and sustainable development and what impact, if any, there is on the demolition sector in applying the principles of sustainability within the format of the sectors current working methodology.

The importance of seeking the views of others cannot be marginalised and the answers to the research questions along with the propositions were aimed at understanding the contextual issues associated with work in construction, but more importantly the association with demolition activities. The specific Objectives of the research therefore were:

1. To evaluate the importance that both design and designers have on the ability to provide a safer working environment to reduce significant hazards and therefore risk, which in turn may influence human characteristics or traits.
2. To examine the interactivity between sustainable demolition activities and the propensity for an increase in accidents or incidents.
3. To question the need for small or radical changes in UK safety regulations and workplace policy in order to simplify and make relevant the demands for work in a demolition environment.
4. To identify efficient or effective ways in handling and disposing of secondary materials or products liberated from the demolition process with a specific emphasis on the reduction of accidents or incidents.

Table 1.1: Research Objectives linked to the 4 Key Influences

FOUR KEY INFLUENCES				
OBJECTIVES	**Sustainability**	**Waste Management**	**Accident Causation**	**Legislation**
1.To evaluate the importance that both design and designers have on the ability to provide a safer working environment to reduce significant hazards and therefore risk, which in turn may influence human characteristics or traits	✓	✓	✓	✓
2.To examine the interactivity between sustainable demolition activities and the propensity for an increase in accidents or incidents	✓		✓	
3.To question the need for small or radical changes in UK safety regulations and workplace policy in order to simplify and make relevant the demands for work in a demolition environment	✓			✓
4.To identify efficient or effective ways in handling and disposing of secondary materials or products liberated from the demolition process with a specific emphasis on the reduction of accidents or incidents		✓	✓	

1.4. Chapter Summary

This Chapter has found that the demolition industry has changed some of its methods of operation to accommodate and take advantage of the changes in technology, types of plant and equipment and the structures that need dismantling. However, not all changes can be said to have addressed all the needs of the sector in terms of a reduction in manual handling operations and accidents occurring. The sector has been proactive in recognising training needs, but is constrained by a deficiency in academic or scientific expertise for senior managers and personnel. Add to that the apparent reluctance to share information on safe demolition methodology, which obstructs channels of communication, one can begin to see how changes in common practice could be slow to adapt to government or non government organisations (NGO) initiatives and in some instances to plant and equipment innovation.

Whilst it is agreed that a great deal of change has been made to methods of taking down the structural frame of a building, the process of soft strip has varied little over a long period of time. Equally, how the sector handles and disposes of the arisings it creates may have critical implications for demolition methodology and the reduction of risk. Therefore, it is imperative that we try to understand the reasons behind this mindset and because there is a lack of literature on any demolition related process and procedure, objectives have been set to find those answers and to explore the propositions that exist.

Having clarified the current trends and problems in the UK demolition industry, the following chapter presents a review of literature pertaining to sustainability, waste management, accident causation and legislation.

2. CHAPTER TWO: SUSTAINABILITY, WASTE MANAGEMENT, ACCIDENT CAUSATION AND LEGISLATION

2.1. INTRODUCTION

A detailed explanation of the subject matter relating to occupational and socio-economic activities within the demolition sector, in particular, and in the broader construction and waste industries is of paramount importance for this research. This chapter, therefore, reviews the literature on sustainability, waste management, accident causation and legislation pertaining to the activities of the construction, waste and demolition industry sectors. These diverse industry sectors may appear, on the surface, to be unconnected and autonomous, but can be shown to be linked particularly through the four sub-headings used in this literature review.

Health and safety actions, decision making and risk management are the domain of individuals as well as corporations. This chapter elaborates on these topics as well as identifying key areas of influence for the subject matter in the three industry sectors, in particular. Whilst there are undoubtedly many well documented explanations, taking for example, accident causation, pan-industry influences do not appear to have been sufficiently considered. The construction industry is one of the UK's largest employers, but also records the greatest number of workplace fatalities (HSE, 2010) and is a major driver in delivering sustainable products and the built environment (Jones and Clements-Croome, 2004). However, it is also reliant on other industry sectors to function efficiently, effectively and safely. Timely and correct decision making within the framework of a structured risk management process is key to ensuring that profitability and therefore longevity in business continues to ensure a robust safety culture where accident and incident is reduced to the lowest levels. Adding in the requirements of meeting sustainability targets set by Government as well as industry and the complications and legislative constraints associated with waste, these issues have combined to create a complex debate.

The chapter concludes by drawing inference on the possible influences brought about changes in product and building design, changes in legislation and the propensity for risk taking.

2.2. SUSTAINABLE DEMOLITION

2.2.1. Introduction

The issues surrounding sustainable development are wide-ranging. They also cover every industry sector regardless of whether they are constructors, manufacturers, wholesalers, retailers or service-led providers. These issues affect the way in which Government, Non Governmental Organisations (NGO's) and industry make decisions for socio-economic, fiscal and productivity growth reasons. This section therefore reviews the literature on two areas within sustainability that are of specific relevance and importance to this research. First, to look closely at one particular issue of sustainability, namely the propensity for an increase in accident/incident rates, through applying the principles of sustainability in a demolition environment. Secondly, to analyse the principles of operation, within the demolition industry, that may have impact on the application of sustainable initiatives.

2.2.2. Definition of the term 'Sustainable Development'

Prior to any debate on the merits or otherwise of the subject matter it is important to establish a definition of sustainable development. It is also relevant to point to the fact that the UK Government has targets in place to meet its own expectations as well as those of the European Union. The UK Government's historical definition of sustainable development is:

> '*Ensuring a better quality of life for everyone, now and for generations to come' (UK Government*, 1999, p8).

This statement, although given to address the excessive use of the world's finite resources by the developed nations and the poverty experienced by the low and middle income countries, has a certain synergy with the purpose of this research, in that what people do today must not compromise those achievements gained by the demolition sector, particularly in health, safety and welfare.

2.2.3. Aspirations and Targets

The UK Government has, since the late 1990s, produced a variety of reports concerning sustainability and the construction process. The Department of Trade and Industry (DTI) review of 2006 portrayed itself as the first step in the development of industry targets for the future. These were again reviewed and adjusted in 2008 by the Government in conjunction with the Strategic Forum, but the lines were drawn in 2006 and the strategy for the way forward mapped out, as can be seen in Figure 2.1.

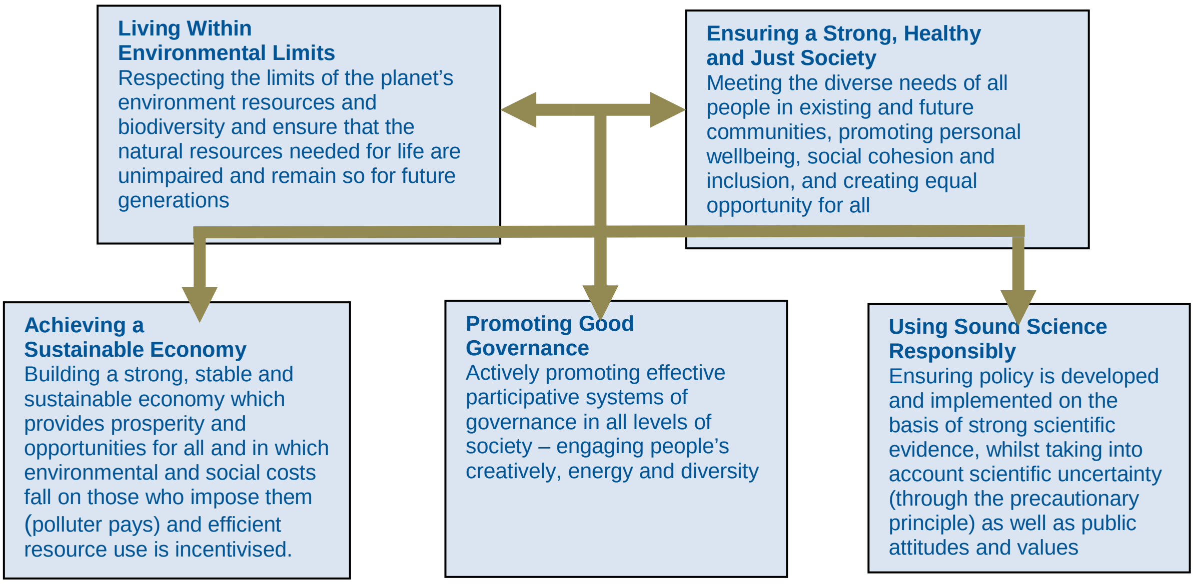

Figure 2.1: The Five Guiding Principles of Sustainable Development (DTI, 2006).

However, meeting the aspirations of government and others does not guarantee to satisfy the fundamental rights of society as a whole, nor will it necessarily appease all industry sectors. The term sustainability is a much used phrase that has become almost commonplace, however, unless one were to ask those with an environmental focus or those tasked with associating the socio-economic dependencies to the new built environment, the range of interpretations will be extensive (often running into hundreds of different definitions). Managers of the construction process may well have discussed, deliberated upon and in some instances actioned sustainability, but this is less likely for the site operative. It is at this level of site operation that the more complex the issue, the more likely that communication will break down. Hence, if it is unlikely that those working at site level will understand the rudiments of sustainable development, it is reasonable to predict that they may not associate a change in accident incident rates with an increase in recycling and reclamation. Published sources on the subject of sustainable development and sustainability tend not to concur on their interpretations, although there are similarities. It is unquestionable that the greater majority agree that society must limit its apparent insatiable appetite for the earth's natural resources and ensure that alternative energy and materials are developed. Rainey (2006) suggests that sustainable outcomes are those that balance the performance objectives of the present with the needs and expectations of the future. This clearly has major ramifications for the built environment and the construction industry.

2.2.4. Applying the Principles of Sustainability

Understanding the definition of sustainable development, as per the UK Government's model (UK Government, 1999, p8), is to associate the process as being managed over a period of time which would entail planning for the future and for future generations. Whereas sustainability, as the Brundtland Report suggests (Brundtland, 1987), is what society is doing now to improve matters and not just what needs to be addressed in the future. The differences may be subtle but are nevertheless important, particularly when applied to the daily routine of a construction site. Many materials used in the construction process, for example aggregates, are non- renewable resources that over a period of time may be recouped during the demolition phase of a structure or building and thus recycled for use again. Non-renewable resources should be used in such a way that their environmental effects are fully accounted for, meaning that sustainability must ensure that those resources are replaced with readily available renewable resources before they become scarce. Pearce et al (1993) argue that the idea of maintaining some overall equilibrium between resource use and resource availability is the essence of sustainable development. It is difficult to argue against such a point, particularly where aggregate consumption is concerned. However, applying the same principles against the use of, e.g. hardwoods is proving immeasurably difficult where life style changes are needed as much as economic and environmental change.

There would appear to be a growing consensus amongst the environmental lobby for greater use of reclaimed materials, irrespective of their fundamental origins or place in the build process. However, what is needed to ensure that sustainable ideals are implemented is a radical re-think on the primary use of materials in the new build to facilitate ease of reclamation and ultimately re-use. However, it is increasingly evident that those involved in the design of the built environment are not all acting on this ideal. That said, all structures and buildings are subjected to a total life cycle consisting of design, cost, engineering, maintenance and disposal, and within this process it would appear that demolition and or deconstruction of a structure or building is one area that shows consistent 'buy-in', in that maximising recycling and reclamation, wherever reasonably practicable, is carried out (NFDC, 2009).

2.2.5. Design for Deconstruction

Design is distinct from the construction process; it is the essential act by which it can established what is to be done and how. Designing is thinking widely, critically and cleverly (Harrison et al, 2006, p269). Designers fundamentally ensure that their ideas are feasible and ultimately workable. They are relied upon to solve the basic and increasingly complex problems associated with the new build process and to deliver with a view on cost and efficiency. They include individuals and organisations with the title of Architect, Planner, Engineer, Developer and or any other professional body, including clients, concerned with the design element of a structure or buildings. The UK Government, with input from the Strategic Forum, a group of government departments and construction industry experts, delivered their view on construction design as:

> *The overall objective of good design is to ensure that buildings, infrastructure, public spaces and places are buildable, fit for purpose, resource efficient, sustainable, resilient, adaptable and attractive. Good design is synonymous with sustainable construction* (BERR, 2008, p16).

So, one could argue that the design stage is the crucial and most influential part of the new build process. It is, quintessentially, where technology meets materials meets imagination. It is the natural and ideal starting place to originate and drive the sustainable development aspirations of all projects and project teams. Despite this there would appear to be a consistent failure for engineering solutions to tackle the re-use of materials or a building's individual elements. The principles of design for deconstruction (dfd) were addressed by a Construction Industry Research and Information Association (CIRIA) managed steering group in 2004. The study which resulted was an attempt to guide 'designers' and others, who could be said to have a responsibility for the sustainability of the environment, to move from a linear thinking process to a closed loop process (Addis and Schouten, 2004). Discussion and advice addressed elementary topics such as substitution of welding for use of bolts, clips in place of glue and standard fixings in favour on non standard, but there is little evidence of this being implemented in the majority of new build projects. Innovative building designs show little use of dfd, i.e. the buildings use composite materials and non-organic insulation. This use of materials that are difficult to recycle is surprising when one considers the work that many groups have undertaken to promote sustainable solutions for the recycling and reclamation of building materials and components. This is particularly true for the long standing 'deconstruction advisory group' whose members are drawn from the demolition, concrete and steel industries as well as the BRE. This brings into question the work that NGO's such as BRE and CIRIA undertake and their reliance on commercial exploitation as much as vital research obligations. This is illustrated by 'Principles of design to facilitate reuse and recycling' (CIRIA, 2004), in that no analysis of results or follow-up monitoring has been undertaken to determine what impact, if any, the research had on designers and industry in general. It is regrettable that in the pursuit of answers there are very often many more questions left unanswered.

2.2.6. Design and Technology

The outcome of many research projects into material usage is to find and develop new products. This process is inevitably the result of new technology and innovation, but some do not lend themselves easily to reuse, recycling and reclamation. However, change is inevitable and welcome especially when applied to the advancement of science and product development. Technological innovation is the systematic creation of 'new to the world' technologies that are superior to their predecessors (Rainey, 2006). Product and technological innovation therefore go hand in hand, but are not necessarily linked to sustainable development. Although it can be shown that many new and innovative products fit well in their environment in terms of efficiency and the cost effectiveness of manufacture, they do not always carry that mantle through to their end of life cycle and disposal. In a sustainable world, environmental limits would be accepted and there would be recognition that even extravagant benefits from new technologies are not worthwhile if they involve the risk of serious or irreversible environmental impacts (Dresner, 2002). Society does not always appear to recognise those warnings despite the obvious creation of waste products that are inevitably destined for landfill. Rainey (2006) surmises that at the end of the life cycle, or when the technology becomes a detriment rather than an asset, the question of divestment arises. This involves making determinations as soon as possible and to recover assets and resources to the greatest extent feasible. He concludes that the more time there is for initiating such actions, the greater the probability of transforming the remaining value of the old into the new. This strategy or closed-loop thinking should be initiated at the design stage with design for deconstruction being of equal importance to the principles of engineering and those of health and safety, but it is not clear how this can be achieved in practice.

2.2.7. Incorporating Design into Sustainability Thinking

In an etymological sense, sustainability is an absolute term, which implies the total accomplishment of its well intentioned proposition (Chapman et al, 2007), so it can be said that sustainable technology, in the form of product design for use in the built environment, should take on a holistic approach incorporating excellence, cost effectiveness, efficiency, safety in use and reuse/recycling ability (BERR, 2008). However, there is very little evidence to suggest that designers are willing or able to commit to sustainability in either product design or product use (Chapman et al, 2007). Further, in contrast to this, it would appear that there is little or no evidence to suggest that even a small percentage of the design element in new build projects, so far as material usage is concerned, incorporates sustainability in its concept. Chapman et al (2007) point to a recent survey staged at the 100% Design exhibition in London (2006), in which it was found that 53% of those of the design industry that took part in the survey believed that 100% sustainability is possible, whereas 47% felt it was not. They concluded that the similarity in these opposing results suggests that consensus is far from reached and sustainable practice is driven largely by perception as to what is and what is not effective and achievable. It is also tempting to question whether those taking part in the survey understood the meaning of sustainability and to what extent they felt it could be incorporated into their designs.

Sustainable technology and sustainable innovation should be an obvious fit with sustainable development. Making decisions in the future use of a combined and systematic process for new build products and materials has to become intimately associated with the design strategy. The term ‘sustainable’ or ‘sustainability’ designer needs to become synonymous with all new build projects to ensure that the optimum route is taken in the maximisation of reuse of a structure’s elements at best and or at least the ability to recycle and reclaim with ease. Taking those first steps in developing technologies for sustainable development should be to analyse the need that is fulfilled by the product and to recognise the importance of any hidden needs, of the consumer, that are not necessarily articulated (Mulder, 2006).

Take the example of sheet cladding: in the 1960's-1990's asbestos cement was favoured, until 1999, when legislation was brought in by the UK Government to put a stop to its use. Asbestos insulation board, which generally formed the internal lining, was widely used until 1985 when its use was stopped by UK legislation. The needs of the consumer, one assumes up until these times, were adequately fulfilled. But asbestos was recognised for its ability to kill and as such asbestos usage became illegal and was replaced, for the most part, by insulated steel profile sheet cladding. Much of this cladding, which saw production started around 1995, came with a blown foam insulated layer that added to its thermal efficiency (EPIC, 2009), but it contained cfc's and or hcfc's which are ozone depleting substances. It is therefore important to take into account moral issues and occupational safety as well as fiscal considerations and the needs of the consumer; indeed Mulder (2006) argues that the improvement of existing technology is often less risky than breakthrough technology.

2.2.8. Integrating Change

Integrating across the construction industry to share and disseminate knowledge for the good of each other's activities, in this case the finished build project is normal, but getting people to integrate the ideals of sustainability seems to be a harder proposition (Rogers et al, 2008). This point should not be marginalised as it not a problem experienced only within the UK. At the 2002 World Symposium for Sustainable Development in Johannesburg there were two issues that needed to be addressed: the less developed countries were concerned more with development and sustainability and the developed countries with sustainability and environmental protection. Clearly there was a mismatch in goals when ideally the two should have been merged. Rogers et al (2008) point out that there are ways to increase industrial development in a manner that is environmentally friendly by doing things differently than in the past and that fixed views on technology, relying solely on economic cost, are not considered satisfactory.

Pearce (2003) believe that flexible design can also allow buildings designed for instance for one form of occupation to be converted fairly readily to alternative uses, thus reducing whole life costs. In cities around the world and in particular close to harbour and water sides, there is an abundance of such activities as old commercial premises are converted to dwellings and leisure outlets. Indeed, such abundance is proof enough that there are huge benefits in the conversion of the old to create the new. Pearce (2003) supports this view by stating that economic accounting enables sustainability of the industry to be measured directly by building on the idea of a savings rule, whereby no enterprise can be regarded as sustainable if it fails to save more than the level of depreciation on its assets. Notwithstanding location and fluctuations in real-estate values and providing that a building has been maintained over its life cycle, the general trend is in favour with an exponential rise in value. There is of course a measure of difference between what economists and environmentalists define as sustainability. The former prefers to associate the term with 'non depletion of capital', whereas the latter prefers to argue that we are depleting the 'natural capital' of the earth (Dresden, 2008).

The conventional approach to managing innovation for sustainability is influenced mainly through regulation and control with the setting of targets and incentives using systems of regulation and usually punishments for non compliance (Bessant et al, 2007). This though, is a rather blunt instrument to encourage change and can be slow and incremental, whereas a more balanced and effective approach tries to understand how technology, markets and society co-evolve through a process of negotiation, consultation and experimentation with new ways of doing things (Bessant et al, 2007). The world has been constantly evolving and society has changed the face of the earth by putting up structures, eroding mountains and changing the course of rivers etc. According to Dresden (2000), this evolution is termed as 'progress', in which we drive towards modernity, but sustainability is a rather different idea from modernity; it is about maintaining things, whilst modernity is about constant change. Sustainability is about the control of human society in order to protect nature, whilst modernity is about human control of nature. Argument and counter-argument may abound, but sustainability is here to stay, or so it would appear. Change in the construction process is not a radical concept it is a natural evolution as new materials and new design dictate methodology. Where change is not necessarily addressed in its impact on the sustainability agenda is rather more fundamental. Construction products which are recycled, or have a high recycled content, will normally be produced using less energy than required for primary materials such as quarried aggregates (ICE, 2008).

2.2.9. Effective and Efficient Use of Resources

BERR (2008) informs that the Construction Products Association has embedded sustainability thinking within its organisational objectives and is encouraging the industry to develop products and processes that contribute to a more sustainable built environment. Equally, government and industry will collaborate to consider what additional tools and mechanisms are needed to promote both increased use of sustainable materials in construction and improvements in materials themselves (BERR, 2008). This is of course a welcome move, but will need the 'buy in' of all parties involved in the construction and demolition process from inception to end of life if it is to be truly effective. Reuse and recycling of materials will only happen if designers and manufacturers can find ways of constructing buildings that will make their deconstruction commercially favourable (CIRIA, 2004). There is no shortage of good advice and guidance on the subject of materials usage either at the end or throughout the life cycle of a building. WRAP (2007) suggest that introducing good practice in the efficient use of materials involves:

1. effective design
2. efficient procurement; and
3. recycling of site arisings.

The rate at which resources are consumed is a key aspect of sustainable development. Buildings are responsible for almost half of the UK's carbon emissions, half of the water consumption, about one third of landfill waste and one quarter of all raw materials used in the UK. Through its impact on the built environment, construction plays a central role in the drive to promote sustainable growth and development (BERR, 2008). The demolition industry, according to Hurley, (2001), has a crucial role to play in developing a modern outlook to its business approach (Hurley, 2001). In addition to external factors such as time and safety, future factors may well include the fate of the components, the culture of the demolition contractor and the true cost of the process. Barriers to uptake include the perception of planners and developers, time and money, availability of quality information about the structure, prohibitively expensive health and safety measures, infrastructure, markets quality of components, codes and standards, location, client perception and risk (Hurley, 2001).

2.2.10. Materials (Handling & Processing)

Materials handling and processing is an integral link in the demolition chain of site activities. Actual reduction of a building or structure is closely related to how the ensuing materials are dealt with as they build up. For example, mechanical reduction of a steel framed building with brick infill panels will necessitate the removal of the brickwork prior to gaining access to the steel elements. Equally, the reduction of a masonry dwelling by mechanical means will necessitate the removal of all internal fixtures, fittings and timber products etc by hand prior to structural demolition. The type and quantity of materials expected to accumulate is also an important factor particularly where logistics of handling and processing may be constrained by site conditions.

'Soft strip' of a building is usually the precursor to all other site operations with the possible exception of hazardous waste such as asbestos. Although however, it is commonly recognised by most demolition contractors that a degree of soft strip can be helpful prior to asbestos removal particularly where materials may mask or hide the position of the asbestos. It is in this soft strip process that one could expect the majority of minor and over three day accidents to occur when there is a requirement for workers to remove and handle a large diversity of products and materials. Over the research period between 2003 and 2008, the RIDDOR recorded injuries for demolition stood at 1,039 (Tunnicliffe, 2010). But if one were to add in those injuries that went unreported (Disson, 2005) it could be ten times this figure, particularly given the number of injuries recorded by the nine regional contractors within this period (refer to Chapter Four, Section 4.3). Any increase in manual handling of materials, industry wide, could therefore be considered as undesirable, given that accident rates may be adversely affected.

In recent years the propensity for machine based operations in demolition has been employed to good effect in the reduction of accidents, despite the apparent dismal figures for more minor injuries suggested via RIDDOR. In 1997 the demolition industry employed 4,400 persons with a gross value of work undertaken at £56m. By 2008 the numbers had risen to 13,600 employed, with a gross annual turnover of work at £301m (see Figure 2.2).

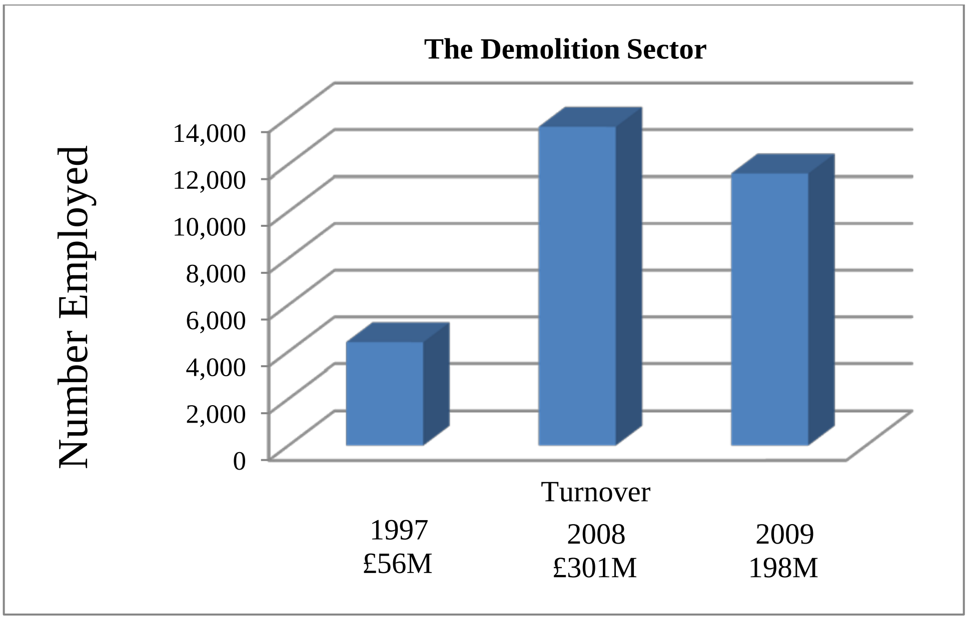

Figure 2.2: The demolition sector's turnover and labour numbers

At the end of the third quarter for 2009, the employed count had dropped to 11,600 and turnover had reduced to £198m (ONS, 2010). However, the accident rates remain high although there has been a slight fall in major and over three day accidents during 2009, according to RIDDOR (see Figure 4.4, Chapter 4).

This last improvement, though somewhat imperceptible, has coincided with an increase in the variety and adaptability of machine-mounted attachments to handle and process arisings more efficiently, effectively and safely. The UK Government and the wider European community's drive for greater effort into recycling and reclamation largely negates the wholesale use of mechanical machinery in operations such as 'soft strip' where damage to individual components of the building or fabric is to be expected. Anecdotal reports of the process of mechanical stripping and extraction of component parts from a building or structure will point to some damage to the components in over 90% of cases. This situation is of course unfortunate given that plant and equipment is designed specifically to speed up and ease material handling operations. Even with the most adept and experienced operator picking out or extracting fragile elements, such as timber sections, the most imperceptible movement of the hydraulically operated tool can crush or fracture the material.

The often vast diversity of materials generated from the stripping of buildings and structures is often dependent on the type, number and size of the building in question. For example, clearing out and stripping back fixtures, fittings and furnishings etc from decamped offices, schools and hospitals etc is likely to produce a large range of materials that will necessitate a greater degree of hand segregation and separation throughout the processing stages. In contrast to these types of buildings, the clearing out and stripping of an industrial unit, warehouse or transport depot etc, may well involve only minimal effort which could easily and efficiently be completed by mechanical plant as opposed to hand/manual labour.

From a purely occupational health & safety point of view, it is ultimately desirable that the minimum of hand working is undertaken and that use of mechanical operations be employed wherever practical and safe to do so. In terms of meeting targets for waste reduction and an increase in recycled/reclaimed materials usage, this anomaly is most likely to be the greatest hurdle to overcome. There is perhaps a good case to argue that a single or two storey building should be expediently and safely dealt with using a demolition rig fitted with a shear, grapple or selector grab attachment (as shown in Section 1.2.3). However, when buildings of multiple floors need tackling, the type and size of demolition rig becomes critical to weight loadings of floors and reach capabilities. In these conditions manual handling is an essential part of the process.

How to achieve the aspirations of those with sustainability high on the agenda and those tasked with bringing a demolition project to a safe and successful conclusion is an important subject matter that has to be resolved. A good starting point, therefore, is to assess and evaluate the different types of materials likely to be encountered on most domestic, commercial and industrial demolition sites and to associate those materials with the different forms of removal and handling commonly in use.

The following lists are indicative only and have been formulated from the author's knowledge of the demolition industry and the materials derived from the demolition process.

Doors	Rafters
Windows	Soffits
Architrave	Bargeboards
Skirting	Cladding
Partitions	Decking
Panelling	Purlins
Stud Work	Joists
Furniture	Floorboard

Table 2.1: Timber Materials

Timber materials prove to be the easiest to remove where there is no intent to salvage. Conversely, they are one of the most difficult when salvage is a high priority. A simple explanation is that a forceful approach is often used in timber extraction where damage to components is of no consequence. Yet where damage limitation is paramount to achieving high recycling or re-uses capability, dexterity, patience and care is the best approach. Therefore salvage of timber products has to meet the contractor's expectations regarding cost reduction and economic gain. This is a difficult exercise where manpower and hand tools are the only viable option. Add to this the extra time necessary to unfasten, release, carefully prise or manoeuvre apart the individual elements as well as lift, carry, stack and reload, the logistics can be expensive in labour time. Further constraints may include tight working conditions where space is at a premium and there are no free areas to process, stack or load. Many such situations will exist in town and city centre sites or where adjacent units are occupied and access/egress is shared.

There is little doubt amongst many exponents of salvage that some timber materials have a high value, particularly those with an architectural interest. However, results from a research questionnaire of demolition contractors (see Section 4.1.1) point to an anomaly; the respondents who were asked if they would salvage more should markets be freely available, 93% said 'yes', although when asked if they always took the value of soft strip materials into account only 65% agreed they did. Despite the Building Research Establishment's (BRE) initiatives regarding marketability and value analysis for many ex demolition materials, i.e. SMARTWaste and the Materials Information Exchange (MIE), there does not appear to be quite the expected uptake. The trade journal 'Materials Recycling Week' reports that the UK wood consumption is around 47 million tonnes (MT) per annum and that recycling levels are purported to be at 800,000 tonnes per annum. 90% of this is thought to be raw materials taken up by the particleboard manufacturers and the remainder shared between animal bedding, composting and mulching applications (MRW, 2007). This would suggest that around 1.7% is recycled with the remainder going to landfill or unaccounted for (but this is unconfirmed).

Rolled Steel Joist (RSJ)	Suspended ceilings
Universal Beams	Switches, sockets
Angle Irons	Doors
‘T’ Bar	Containers
Flat Bar	Fire systems
Galvanised Steel	Lighting holders
Nuts & Bolts	Trunking/ducts
Plate & sheet material	Conduit
Other Steel Sections	Pipes
Domestic Appliances	Partitions/fencing etc
Mechanical Equipment	Furniture
Electrical Equipment	Window/Door Frames
Plant & Vehicles	Racking
Radiators	Corrugated sheeting

Table 2.2: Ferrous Metals

Ferrous metals account for a range of materials to be found on most demolition sites, although there is no clear numerical data on the proportion it represents. The propensity of use is as diverse as it is flexible. This can be ascertained when one sees that they may form the building frame, the routes for electrical and ventilation systems and the furnishings. In terms of recycling value and ease, they lend themselves to the process in a most efficient manner with a total reliance only on daily world market prices for commercial and fiscal desirability. Ferrous metals may also be judged to be one of the easiest components to remove from their fixings. They are arguably more difficult to remove whole and undamaged, in terms of salvage for re-use, particularly where mechanical applications will be employed for extraction. For the process of materials handling there are distinct differences between demolition and dismantling when it comes to extraction of individual components. The dismantling of a structure or parts of a structure will usually be carried out with an emphasis on re-use capabilities of the component. Therefore extraction is likely to be largely via crane, or similar, and the disassembly process by hand working. Conversely, demolition is associated with whole or large scale reduction processes with little or no regard for re-use of an individual element within the structures frame or fabric. This dichotomy is rarely understood by those who work outside the demolition industry and is likely to remain so until such time as the generation of materials from demolition sites produces cost and time savings for the contractor.

The gain for the demolition contractor, feeding into the scrap metals sector, is that UK steel production has remained buoyant for several years and although there is an anomaly between the high of 1988, when steel production was at 18.7 MT, and the 2005 figures of 13.2 MT, the foreseeable longer term prediction is for continued growth (EEF, 2006). The UK Steel Statistics 2009 report shows that of all UK consumption, 29% went to the construction sector and 25% to the engineering sector. This is of course helpful to those materials handlers dealing in used scrap markets, especially when one could presume that a certain percentage of the engineering sectors steel ends up as mechanical and electrical equipment used in new build projects. In 2008 the UK steel making industry used 4.9 MT of scrap steel of which 1.6 MT was produced by the steel making process (EEF, 2009). Therefore it can be derived that some 3.3 MT is used from recycling processes in all industries. The British Metals Recycling Association report that UK recyclers recover around 15 MT of metal each year (BMRA, 2010). As stated, the actual tonnage derived direct from demolition projects is unknown although it can be assumed to be significant. Indeed, if one were to take an example, one UK based demolition contractor became the largest producer of scrap ferrous metals in Ireland for a period of five years when they demolished the former Harland and Wolfe Shipyard in Belfast, which produced nearly 100,000 tonnes (TDS, 2006). This form of materials handling is very much based on mechanical operations with large demolition rigs equipped with steel shears, grapples and grabs. Both loading and sorting can easily be accomplished without any manual handling, which makes the process safer by applying the 'one man one machine' ethos. Consideration does have to be given to ergonomics and operator comfort. However, with excavator base machines and wheeled or tracked loading shovels meeting very high specifications, the placement of machine controls for operator comfort and efficiency is one of the manufacturers' top priorities.

Valves	Partitions
Taps	Trims, Beading etc
Pipes	Furniture
Fittings	Windows & Doors
Screws, Nuts etc	Machinery
Cable	Equipment
Electrical Equipment	Batteries
Gaskets, Shims etc	Heating

Motors	Refrigeration
Lighting	Cladding
Instruments	Engines & gearboxes

Table 2.3: Non Ferrous Metals

Over 1M tonnes of non ferrous metals were processed within the UK in 2005. It is thought that these figures are consistent for 2009, although accurate and up to date data is difficult to source. Approximately 45% of this was aluminium, 31% copper and significant quantities of nickel, brass, zinc and lead. UK exports have an annual figure of around 800,000 tonnes, with Europe, China and India being the main destinations (BMRA, 2006). How much of this material was produced as part of a demolition or dismantling process is unknown, as indeed is that for ferrous metals. This anomaly is surprising considering the quantities that are mooted as being consistently generated annually with increases being forecast over the next few years. It must surely be of interest to understand the various industry sectors' involvement in the production of materials that clearly have an economic value as well as international trading links. It is incongruous to think that any industry sector handling and dealing in materials recycling and manufacture would have no record of the origin of its raw materials, as does the scrap industry, or so it would seem. In view of the fact that the scrap metal companies receiving the waste are now subject to Environmental Permitting, the simple solution may be for the Environment Agency to insist on annual or even quarterly returns listing the origin of their deliveries. This simple act would have no consequence for extra staffing or cost as such information is already required to be given on all waste transfer notes.

The removal of non ferrous metals from the workplace is often undertaken using a variety of methods with most initially implemented by mechanical means to access or extract, i.e. ferrous components containing non ferrous elements. It is usual from that point on to extract the non ferrous element and to put it aside for recycling and re-sale. Because of the high value of non ferrous metals the cost-benefit analysis is very favourable in ensuring complete separation from other metals of a lesser value.

Windows & Doors	Containers
Cladding	Boards
Trims, Beading etc	Soffits
Partitions	Barge Boards
Electrical Fittings	Roof Coverings

Electrical Goods	Rainwater Goods
Floor Coverings	Pipes
Furniture	Cables
Mechanical Goods	Appliances
Covers, Lids etc	Wrapping
Frames	Packaging

Table 2.4: Plastics

Second only to timber products, plastics make up the bulk of materials handled and placed into waste containers for dispatch to landfill or waste transfer stations. The world's plastic production has risen from 1.5 MT in 1950 to over 230 MT in 2009, with 45M tonnes going into the European building and construction market (EPRO, 2009). In March of 2010, the UK exported around 82,000 tonnes of recovered plastics (WRAP, 2010) and with around 20 distinct groups of plastics, training is clearly needed to separate and sort these materials to have any chance of realising full economic values. Of course mixing plastic waste on site and sending to a waste transfer station (WTS) for separation is good environmental practice, but how much more rewarding, financially, would it be if contractors separated out their plastics particularly when plastic bottles, can fetch as much as £284 per tonne at November 2010 prices (WRAP, 2010). The UK demolition industry has yet to fully embrace all aspects of environmental management and this is highlighted further when recycling of all types of materials does not appear to be the first consideration.

What is not known is how much plastic is disposed of annually from demolition sites. It would appear, from many different organisations reporting, that on average the UK landfills up to 75% of plastic products, incinerates around 7% and recycles about 18% (letsrecycle, 2010). It would not be unreasonable to suggest that almost all plastic materials generated from the demolition process are mixed in as soft strip material and either sent to landfill or to a WTS. To reverse this trend will require a high degree of manual handling at source when the fabric and internal areas of a building are stripped out. At present it is common for plastics to be classed as non-recyclable material and therefore subject to rough handling and mechanical reduction/mulching to reduce volume in the waste container. Detailing members of the demolition team to separate and sort the polymers by colour and type may prove to be a difficult undertaking, particularly where time and space are major constraints.

Windows & Doors	Insulation
Partitions	Soundproofing
Furniture	Cladding
Decorative Mouldings	Electrical Equipment
Decorative Coverings	Lighting
Crockery	Heating
Earthenware	Bottles

Table 2.5: Glass & Ceramics

Handling of glass, in particular, and to some extent ceramic products has its hazards. So it is vitally important that materials handling of this nature be by mechanical operations where practical. Current best practice within the demolition industry is to reduce the amount of glass finding its way into hardcore, to ensure that the finished product has the minimum of foreign material. By taking out the glazing at an early stage one can also eliminate the risk of shattering of glass during the mechanical reduction process, thereby reducing the hazard associated with glass shards and serrated edges in window and door frames etc. Recycling of flat glass has in the past proved to be a costly exercise both in time and economic value (Quarmby, 2002). Approximately half of the glass merchants do not take flat glass and all appear unwilling to offer any monetary reward, although flat glass will be accepted free of charge if brought to them.

Wallpaper	Magazines & Papers
Stationary	Decorative Coatings
Files	Packaging
Books & Journals	Wrapping
Waste	

Table 2.6: Paper & Cardboard

Paper and cardboard are commodities that have retained value as a recycled material for many years. However, in terms of cost- benefit the separation of such materials, the subsequent storage and disposal necessary for the actual weights recovered mean that in general there is no immediate value for the demolition contractor. There are of course projects where large amounts of waste paper or cardboard are present on site and that the collection of such may make it viable, but these occasions, it could be argued, would generally be rare. Paper and cardboard are invariably handled manually and mixed in with other controlled waste bound for landfill or a WTS. These products are referred to as ‘nuisance’ materials rather than a commodity for recycling and perhaps a step change is needed to promote best practicable environmental options.

Asbestos	Alkali
Man Made Mineral Fibre	Chemicals
Solvents	Gas Containers
Inks	Pressure Vessels
Paints	Tar & Bitumen
Oils	Hospital Waste
Fuels & Fuel Tanks	Sewage & Excrement
Acids	Animal & Bird Droppings
Radioactive material	Lead (as a dust)
CFC’s, HCFC’s	PCB’s & PCP’s
VOC’s	

Table 2.7: Hazardous Materials

These types of materials have an inherent risk built into each one, for the purposes of safe handling and disposal, at the end of their life cycle. Only through careful analysis and research, which is usually undertaken in the form of a hazardous survey prior to commencement of the project, can the best approach to dealing with them be determined. Unless the products are contained within vessels, in which case it may be possible to pump off, they are generally handled by operatives wearing the correct RPE and PPE. Each substance or material will require a certain protocol for handling and disposal and depending on its hazardous nature may necessitate medical surveillance. This process of materials handling is very much a risk based approach requiring those persons affected to be competent.

The list of hazardous substances and materials in Table 2.7, to be commonly found on demolition sites, is of course only indicative but there can be no other profession, and this will include the waste management sector, where a contractor is expected to handle such a diverse range of products during a normal daily working routine. Statutory regulation, guidance and codes of practice are designed to steer those tasked with undertaking various works towards a risk based approach. What they do not provide is solutions to real time problems and unforeseeable circumstances that arise during strip out and structural demolition. Taking asbestos as an example; the standard of asbestos surveys conducted by many surveyors had, in the main, declined in recent years. This is a problem that may have arisen because of various factors, some of which could be attributed to a poor standard of training, a lack of knowledge of the hazard and its properties, an unprofessional approach by the surveyor or just a poor standard overall. Whatever the reason, the quality of the survey has a direct bearing on how those materials are identified and best removed.

In 2010 the incumbent guidance on survey work (MDHS100) was revoked and a new standard, HSG264, was brought in to try to eliminate the many discrepancies prevalent in the previous standard. In all cases of demolition and or major structural refurbishment works, the HSG264 Guidance document informs that a Demolition and Refurbishment intrusive survey must be conducted. For intrusive, one can read destructive, especially where applied to a site due for demolition that is vacant. There can be no excuse for not detecting all asbestos present except where that material may have been built into the structure and it is physically impossible to detect. To discover asbestos materials after a project has commenced is a commercial liability as well as a hazard to health, therefore exposure to asbestos fibres is a real threat to employees and the general public in the wake of a poor survey or advice.

One could, no doubt, unearth a multitude of similar examples regarding the latent discovery of hazardous substances and materials commonly or uncommonly found on a demolition site. However, there can be little doubt that, in the majority of cases, it is down to the demolition contractor to provide the waste management solution, the methodology and the disposal route for all such instances of hazardous waste handling and removal. This does raise the question of the validity of associating and even badging the demolition contractor as a constructor. The evidence, by virtue of the legal definition of waste, that he or she is a waste handler and in some cases a hazardous waste handler, is compelling. Given that case law has succinctly defined what is and is not waste, it may be time for the statutory authorities to cease labelling demolition as a construction-related operation and to reposition it as part of the waste industry.

2.2.11. Summary

The commitment to achieve projected and intended targets for sustainable development, by Government and major NGO's is tangible and there has been some success. However, the overriding impression from the literature is that interpretation of the principles of sustainability and the efforts required to comply are falling short of expectations. The act of being ‘sustainable’ is defined broadly, for example, the UK Government’s stance, in the past, has been to legislate and bring about change by punitive measures. Perhaps a less prescriptive move would be to engage with product manufacturers, for example, to produce materials and goods with a low carbon footprint and/or recycle friendly.

Environmentalists and supporters of sustainability agree that designers have a major role to play, not only in product design, but also in the approach to the whole built environment. There appears to be a growing lobby for the concept of ‘design for deconstruction’ allowing for ease of dismantling a structure or building to re-use components as opposed to purely recycling materials. Bringing together the financial aspects, society’s desires and build ability of a project is challenging. It is recognised that change is necessary across the whole spectrum of the construction but cost, time and logistics are among the perceived barriers to that change process.

This section highlighted some key issues:

1. The inability or unwillingness of product and/or building designers to take a holistic approach to sustainability in the built environment and design for deconstruction.
2. The apparent indifference displayed by those who have a major influence on the procurement process.
3. Unrealistic targets and objectives for sustainable initiatives, without placement of the infrastructure necessary to drive through change and the lack of or inconsistencies in the markets to take back reusable and recyclable products and materials.

Furthermore, two pertinent research questions arise from this review. These are:

1. What new initiatives, processes or procedures could be implemented or adopted to improve the design and or use of sustainable products and materials in the new build process?
2. How can improvements be made or driven in the use of used or secondary products or materials either in the new build process or on the open market?

2.3. WASTE MANAGEMENT

2.3.1. Introduction

The link between demolition operations, waste management and workplace accidents may appear, on the surface, to be entirely separate issues. However, as a result of case law which established what is and is not waste, it is apparent that demolition contractors, in the main, can be said to be waste handlers as opposed to the traditional interpretation of their role as a materials processor and supplier of secondary products. Where there is a requirement for manual handling (and this is certainly true within the demolition and waste sectors) workplace accidents are prevalent. This section of the chapter reviews the literature on accidents recorded for waste, construction and demolition sectors, the role the demolition industry plays in these statistics, waste production and handling factors as well as the barriers and drivers to waste reduction.

2.3.2. What is or is not Waste

It is important to determine the meaning of and the terms of waste and waste management. Recent European and UK case law have defined waste as being "*any substance or object in the categories set out in article 1, of the Waste Framework Directive, which the holder discards or intends to, or is required to discard*" (as originally defined in EEC, 1975, p39). This unequivocal statement leaves little room for ambiguity or misinterpretation by waste handlers in the waste management industry, per se. However, it does have implications for demolition contractors. The interpretation of what is and what is not waste was brought into the public domain following some significant court cases during the 1990's. One of the first judgments involved two companies from the Federal Republic of Germany, Vessoso and Zanetti (1990), concerned the passing on of waste for others to process where the materials themselves had an economic re-utilisation. The judgment favoured the Italian Authorities, who instigated proceedings to determine that waste was waste until it had been processed ready for resale as a product. Of those cases with a specific interest to UK companies was Mayer Parry Recycling Limited v The Environment Agency (English High Court, 1998) in which the subject of scrap metals constituting a waste was decided. The judge's ruling on this matter declared that any material that required to be processed prior to its eventual disposal constituted a waste and that any material which did not require any process to be passed on as a resource was not waste.

However, a more recent case, which had a surprising twist in its verdict, was that of Environment Agency v Inglenorth (2009), in which the defendant Inglenorth demolished a set of greenhouses at a garden centre on ‘Site A’ for their client and transported the rubble arisings to ‘Site B’ for reuse as hard standing in the car park. Because there was never any intent to discard the materials the judge found in favour of the defendant and declared the arisings not to be a waste. These diverse interpretations, which may have come as some surprise to the scrap industry and demolition sector, may have an impact on demolition operations when classifying whole buildings and even large industrial complexes as waste. The demolition sector has traditionally been grouped in with the construction industry, but should legislation infer otherwise, through wholesale licensing of the process, the sector could find itself reclassified within the ‘Waste Management Industry’ and subject to much more environmental as well as health & safety legislation.

2.3.3. The Demolition Industry’s Unique Role

The demolition industry has a unique role to play in terms of the management of waste. Few demolition companies hold a waste management licence, yet all handle and dispose of hundreds of thousands of tonnes of waste materials each year (Button, 2007). This large amount of waste materials arises, in the main, from previous owners of a site decamping from premises and hence becomes the problem for the incoming contractor. The nature of this waste varies from site to site, but can range from fly tipped materials to whole buildings and structures. This variety of material encompasses all three general waste categories (i.e. municipal, controlled and hazardous) with no particular emphasis on any one, although one may assume that the propensity to have large amounts of municipal waste is low on most demolition sites, by nature of the projects being largely commercial and industrial buildings (Quarmby, 2010). The types of waste present will, to a greater extent, be dependent on the previous owner’s work activities and therefore the demolition contractor’s safe and healthy operations will be equally dependent on a risk assessment process that is reinforced by robust control measures.

2.3.4. Accident Comparisons within the Waste & Construction Sectors

The construction industry per se would appear to have a poor record regarding accident rates. Pearce (2003), for the Construction Industry Research and Innovation Strategy Panel, claims that the industry has the worst record for fatalities and major injuries, although when taken as a percentage of the labour force, it ranks in fourth place behind quarrying, agriculture and energy resource extraction. The Reporting of Injuries, Diseases and Dangerous Occurrences Regulations (RIDDOR) records show that fatalities within construction can clearly be seen to have dropped dramatically from a high of 257 in the early 1960's, to 73 by the mid 1990's and have remained around this figure up to 2008. When comparing accidents recorded in the waste management sector the picture is far from healthy. Bomel (2004) informs that there are around 160,000 workers employed in the waste industry with a further potential for an extra 45,000 jobs by 2010. There are over 4,000 recorded accidents per annum, i.e. over 3 days off work, of which between 1,700 and 2,000 are within the private sector and the rest throughout local authorities.

Taking the current approach used by the Health & Safety Executive in measuring rates per 100,000 workers the overall accident rate, within the waste sector, of 2,500 per 100,000 workers is around four times the national rate of 559 per 100,00. Fatalities are recorded at 10 per 100,000 around ten times the national average of 0.9 per 100,000 with major injuries at 330 per 100,000, more than three times the national rate of 101 per 100,000. Within the waste industry sector the largest proportion of accidents is attributable to refuse workers, approximately 85% (Bomel, 2004), the remainder is distributed amongst other private sector companies engaged in recycling and wholesale waste handling.

2.3.5. Accident Comparisons within the Waste & Demolition Sectors

Research into waste management safety standards conducted by Bomel (2004) examined all aspects of the waste industry including numbers and causation of accidents in the private and public sector. As reported, there are around 160,000 workers within the waste industry with the majority, about 120,000 workers, employed by the private sector. Of these workers, Bomel (2004) stated that around 15,000 are employed in recycling and 10,000 handling wholesale waste. This equates to around 16% of the overall industry workforce dealing with those waste materials unconnected with refuse collection activities. In contrast, the DTI Construction Statistics Annual Report for 2006 informed that the demolition industry in 2004 was made up of around 1,090 companies employing around 9,700 people. In year ending 2004, there were 186 reported accidents, recorded under RIDDOR, concerning the demolition industry (Tunnicliffe, 2010). By extrapolation, the demolition accident rate at this same period appears to be twice the national average of 618 per 100,000 workers (HSE, 2010). This is not in itself a significant statement until other figures given within the Bomel report of 2004 are considered, in which it was reported that of the 4,000 over three day accidents, 85% were refuse collection related, leaving around 600 injuries to those workers in wholesale waste and recycling activities. Those workers represent approximately 0.4% of the workforce accident rate which is a significantly lower figure in comparison to the demolition industry within which recycling and wholesale waste handling are part of their overall activities.

2.3.6. Similarities of Causal Accident Factors

According to RIDDOR there appears to be a rise in accident rates recorded for the demolition industry (Tunnicliffe, 2010). The rate of increase would appear to be consistent with the rate of change regarding attitudes towards recuperation of materials from sites that use manual methods in their demolition methodology. The 2004 Bomel report produced for the waste industry identified that when considering all injury severities, handling/sprain injuries were the most significant, with the movement of heavy weights being the most frequent handling injuries, followed by sharp objects and awkward loads. Notwithstanding any accidents resulting in fatal or major injuries from being struck by or close to refuse collection vehicles, it appears that with very few exceptions, similar causes may well be reflected in the demolition sector accident causation as this is borne out by Bomel (2003) and results from this research (see Chapter 4 for details). It could be argued therefore that if similar accident causation is consistent within both industry sectors, then any rise in waste handling and processing activities could result in higher accident rates being recorded.

2.3.7. C & D Waste - Historical Production and Future Targets

The demolition industry could be seen as the construction industry’s waste handler in that all manner of waste discarded by a site’s previous owner has to be processed and cleared as part of the overall works. This synergy is an unmistakable indicator that not all waste materials are currently handled by the waste industry. In 2005 the Department for Communities and Local Government (DCLG) carried out a survey into the arisings and use of Construction and Demolition wastes (C&D) in England mapping the process from 1999 to 2005. The total construction and demolition waste for England was estimated at 89.6 million tonnes in 2005, of which 46 million tonnes were recycled and a further 15 million tonnes were spread on exempt sites (usually land reclamation, agricultural improvement or infrastructure projects). The remaining 28 million tonnes were sent to landfill (including backfilling at quarries, and landfill engineering) as waste. This is a significant shift from recorded estimated figures of 1994, showing approximately 42 million tonnes of C&D waste deposited into landfill (Humphrey et al, 1994), but, as explained in Section 2.3.9, this will have to be dramatically reduced to meet UK Government expectations.

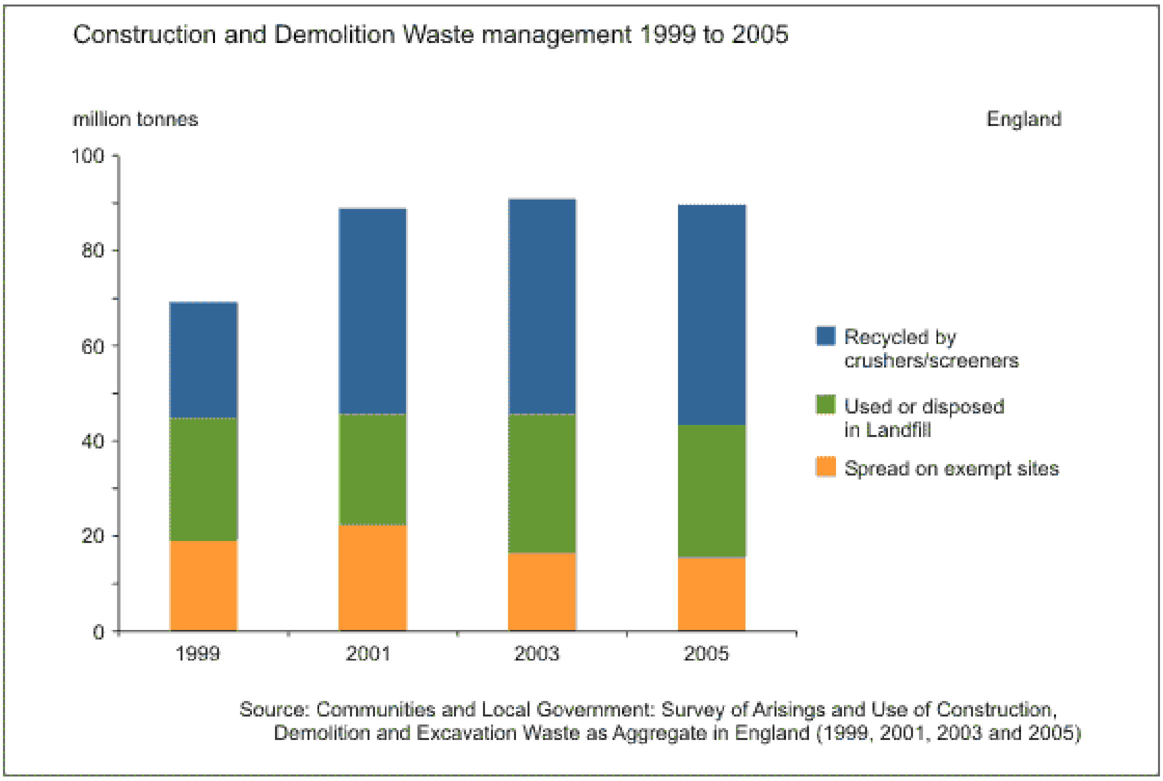

Figure 2.3: Waste Arisings Chart (DCLG, 2005)

As shown in Figure 2.3, DCLG (2005) suggested that the amount of construction and demolition waste generated in England has remained stable at around 90 million tonnes from 2001 to 2005 (NB: Until March 2010 the DCLG report remained the only in-depth measure of C & D waste arisings UK wide, although the BERR 2008 report sets a base line for

England at 90 million tonnes). This is an increase from about 69 million tonnes in 1999. As an indication of the use of secondary aggregates on site, the proportion of construction and demolition waste recycled by crushers and screeners between 2001 and 2005 had increased from 49% to 52%. The proportion of construction and demolition waste sent to landfill had increased from 26% to 31% and the amount of waste going to exempt sites, for such as landscaping, had fallen from around 25% to 17%. The UK Government together with the Strategic Forum, a quasi government and industry body, have declared a target of 50% reduction of construction, demolition and excavation waste sent to landfill by 2012 (BERR, 2008) and zero % by 2020.

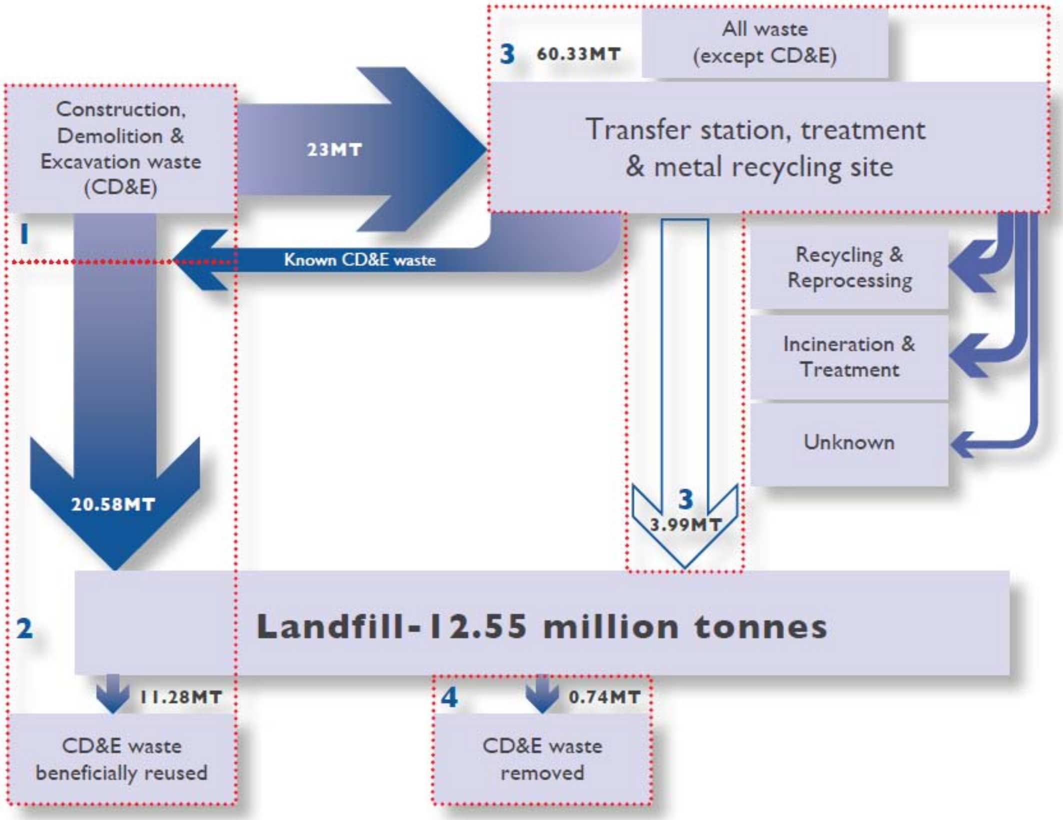

Figure 2.4: Results for CD&E Waste to Landfill in 2008 (Adams, 2010)

Up to spring 2010, estimates on the amount of CD&E waste that was recovered for re-use were inconsistent, but the Strategy for Sustainable Construction Report of 2008 suggested that in England it was around 78% with the remainder going to landfill (BERR, 2008). In March 2010 the Strategic Forum for Construction Waste Sub-Group determined that a 2008 base line (refer to Figure 2.4) for CD&E waste sent to landfill in England was 12.55 million tonnes (Adams 2010). The purpose of setting a baseline tonnage was to measure what improvements could be made in reducing waste to landfill in line with the target of 'halving waste to landfill' by 2012 set within the Strategy for Sustainable Construction.

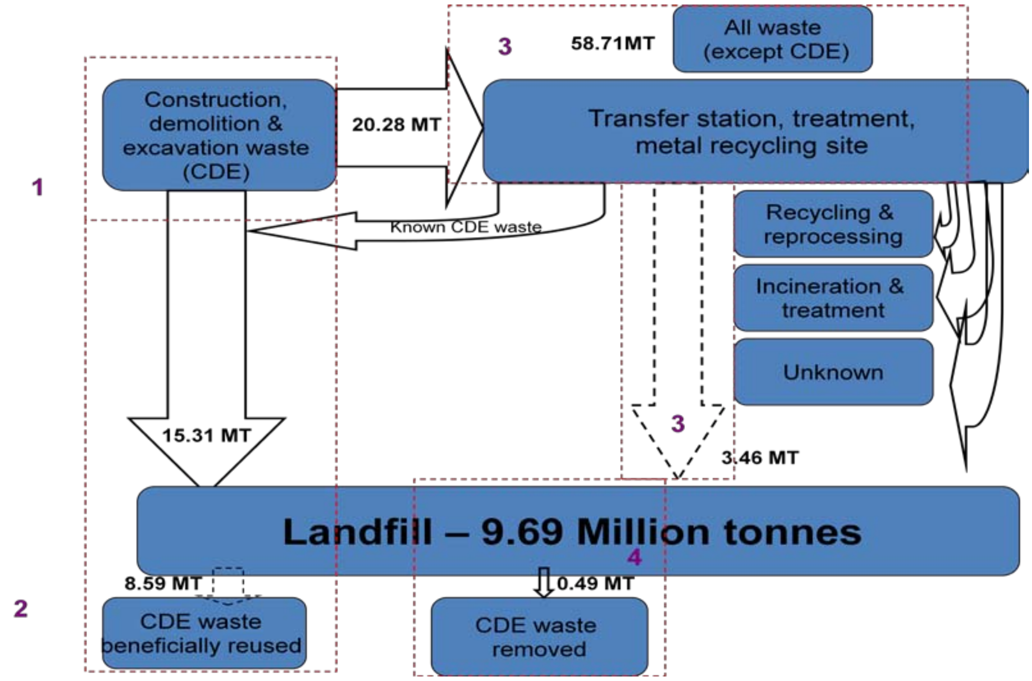

Figure 2.5: Results for CD&E Waste to Landfill in 2009 (Adams, 2010)

In March 2011, WRAP announced that waste to landfill, in England alone, had fallen to 9.7 million tonnes between 2008 and 2009 (refer to Figure 2.5). This represented a 13% decrease which is a substantial indication that industry is on line to meet the 2012 target (WRAP, 2011), however, the industry did experience a downturn in workload during that period, so the waste reduction in real terms will be somewhat smaller.

2.3.8. Waste - General Perceptions and Values

The challenges of dealing with waste generated by industrial activities are not new, although people's perception of waste may be said to be changing. This can be identified in a 2007 document commissioned by the EU Council and the European Parliament on waste and by-products (CEC, 2007). The theme of the subject matter concentrates on what constitutes waste and how case law and legislation deals with the issues. The document states that: '*In EU waste law, notions such as by-product or secondary raw material have no legal meaning – materials are simply waste or not*'. The document attempts to inform the reader that as an illustrative term and in addition to waste as defined in the Directive, that – Product – refers to all material that is deliberately created in a production process. '*In many cases it is possible to identify one (or more) "primary" products, which is the material produced'* (CEC, 2007 p3-4). This is of particular interest to those companies dealing with other organisations waste products, i.e. demolition companies that seek to maximise reuse or recycling of such waste thereby, minimising the amount destined for landfill. EU waste law and indeed European case law have no mechanism to interpret discarded reusable building or construction products in any other way than that which is laid down within the interpretation of waste under article 1 of the waste directive. This narrow view of what is and is not waste is a much debated topic which has increased in intensity throughout the 2000-2009 period. The Sixth Environmental Action Programme Waste Strategy instituted by the European Commission (EU) in 2005 discusses waste as being associated with things that are no longer wanted and that because of the long history of mismanagement waste do not have a good reputation. The strategy interprets this as being generally viewed in negative terms as a problem, a cost, a pollutant. Yet more recently the waste business and waste impacts have been changing. A gap is opening up between the perception of waste as a significant environmental problem - something to be strictly controlled and disposed of as cheaply as possible - and the increasing evidence that waste can be a resource to be exploited (EU, 2005).

However, change is evident, for example in BRE's web-based materials management facility BREMAP (BRE, 2010). The value that secondary products and materials can generate is illustrated within the web base pages to encourage producers of secondary materials to embrace the BRE's waste strategy. BREMAP's remit is to:

- Create firm relationships between the CD&E Industry and local reclamations, recyclers and re-processors
- Create markets for recycling and reuse of materials and products
- Reduce the transportation of waste
- Increase the knowledge of available waste disposal options and materials/products available in the vicinity of your site.

Knowledge of products and materials and their availability or predisposition to reuse or recycling are key to a successful waste management process. This in turn fulfils the desire to meet sustainable targets either set within the company or by others such as Government. The relationship with workplace accidents is not apparent until one considers the types of waste being managed by demolition contractors, which are characteristically made up of the materials presented earlier, in Section 2.2.10 (i.e. wood, concrete and masonry, soils, drywall, roofing, metals, paper and cardboard, plastic, other materials and hazardous waste)

2.3.9. UK Waste Reduction Targets

DCLG (2005) figures suggest that at least 50% of the previously named materials are traditionally recycled by the waste handlers. Waste handlers, by definition, are all organisations having an active association with CD&E waste management. It is reasonable to presume that the majority of the millions of tonnes of CD&E waste produced in the UK each year are handled with intent to recycle rather than reuse, given that there is little evidence to show otherwise. There is however, evidence of the increased use of waste transfer stations (WTS) processing CD&E waste. The Strategic Forum for Construction in their 2010 report announced that 23 MT out of a total 83 MT for all types of waste was received at WTS's, treatment plants and metal recycling sites and that only 3.9 MT of this material was assumed to end up in landfill (Adams, 2010). This is encouraging, although a 13% annual decrease in CD&E waste to landfill is still required to meet the 2012 target and 2020 target of 70% reduction to landfill (Defra, 2009). The Waste and Resources Evidence Strategy 2007 – 2011 (Defra, 2007), proclaims an increase in investment by Government to meet all expectations, in line with key objectives such as:

- securing the investment in infrastructure needed to divert waste from landfill and for the management of hazardous waste; and
- getting the most environmental benefit from that investment, through increased recycling of resources and recovery of energy from residual waste using a mix of technologies.

The Egan Review of Skills for Sustainable Communities, (Egan, 2004) described how Government should incentivise progress that enables consistent waste minimisation standards, within eight years, i.e. by 2012. This theme is also taken up by the Institution of Civil Engineers (ICE) in the revised 'Demolition Protocol 2008' that calls for an increase in the re-use of products as mentioned in the England Waste Strategy (DEFRA, 2007). The ICE 2008 protocol is very firmly anchored on the belief that building materials and components should be considered firstly for re-use, followed by reclaim, recycle and landfill as the last resort. This waste hierarchy is intended to reflect the most sustainable approach involving building/infrastructure re-use, followed by deconstruction then demolition (ICE, 2008).

2.3.10. Designing out Waste

There are potentially many keys to unlock good practice in waste management. Ideally, the elimination of all waste created, in particular C D&E waste, is the UK Government's goal by the year 2020 (DEFRA, 2009). In the short term, reducing waste produced at source (i.e. before and during the build programme), by efficient and effective planning and constructability, is a key issue.

Bomel (2004) identified a possible increase in waste industry personnel of around 45,000 by 2010 and this is confirmed somewhat within the updated Bomel Report of 2009 which indicated a 7% rise is staffing levels up to the 2005-6 period. The need for these extra workers is in part due to the expected rise in recycling activities and the creation of waste through inflationary upturns or a surge in construction build programmes. No such increase has been predicted for demolition personnel numbers despite the former DTI's well documented figures showing the industry operating at increased growth levels over the last decade (ONS, 2009). The reasons for this are explored in Chapters 4 and 5, but it is reasonable to assume that over an extended period of time, in the workplace, that manual work has gradually been replaced by the machine. However, one must ask whether this method of work will, or even can, continue if recycling and reclamation targets are to be achieved.

Osmani et al (2007, p1) explored the idea that at least 33% of all waste generated on a construction site could have been eradicated if architects had designed it out, stating that:

> *...in order to maximise their influence, architects need to understand the issues, constraints and opportunities related to waste prevention, and the practical means by which improvements can be achieved. By improving waste minimisation design practices, architects could realistically and successfully accelerate the pace of change.*

Addis et al (2008) call for the consideration of waste, as with other environmental issues, to have progressively moved from ‘end-of-pipe’ waste management to one of resource management throughout the construction process. Further intimating that one such approach receiving increasing attention is design for deconstruction (see Section 2.2.5).

2.3.11. Waste and the Principles of Sustainability

Powrie et al (2006) argue that waste outputs from one process can sometimes be used as resource inputs to another, or even the same, process. Sustainability principles require that resources are used with maximum efficiency while they are within the human part of the cycle, and that they are returned to the environment in a way that enables them to be extracted and used again - something that at present happens only rarely, haphazardly and on a geological timescale. Reid (2006) maintains that the sustainable development strategy states that the overall objective of government policy on waste is to protect human health and the environment by producing less waste and by using it as a resource wherever possible.

Bjerregaard (2008) however, is of the opinion that if the demolition industry relies only on following the ICE demolition protocol (ICE, 2008) it runs the risk of using recycling rates as the only sustainability indicator, which is an unbalanced approach to integrating sustainability into demolition and subsequent construction works. This may be the view of some but, as early as 1994, the UK Government had a strategy (the now defunct Department of the Environment’s Minerals Planning Guidance Note 6) advising on the nation’s supply requirements for aggregates (Humphreys et al, 1994) and Arup (1991) reported that of the estimated 24 million tonnes of C&D waste produced annually in the UK, only half was recycled for use as crushed and graded aggregates. Yet DCLG (2005) figures contend that the 50% recycling rate has remained stagnant for at least 15 years. However, more recent studies by the Construction Resource and Waste Platform (CRW) estimate that nearly 33M tonnes of demolition arisings were processed in 2007 and that approximately 88% of the inert materials handled by the demolition contractors are either recycled and used on site or recycled on site and sent for off-site sale (Zakar, 2008). This can be further corroborated with the increased use of WTS’s as shown in Figure 2.5, where 20.28 MT of CD&E waste were sent to such facilities which produced only 3.4 MT ending up in landfill, a recycling rate of 83% (Adams, 2010).

It would therefore appear that although site-based personnel know the value of secondary aggregate materials and their suitability for use in new build, the wholesale use of such a valuable commodity seems to be lost on those agencies or individuals that have the power or authority to insist on its use. WRAP (2008, p2) continue to try to persuade designers, in particular, stating that: '*initial planning of the demolition works can be undertaken at the design stage by designers reviewing the feasibility of on-site reclamation and recycling of materials and for best results this should include the demolition contractor*.' Hurley (2001), as head of the BRE Centre for Waste and Recycling, had a reasonably clear insight into why there are barriers to re-use and recycling of components and materials, citing these reasons:

> '*the perception of planners and developers, time and money, availability of quality information about the structure, prohibitively expensive H&S measures, infrastructure, markets quality of components, codes and standards, location, client perception and risk.*'

He reiterates that only by working together will it be possible to achieve a more sustainable future.

2.3.12. Industry use of Secondary Aggregates

Setting aside the use of reclaimed timber, slates, tiles and bricks etc, it is unrealistic to ignore the value of secondary aggregates particularly as there are strong scientific reasons to show that such material usage is a viable option to quarried materials. The UK construction industry consumed about 235MT of primary aggregates in 2005 for applications such as pavement engineering, concrete production and engineering fill (Chidiroglou et al, 2007) increasing to around 280MT up to 2010 (Barritt, 2010). Over the past 15 years the use of demolition waste materials in the production of concrete has been researched all over the world, for example, it has been shown that crushed concrete can be used in the production of new concrete and concrete masonry blocks. In addition to investigations of recycling/reusing crushed concrete, research on the utilisation of other demolition wastes, such as fine crushed bricks has gained momentum to show that structural concrete and bricks have adequate strength characteristics to be utilised as general bulk backfill and or road sub-bases (Chidiroglou et al, 2007). In Japan, research into utilising materials such as crushed concrete for use in making new concrete products is further advanced with the results showing:

(a) Recycled coarse aggregate concrete using a developed aggregate replacement method can be made through material design with sufficient quality as structural concrete by using materials that conform to all the related quality standards.

(b) Recycled fine aggregate concrete, as well as recycled coarse aggregate concrete, can also be designed by applying relative quality method values. Therefore, it could be used as aggregate for precast concrete products.

(c) Using the newly developed recycling system, it is possible to recycle concrete waste produced from the demolition of buildings, at a lower recycling cost and with less environmental impact.

(d) The newly developed recycling system could be used for scrap and/or construction of general buildings, etc (Dosho, 2007).

2.3.13. Waste Prevention for Waste Reduction

The literature concentrates mainly on the production of C&D waste and the use of secondary aggregates for reuse and recycling. Although in terms of weight, this material constitutes the greater tonnage to be measured, it is by no means the greatest in terms of mass, the remainder of the product being made up of biodegradable, non biodegradable and or organic materials (i.e. paper, timber, plastics, glass, ceramics and composite materials). These materials 'bulk up' in volume when extracted and are extremely difficult to recycle, reuse and or reclaim as well as costly to transport and dispose of to landfill. It is this material that is likely to pose the greatest challenge in applying a good waste reduction strategy. Ready markets for individual products or materials are not sufficiently developed to make it cost effective, on site, to separate out and in the case of some materials, i.e. plastics, discriminate between the various grades. That said, most demolition contractors will separate at source all aggregate materials from others, as these materials are ultimately easier to manage. However, there is a sting in the tail in the form of an £8 per tonne per year increase in landfill tax, from 2009-2013, which came into force from 1st April 2008 (Defra, 2007) and currently stands at £56 per tonne. This is one of the ways in which the UK Government aims to increase awareness and wean waste producers off landfill. The Waste Strategy for England 2007 sets out the UK Government's objectives for waste produced by all sectors, its aim being to:

> *…reduce waste by making products with fewer natural resources. We must break the link between economic growth and waste growth. Most products should be re-used or*

their materials recycled. Energy should be recovered from other wastes where possible. For a small amount of residual material, landfill will be necessary. (DEFRA, 2007, p9).

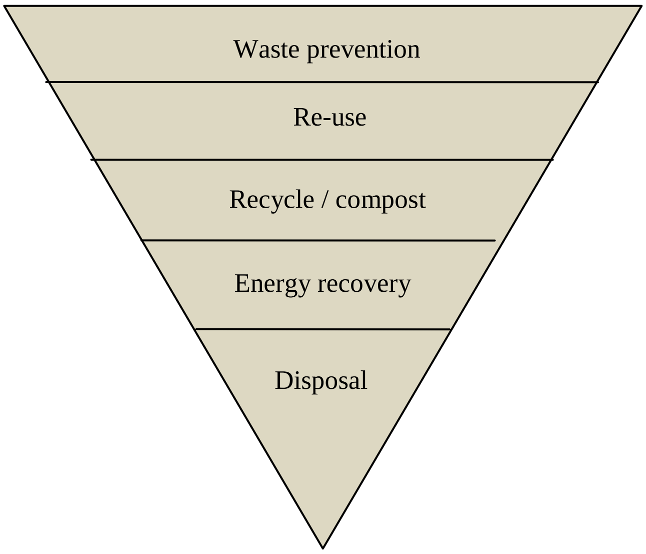

Figure 2.6: Waste Hierarchy (Defra, 2007)

Product design is an important means of achieving waste prevention in manufacture, use, re-use and disposal as shown in Figure 2.6. Producers and retailers can reduce waste impacts through designing and marketing products that use less material and avoid the use of harmful substances, last longer and are easy to disassemble and recycle (DEFRA, 2007). Other initiatives, which have been implemented, to reduce landfill waste are the Aggregates Levy which encourages the use of recycled rather than virgin materials (HM Revenue and Customs, 2010), new legislation making Site Waste Management Plans (SWMPs) mandatory for construction projects in England worth over £300,000 (OPSI, 2008) and the Code for Sustainable Homes against which ratings were made mandatory for all new homes from May 2008 (BERR, 2008).

2.3.14. Summary

This section has shown that production, handling and disposal of waste are areas of concern. Waste production rises exponentially with an increase in population and changes to the built environment. The UK Government has recognised the need for action, particularly in terms of waste reduction, by setting ambitious targets for waste minimisation as well as increasing the need for greater reuse and recycling of recovered materials. Society has a predisposition to 'throw away' and replace rather than to reuse and recycle which in many ways is symptomatic of the types of products and materials that are manufactured for use in the built environment. Exponents of sustainability are calling for the use of materials and products that lend themselves readily to reuse and or recycle and this in turn calls for a radical re-think on how we design the built environment to reduce waste at source or produce a waste product at the end of life cycle that can be utilised in other ways. The handling of waste, as this discussion has unearthed, is a major source of accidents which strategies for waste minimisation should help to reduce, if not eliminate altogether. The construction industry has a poor record of dealing with waste produced by construction, whilst the demolition sector, despite being a good producer of secondary aggregates, struggles to meet targets for improvement because of a lack of market or legislation/standards. Discussion has also centred on those organisations or individuals that have an influence on the design of building products and/or components as well as a building or structure and the preparation of sites prior to or after demolition has occurred.

A number of key issues have been identified, within this section of Chapter 2, of which the following are significant:

1. Waste from construction and demolition sites must be separated at source and disposed of in the most economic, but also environmentally friendly manner to realise its full potential
2. Waste production from construction and demolition sites must be minimised by better design and use of technology
3. Product design must meet sustainable aspirations to protect the environment, reduce accidents at work and minimise the waste sent to landfill

Those who would influence product utilisation and or shape the built environment must embrace sustainability and sustainable development to reuse components or materials of a secondary/recovered nature

Two further key research questions can therefore be posed:

1. What are the greatest barriers to implementing a sustainable waste strategy in the demolition sector and how can these best be broken down?
2. Could regulatory/legislator changes or a relaxing of the present regime make a significant difference to waste handling and utilisation?

2.4. ACCIDENTS, CAUSATION AND RISK

2.4.1. Introduction

Accidents can be regarded as any unplanned event that resulted in injury or ill health of people, or damage or loss to property, plant, materials or the environment or a loss of business opportunity (HSE, 1997; NHS.2007, p3). Green (1997) argues that an accident is an unmotivated event that is as unpredictable as it is unique. Unique they may be, but as to whether any particular accident could be classed as being unpredictable may well be a matter of conjecture.

'Rethinking Construction' (Egan, 1998, p.4-5), commented that "*the (construction) industry had to commit itself to change and that its culture and approach to the health, safety and welfare of its employees was highly detrimental to its future economic success*"; a view endorsed further in 'Accelerating Change' (Strategic Forum for Construction, 2002). Despite a plethora of health and safety initiatives in the industry, fatal and major injuries have remained unacceptably high. This section analyses the available accident statistics from the construction, demolition and waste sectors against the national average and highlights causes for concern.

There are myriad reasons why and how accidents happen and a large part of this section is devoted to discussion of some of these, as well as factors that influence why decisions or actions made by accident victims can be contributory in their own or other's injuries. Equally, other contributing aspects are discussed, including; time and place, behavioural patterns, risk taking, experiences, technology, plant and equipment use, culture, communication, health and safety etc. One continuing theme that has been raised in other sections and has continued to be prominent here is the question of design and the influence that designers have in reducing or eliminating risk and the potential for error leading to accidents or incidents.

2.4.2. Construction Accident Statistics

The Health & Safety Executive (HSE, 2002) discussion document 'Revitalising Health and Safety in Construction' states that construction workers are six times more likely to be killed at work than other workers. This equates, at year 2007/2008 figures of 72 fatalities, to a rate of 3.4 per 100,000 workers (HSE Construction Statistics, 2008). The overall major injury figures are put at 599.2 per 100,000 workers, the highest in any industry group, despite a purported fall (HSE, Construction Intelligence Report, 2008). The HSE (2002) states, that most people (and by this we must assume those working in the construction and safety industries), agree that the safety record is unacceptable and must improve. In addition, there is a further warning that the health record is even worse when one considers the legacy of asbestos, noise, solvents, vibration, dust, allergies and musculoskeletal disorders.

2.4.3. Waste Industry Accident Statistics

The UK Waste Industry sectors health and safety performance was the subject of a detailed survey in 2004 by Bomel. Their findings for year 2001/02, show that typically around 3,800 to 4,300 accidents a year are reported. This is estimated to be around 2,500 per 100,000 which is four times the national average. The fatal injury rate being 10 per 100,000, ten times the national average and a major injury rate of 330 per 100,000 workers over three times the national average (Bomel, 2004). In 2009, Bomel carried out a further report with the purpose of updating the waste industry's figures. The statistics produced by this report show that the overall accident rate, in 2005/06, has reduced by 3% whilst employment levels have risen by 7% (Nobel et al, 2009).

2.4.4. All Industries Accident Statistics

The HSE's Health & Safety National Statistics for year 2007/08 for all industries, amounted to an overall figure of 299 fatalities (provisional), equivalent to a rate of 0.8 per 100,000 workers. Reportable injuries (over 3 days absence) were recorded as being 108,795, at a rate of 411.9 per 100,000 workers and major injuries as 27,976, a rate of 105.9 per 100,000. The Health & Safety Commission (2002) advised that over 40 million days were lost to occupational ill health and injury in 2001/02 and that 33 million days were attributable to ill health. HSE (2002) raises concern about the high proportion of casualties that occur in refurbishment, demolition and dismantling work and asks whether this potentially high risk work requires a higher standard of management and expert advice. In a bid to explain this, Duffy et al (2003) expound the theory that there is a base rate of risk that cannot be reduced further. This may not be far from reality, even if it would appear to be extreme. Evidence of improvement to the reduction of workplace fatalities over many decades abound, yet over recent years it has been noticeable that annual figures do not appear to be reducing exponentially or at a consistent rate despite the improvements to safe systems of work and equipment. This trend is noticeable, as shown in Figure 2.7, as the relative fall in fatalities between 1974 and 1996 has not been repeated since.

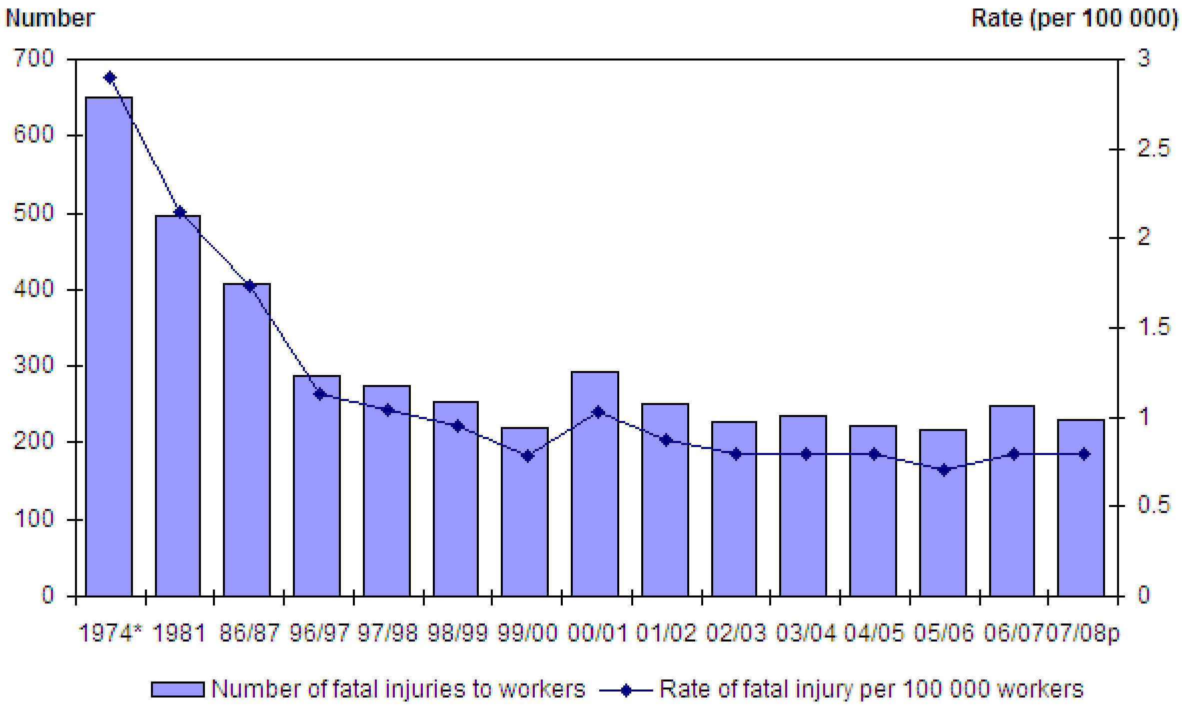

Figure 2.7: Fatal injuries to all workers (HSE, 2008)

Figure 2.7 covers all UK workers in all industries, but similar trends are reported for the construction industry. Over the past 15 years there has been an overall downward trend in the rate of fatal injuries to workers, with the recent five years showing little change and recording an average yearly rate of 3.5 per 100,000 (HSE, 2008). There is little doubt that the Health and Safety Executive is committed to reducing deaths, injuries and ill health in the construction industry. Having set out that commitment and with dates set in the June 2000 ‘Strategy Statement’ produced by the Deputy Prime Minister and the Health and Safety Commission under the ‘Revitalising Health and Safety initiative (HSE, 2000). However, this is a wish list, a paradigm based on what is known or considered to be the causation of accidents and incidents leading to workers deaths or injuries; it is possible that looking in other directions for answers may lead to improvements in the future.

2.4.5. The Demolition Sector's Accident Statistics

The specific accident rates for the demolition industry sector alone are difficult to evaluate, however, some figures have been produced by HSE working from a RIDDOR data extraction tool designed by Bomel Limited (Bomel, 2004). These figures, (see Figure 2.8) for January 2009, show that in year 2008/2009 there were 3 recorded fatalities, 85 major injuries and 79 over three day injuries. The Construction Statistics Annual (2010) states that in the 3rd quarter of 2008 some 13,600 persons were engaged in the demolition sector. Using the HSE accident frequency rate calculation of number of reported accidents divided by the number employed and multiplied by 100,000 the injury frequency rate can be extrapolated to give an over three day injury rate of 1,228 per 100,00 workers. This equates to a little under 2.5 times the national average (HSE 2009) and nearly three times greater than the entire construction industry, whose workforce was 1,266,300 (ONS, 2010) people during the same period and, for this reason, the demolition industry appears to have a major problem.

Accident/injury figures derived from Bomel (2004) and Tunnicliffe (2010) taken over a six year period between 1996 up to 2002, suggest that fatal injuries in the demolition sector are approximately 1.7% of the total fatalities recorded for the construction industry per se. In this same period, major accidents ran at approximately 0.1% and over three day injuries at 0.05% of the total recorded for construction.

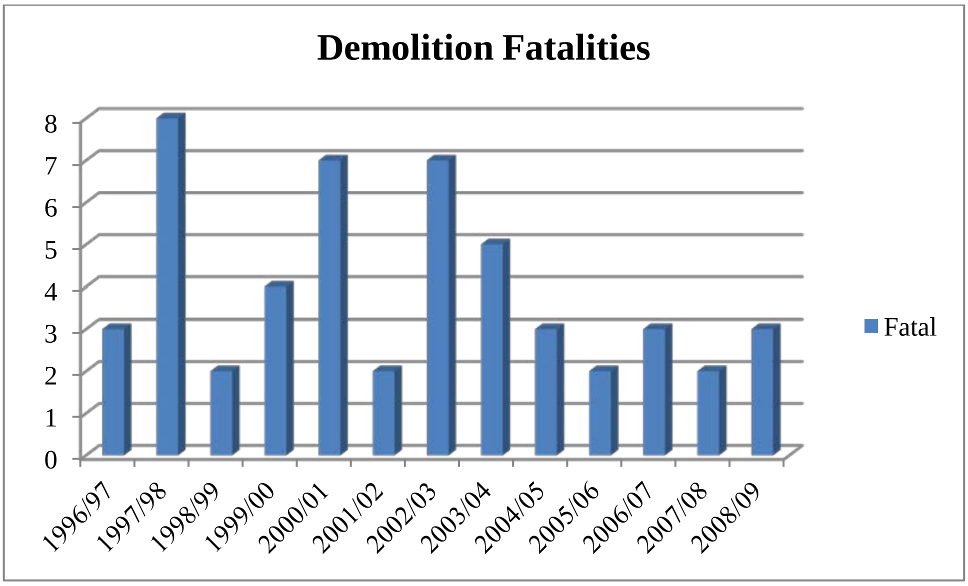

Figure 2.8. Demolition Fatalities, (Tunnicliffe, 2010)

These figures may not appear to represent a significant shift in safety performance for the demolition sector, but it is noteworthy that this sector represented a mere 1% of the overall construction workforce in the UK at this period. So, the demolition sector does appear to have a disproportionate accident rate compared to construction as a whole.

2.4.6. Significant Causes of Accidents

Falls from height has remained the number one cause of fatalities in the construction industry with 'struck by' accidents being the next largest. Bomel (2004) states that during 1996 to 2002, 12% of the fatal injury accidents were due to construction workplace transport. It is also recognisable that plant and vehicle use in construction has increased over the years and although technology has provided certain safeguards, the human element controls the operations. In the demolition sector, this usage of heavy plant, in particular, has transformed the efficiency of work and has allowed the industry to reduce the number of operatives needed to perform many of the traditionally manually operated tasks. However, removal of one hazard, i.e. manual handling may have been replaced with another, that of being 'struck by' workplace transport/machinery. When combined with human error, we have what may commonly be described as a man machine interface or human machine interface. Duffy et al (2003) defines such an error as something that has a consequence that results in some measurable effect he states, '*the path to the present is littered with the mistakes and errors of the past, most of which we did not foresee or simply did not believe could happen*'. Errors in judgement, operation, system applications or design etc, will always occur in situations requiring instant or hurried decisions. Haslam et al (2003) found that 70% of the accidents studied had arisen from problems related to worker actions, behaviour or capabilities. Shaw (2002, p1-7) speaks of human factors, which he defines as referring to "*environmental, organisational and job factors and human and individual characteristics which influence behaviour at work in a way which can affect health and safety*." He suggests that 80% of accidents are attributed to human causes and that this is a trend likely to increase in proportion to the reliability and probable sophistication of the hardware tools. However, there is a need to 'manage' the factors that influence human performance. Examples of which are; fatigue and shift work, communication, risk perception/risk taking behaviour, health and safety culture of the organisation.

2.4.7. Risk and Risk Taking

One of the most emotive factors regarding accident causation is the propensity for risk taking or risk perception. A common theme found in many risk management publications is that human fallibility and the propensity to take risks are two of the root causes of accidents. Trimpop and Wilde (1994) suggest that people willingly take risks and offer the example that gamblers may not like losing, but they do like gambling. Outside of the casino, gambling and losing could be referred to as having an accident. Errors of judgement are themselves common amongst all of us at some stage in professional and or social lives and it could be reasoned that for the most part we would wish to eliminate or reduce these errors or mistakes. However, it is only when those errors lead to injury or death that the magnitude of the act becomes evident. Whilst society may accept a certain amount of risk as being normal, i.e. the uncertainty of injury whilst playing rugby etc, being injured as a spectator at a rugby match may be less acceptable. Duffy et al (2003) sum up this notion as describing events as either voluntary risks, those daily activities such as driving to work or catching a train and involuntary risks, such as a doctor or hospital making a mistake or a tanker or chemical plant exploding. Trimpop and Wilde (1994) elaborate further by suggesting that those who consider human error to be the principal cause of accidents advocate safety measures that reduce the likelihood of nasty surprises by signposting dangers or by improving managing skills, whereas those who favour the gambling explanation conclude that the only way to diminish the casino's profits is to reduce either the amount of gambling or the stakes for which people play. Should the two perspectives be combined, could progress be made in reducing accident losses by measures to improve the ability to calculate the odds? Trimpop and Wilde's (1994) theory suggests not, as where risks are taken, losses will result; giving gamblers better information is unlikely to reduce their losses. With better information they are likely to reduce not only the occasions when the risks are run but also the occasions when they are too small to be of consequence. Duffy et al (2003) also point to analysis and quantification of human error probability (HEP). If we are interested in determining whether we are learning from our mistakes and whether there is a minimum achievable rate for human error, there could be a rate below which error cannot be eliminated in a system or design in which there is human intervention or reliance. This balancing act can be defined, as shown in Figure 2.9, where it is likely that the theory may reflect that:

- Everyone has a propensity to take risks
- This propensity varies from person to person

- This propensity is influenced by the potential rewards of risk taking
- Perception of risk are influenced by experience of one's own and others losses
- A person's risk taking decisions represent a balancing act in which perceptions of risk are weighed against the propensity to take a risk
- Accident losses are by definition a consequence of taking risks. The more risks a person takes the greater, on average, the losses
(Trimpop and Wilde, 1994).

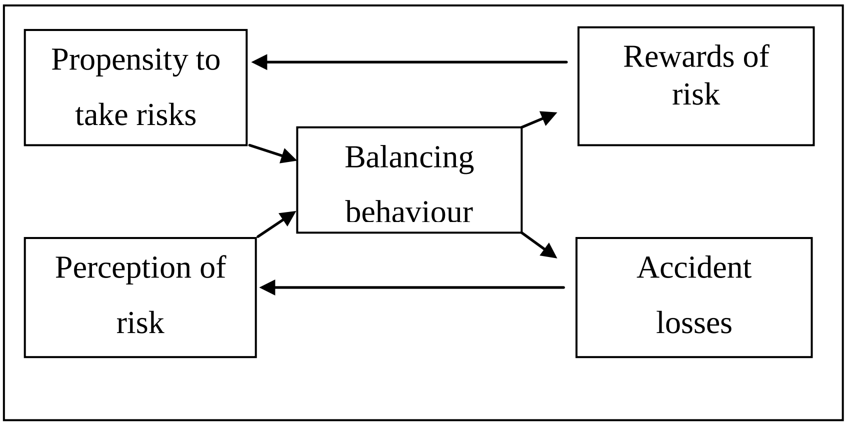

Figure 2.9: A Risk Compensation Model, (Trimpop and Wilde, 1994)

2.4.8. Designing out Risk

Just as a better understanding and involvement by designers of the built environment can influence and enhance sustainability, so too can this context be transferred to worker health and safety during the construction phases. Designers have a key role in designing structures that are safer and healthier to build, maintain and demolish (Habilis, 2004). A recent research project conducted on behalf of HSE has clearly identified that almost half of all accidents in construction could have been prevented by designer intervention and that at least 1 in 6 of all the incidents investigated, during this study, were at least partially the responsibility of the lead designer in that opportunities to prevent incidents were not taken (Habilis, 2004). This is not to say that all risks associated with the construction process can be designed out, for example, falls from height may not be able to be designed out as long as there is a requirement to build upwards and for personnel to access these heights. However, designing in component parts or systems that make the process inherently safer without say the use of external safety implements or tools, i.e. scaffolding/access equipment, may improve risk ratings and reduce significant hazards associated with erection and dismantling. If the Habilis (2004) report statistics are translated across the annual accident statistics for year 2008, this means that 1/6 x 72 = 12 deaths that year could have been prevented by designer action. Haslam et al (2003), in a previous research survey, also focused on the possible contribution of design in the analysis of the accident study data. The research concentrated on four types of designer, as shown in Figures 2.10 to 2.13, i.e. ‘permanent works designers, materials designers, temporary works designers and equipment designers.

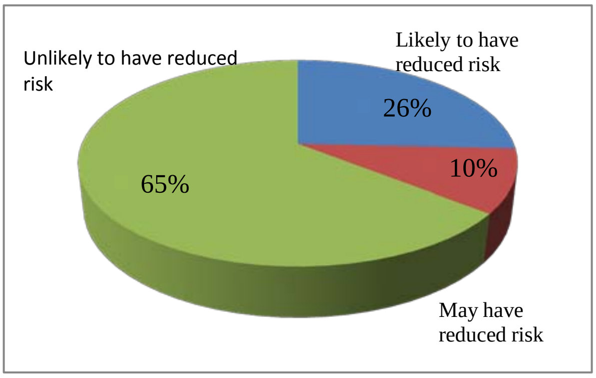

Figure 2.10: Permanent works designers

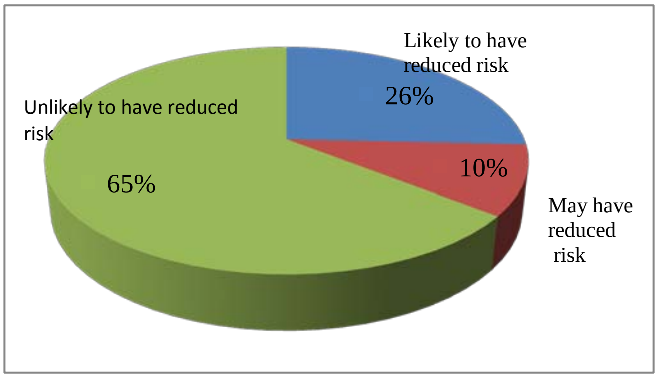

Figure 2.11: Materials designers

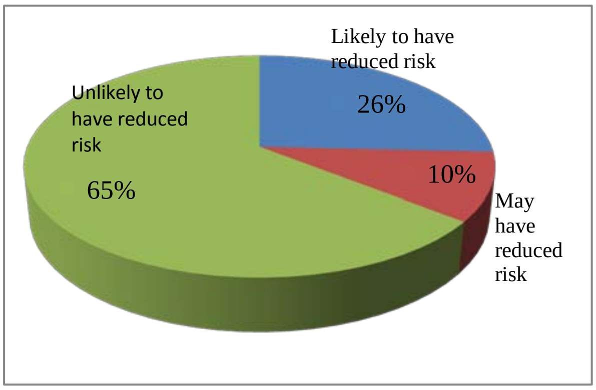

Figure 2.12: Temporary works designers

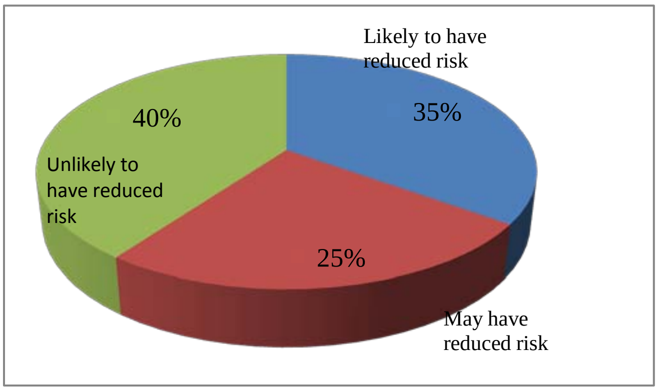

Figure 2.13: Equipment designers

Figures 2.10: to 2.13: The Influence of Designers (Haslam et al, 2003)

2.4.9. Influence of Legislation on Designers

The notion that designers could greatly influence the reduction of accidents culminates legislatively at least, in the Construction (Design & Management) Regulations (CDM). If the thinking, within the enforcing authorities in the early 1990's, was that designers had a large role to play in influencing the safety of construction processes, it should come as no surprise that research projects corroborate this fact. However, Haslam et al (2003), in a survey conducted for HSE, point out that the CDM regulations were seen by some as poorly understood or incorrectly addressed by clients and designers. Habilis (2004) also points out that case law suggests that consultant engineers and architects should have no involvement in the construction processes even when the methods chosen by the constructor threaten safety. Therefore, there needs to be greater clarity in relation to legislative changes before designers can be made to act more prescriptively.

Changes to the CDM regulations were released in 2007 to enhance and highlight the responsibilities incumbent upon the client in particular and also the CDM coordinator in ensuring that relevant and significant health and safety information regarding the project was available. It was noticeable that little was changed regarding the role of the designer other than to take account of specific hazards which may cause a risk and to point to an adherence to the Workplace (Health, Safety and Welfare) Regulations 1992. Kind (2006) points to a lack of clarity about what health and safety design requirements fall exclusively within CDM 2007 and are not contained in other regulations, particularly those assessed under planning and building regulations approval requirements. He further notes that it is unclear how the business person in the role as client, especially the small business and one-off occasional client, can ensure what is to be built is compliant with the design elements in the CDM 2007 regulations and be safe when built (Kind, 2006). When assessment of a designer's ability to understand occupational safety is at issue, Carpenter (2006) brings in to question the competency levels of individual designers and corporations stating that a competent person is a person who can demonstrate that they have sufficient professional or technical training, knowledge, actual experience, and authority to enable them to:

- Carry out their assigned duties at the level of responsibility allocated to them
- Understand any potential hazards related to the work (or equipment) under consideration
- Detect any technical defects or omissions in that work (or equipment), recognise any implications for health and safety caused by those defects or omissions, and be able to specify a remedial action to mitigate those implications

(Carpenter, 2006, p17)

2.4.10. Influencing Behavioral Changes

Getting designers to 'buy' in to these fundamental health and safety issues must be at the forefront of any foundation training given to any person or organization involved in design or the procurement of the construction process. Universities, colleges and institutes would therefore be required to include this element within the syllabus and achievement criteria; but many courses already do so if accredited by professional institutions like the ICE and CIOB. Carpenter (2006) identifies that the adequacy of competence and resource cannot be precisely determined. The best one can set out to do is to set some benchmarks, guidelines and requirements which, generally speaking and with sensible judgment, will ensure that those which satisfy them will be of a suitable minimum standard. Although this approach may be simplistic it will create the certainty, efficiency and cost effectiveness that the construction industry needs. As Carpenter (2006, p9) further points out, the intent is to '*eliminate the incompetent, not to identify the most competent*'.

It would be unfair to attribute all the blame for accidents, in construction, on designers although there probably is some culpability. Trimpop and Wilde (1994) have a totally different view on accidents and risk taking in general, stating that risk taking is a genetically determined, evolutionary stable, intrinsically supported and even extrinsically rewarded behaviour on the physiological, emotive and cognitive level; it is therefore illogical to attempt to reduce accidents by preventing people from such a highly-rewarded activity as risk-taking. Whilst this view, at first glance, may appear to be extreme it is founded on the principles that human behaviour is dependent on and largely driven by risk taking and risk assessment for business and social enterprise. Trimpop and Wilde (1994) recommend that instead of trying to eliminate risk taking, there should be a change in risk taking behaviour which would be based on the following:

- An individual assessment of risk seeking tendencies
- The specific way risk taking is individually expressed
- Understanding the variables in different situations that trigger, encourage or discourage certain types of behavior
- On the design of possible alternative risk taking behavior, which fulfill evolutionary controlled needs, without threatening societal values

(Trimpop and Wilde, 1994)

Green (1997) explores many theories on accidents and causation, putting forward an interesting point that there are no absolute ways to measure the success of accident prevention, as gains in reducing accident rates may be offset by losses in other prioritized areas of health or emotional well being, but there is some evidence that engineering and enforcement strategies can have a demonstrable impact on mortality rates for specific causes of death. However, Green (1997) has little faith in the development of education strategies as the major way in preventing accidents, stating that collected statistical data on risk factors for accidental injury are gathered from populations with a bias towards particular social and demographic factors (such as social class, gender, age and occupation). Green (1997) goes on to argue that to develop educational strategies is to imply that the risks can somehow be personalised and that individuals can alter their chance of having an accident. These views may not necessarily be welcomed by the enforcing authorities whose aim has traditionally been to encourage the development of a 'safety culture' within an environment of learning and education at all workplaces.

Haslam et al (2003) found that 70% of the accidents studied had arisen from problems related to worker actions, behaviour or capabilities but can this be generalised? Dekker (2002) theorises that the 70% human contribution to failure occurs because complex systems need an overwhelming human contribution for their safety and that human error is the inevitable by-product of the pursuit of success in an imperfect, unstable, resource-constrained world. Dekker (2002) expands the statement further by stating that to eradicate human error (to depress or reduce the 70%) would mean to eradicate or compromise human expertise – the most profound and most reliable investment in system safety and success. The author also puts forward strong views on the significance of human contribution to accidents and incidents which are illustrated in Figure 2.8.

Table 2.8: Two views on human error (Dekker, 2002, p.67)

The old view of human error	**The new view of human error**
Human error is a cause of accidents	Human error is a symptom of trouble deeper inside a system
To explain failure, you must seek failure	To explain failure, do not try to find where people went wrong
You must find peoples inaccurate assessments, wrong decisions, bad judgements	Instead, find how people's assessments and actions made sense at the time, given the circumstances that surrounded them

Reason (2000, p768-9) also has similar views on human error stating that they can be viewed in two ways; the person approach and the system approach and that understanding these differences has important practical implications for coping with the ever present risk of mishaps. Reason (2000) argues that far from being random, mishaps tend to fall into recurrent patterns. The same set of circumstances can provoke similar errors, regardless of the people involved. He further advises that countermeasures are based on the assumption that we cannot change the human condition, but we can change the conditions under which humans work. This is an argument that fits in well with making the changes to work environments to eliminate or at least reduce the risk of system or human failure by initial or continuing changes to design.

2.4.11. The Influence Network

The views expressed by Dekker (2002) and Reason (2000), particularly in terms of accident investigation, could contribute to a difference to the outcome of any ensuing investigation into causation, dependent on the line taken by the investigator. The factors and variants leading up to and as a direct causation of accidents and incidents can often be subjective, but more usually are likely to be from a tangible source. The severity of the outcome of an accident often depends on chance if organisations fail to identify hazards and control risk (HSE, 1997). For example, if a person slips on a patch of oil leaked from a machine, the consequences may range from soiled clothing to fatal injury (HSE, 1997). The fact that there are subsequent hazards or concerns to be taken into consideration for most events cannot be marginalised. The leaking oil in this case is an obvious fire hazard and/or may contribute to an expensive breakdown of the machine. However, one may evaluate that the largest error, if the oil spill was left unattended, is that served by human inactivity or ignorance. Dekker (2002) advises that human error is not just about humans, it is about how features of people's tools, tasks and environment systematically influence human performance. Research on accident causation has in the past identified all manner of influences. Two further underlying principles are the propensity for human error or the omission of relevant factors that would, or could, have a made a difference. For example, Haslam et al (2003) identify workers concerns regarding the 'next day effect' of high alcohol intake on work colleagues, highlighting the lack of clarity regarding 'competency'; too much emphasis was placed on certification, rather than on site conditions and tools or equipment. Bomel (2003) investigated the causes of over 1,000 serious accidents reported via RIDDOR, applying the principle of 'Influence Network' and combining the many facets that make up the reasons for accidents into four main categories that extend from a central point where there is a human and technical systems interface, which expand like the ripples on a pond to external factors as shown on Figure 2.14.

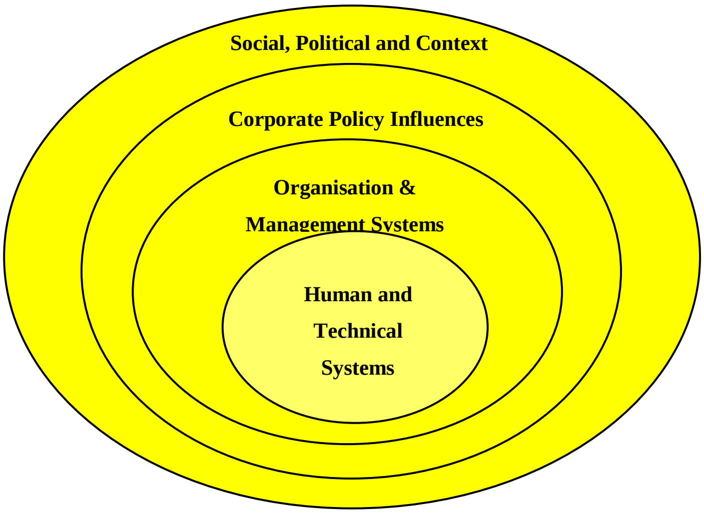

Figure 2.14: Influence Network model (Bomel, 2003, p65)

Bomel (2003) further simplifies the Influence Network as it ripples outwards. At the centre is the event that is being considered, that of a construction related accident. This is the 'stone that hits the water' and directly below is the direct causal level made up of human, hardware and external factors, i.e.

- Direct performance influences – these directly influence the likelihood of an accident being caused.
- Organisational influences – these influence direct influences and reflect the culture, procedures and behaviour promulgated by the organisation
- Policy level influences – these reflect the expectations of the decision makers in the employers of those at risk and the organisations they interface with (e.g. clients, suppliers and sub-contractors).
- Environmental level influences – these cover the wider political, regulatory, market and social influences which impact the policy influences.

2.4.12. Data Collection or Decision Making

The Bomel (2003) report is an attempt to qualify and categorise the factors that had a direct influence on accident causation of 1,000 accidents and although these may be said to be fairly representative, it is a broad-brush approach to data collection and analysis. It also conveniently organises the people involved in these accidents into identifiable categories within a simple hierarchy sampling frame, i.e. site operatives, management, client contract organisations and local or central government stakeholders. However, it would be unfair and inaccurate to dismiss the relevance and usefulness of such reports as they also document opinions from those who were directly involved, notified or dealt with the actual events. Studies of this kind tend to reinforce previous data gathered on the kinds of accidents that are prevalent in a construction environment, of which slips, trips and falls on the same level and handling or lifting injuries are the most common. The HSC's strategy for workplace health and safety to 2010 and beyond (HSC, 2004) indicated a number of initiatives to which HSE and Industry would be active in achieving. HSE in coming to terms with its limitations stated that the "*HSE's role is to stimulate, orchestrate, audit, assure and take appropriate action when things go wrong – reserving its involvement for that which it can do*" (HSC, 2004).

2.4.13. Summary

The literature and published data regarding accidents and accident causation is vast and this literature review has provided an overview. What is all too apparent, from the investigation of some of this data, is that the reasons for people having accidents or being involved in the process of accidents cannot be attributed to one or even several factors; it can be as diverse as the range and nature of the accidents themselves. The reasons for this phenomenon may be varied, but they are just as damaging to individuals, organisations, industry sectors, government and society as a whole. Experts in the field of human nature argue for human error, ignorance, risk taking tendencies, behavioural patterns etc., whereas others point to inadequacies in the design of products, materials, the workplace, built environment and waste management principles. However, beyond all doubt is the realisation that accidents at work are an expensive burden on employers, industry and society overall.

The propensity for accidents to happen at work has not appeared to greatly diminish despite the number of workplace safety initiatives delivered by UK Government and industry in general to try to understand, quantify and prevent accidents occurring. Industry's role must surely to be supportive of all initiatives that may influence a reduction in accidents and incidents, whilst providing a safe and structured working environment that will reduce the frequency and likelihood of incident. As for the employees/operatives, perception of the risk and poor decision making are frequent examples given within much of the available literature; others include inadequate competency levels and lack of training. One is drawn to concluding that those who are empowered with knowledge and information would be better equipped for decision-making than those who are devoid or excluded from this process. In a technologically-advanced world operatives have been replaced, in some areas of work, by machines which have over the preceding years contributed greatly to a reduction in workplace accidents.

The information gathered has highlighted a number of potential issues that need further exploration:

1. Can further advances in technology provide the design, machinery, methodology or framework to increase safety factors and reduce risk?
2. Could design for deconstruction be the answer to a reduction of significant hazards arising from demolition and waste handling?
3. Do designers of products, materials and the built environment need to be brought under the influence of more or stricter legislation to reduce significant hazards arising from use or workplace activities?
4. Does the desire to improve on and drive through sustainability and sustainable development initiatives have an impact on accident occurrence, risk taking or behavioural patterns?
5. Have we reached the limitation to which man can reduce accidents at work given the nature and number of projects undertaken, the natural tendency for risk taking in business activities, the human psyche and societies desire to expand mans influence on the planet?

Two further research questions have also been identified:

1. If design, at all levels, can have a major influence on how we manage our activities should it be obligatory for designers to accept a greater level of responsibility than at present?
2. If the significant risk of an accident occurring is increased by the introduction of the man in the workplace, is it reasonable to expect that the recovery of building components take second place to efficient and effective work methods where safety factors can be increased and sustainability initiatives be decreased?

2.5. LEGISLATION in the UK CONSTRUCTION INDUSTRY

2.5.1. Introduction

Most statutory legislation applied in the UK is derived from laws set by the European Parliament in the form of directives. This section of the chapter identifies some of those laws and the relationship between applying legislation, understanding its inference, as well as what measures should be taken in complying with the law and its further relationship with risk taking and risk management.

2.5.2. The Health & Safety at Work etc Act 1974

In the UK, in terms of Health & Safety legislation, the most sophisticated piece of legislation is the Health and Safety at Work etc Act 1974 (HSWA); this is the primary piece of legislation covering Occupational Health and Safety in the United Kingdom. The Act was made by Parliament and came into force on the 31st July 1974 (HSE, 1974). It is a testament to its accuracy and potency that the longevity of the Act has in no way been compromised and that little by way of revision has been needed. The last new schedule to be added to the 1974 Act was in 2008 under Schedule 3A Offences: relating to 'Mode of Trial and Maximum Offences' given to or applied to offenders who contravene the Act (HSE, 2008). HSWA has three main parts although only part 1 (covering health, safety and welfare), which forms the main crux of the legislation, is of particular interest for the construction industry and demolition sector. The Act is completely prescriptive and sets out the duties expected of an employer, employee and supplier or manufacturer of goods or products to be used on or at work places. Prior to the 1974 Act, the general approach to industrial/commercial safety had been based on legislation enacted in a piecemeal fashion over the past 100 years. Acts of Parliament were passed to deal with particular hazards and work activities as they came to light, either through injuries or peer group protests. However, although there was a vast amount of legislation millions of workers were not covered by law in the course of their employment and there was no statutory provision for the protection of the public.

2.5.3. Robens Report

In 1970 the Government set up a committee, chaired by Lord Robens to review the situation of health and safety at work. The fundamental conclusion was that there were severe practical limits on the extent to which progressively better standards of safety and health at work could be brought about through negative regulation by external agencies; a more effective self-regulating system was called for in the acceptance and exercise of appropriate responsibility at all levels within industry and commerce. Robens (1972) also called for better systems of safety organisation, more management initiative and more involvement of work people themselves. The findings recommended the introduction of measures to reform the regulation of health and safety in British workplaces. Treated as a radical departure from traditional approaches to health and safety regulation, the Report's recommendations were largely enacted in the Health and Safety at Work etc Act 1974. This Act also established the Health and Safety Commission (HSC), Health and Safety Executive (HSE) and the Employment Medical Advisory Service (EMAS) all of which play a part in assuming responsibility for achieving compliance with its provisions. The previous Factory Inspector role, with its limited powers, was removed under this legislation and the present Safety Inspectorate was introduced, via the HSE. The new Inspectorate was given wide-ranging powers with an ability to enter any work premises, question any person, seize any evidence, stop or suspend work activities and prosecute through the courts where necessary. The HSE can be said to be the custodian of the workplace acts and regulations with an official list, (current at Spring 2010) of 17 separate Acts, 192 Regulations and 77 legal publications to which they may be considered to own and enforce (HSE, 2009).

2.5.4. Workplace Regulations

There have been many changes to work place practices since the HSWA, none more so than in the demolition industry sector, with some of those changes brought about by legislation and the need to reduce accidents and incidents. Yet detailed recording of accidents at work did not occur until the introduction of the Reporting of Injuries, Diseases and Dangerous Occurrences Regulations 1985 (RIDDOR). The 1986 figures from RIDDOR suggest that 11,521 over 3 day accidents were reported rising to 14,824 by October 1990 for all employees in all industries (Warwick, 2005). With the introduction of RIDDOR, despite its obvious reliance on an honest approach to reporting, came the opportunity for all stakeholders to evaluate their workplace performance in terms of accident or incident. For many this may have been a defining period and a wake-up call to look at their operational systems, risk evaluations and control measures. It is certainly true that after the HSWA in 1974, there has emerged a raft of workplace Regulations. Amongst those, with particular emphasis on construction and demolition activities, listed by date, are:

Health and Safety (First Aid) Regulations 1981
Manual Handling Regulations 1992
The Workplace (Health, Safety & Welfare) Regulations 1992
Personal Protective Equipment Regulations 1992
Reporting of Injuries, Diseases and Dangerous Occurrences Regulations 1995
Lifting Operations, Lifting Equipment Regulations 1998
Provision and Use of Work Equipment Regulations 1998
Management of Health & Safety at Work Regulations 1999
Control of Lead at Work Regulations 2002
Control of Substances Hazard to Health Regulations 2002
Control of Noise at Work Regulations 2005
The Control of Vibration at Work Regulations 2005
The Work at Height Regulations 2005
Control of Asbestos Regulations 2006
The Construction (Design & Management) Regulations 2007

Other regulations that may be relevant will depend on the work process or work place, but what should be noted is that all Health & Safety Regulations have statutory force, conferred by section 15 of the HSWA (HSE, 1974).

2.5.5. The English Judicial System and European Law

An overview of the judicial system in England and Wales is shown in Figure 2.15. Ashworth (2006) points out that there are 250 County Courts around the country which deal with civil matters and around 120,000 solicitors and 14,000 barristers in England and Wales. It is also worth noting that a completely new source of English law was created when Parliament passed the European Communities Act 1972. Section 2(1) of the Act provides that:

> *All such rights, powers, liabilities, obligations and restrictions from time to time created or arising by or under the Treaties and all such remedies and procedures from time to time provided for by or under the Treaties, as in accordance with the Treaties are without further enactment to be given legal effect or used in the United Kingdom shall be recognized and available in law and be enforced, allowed and followed accordingly* (Ashworth, 2006, p6-11).

Since the UK's entry into the European Community on 1st January 1973 it has been bound by community law which means that all existing and future Community law, which is self executing, meaning it does not require action by UK legislation, is immediately incorporated into English law (Ashworth, 2006).

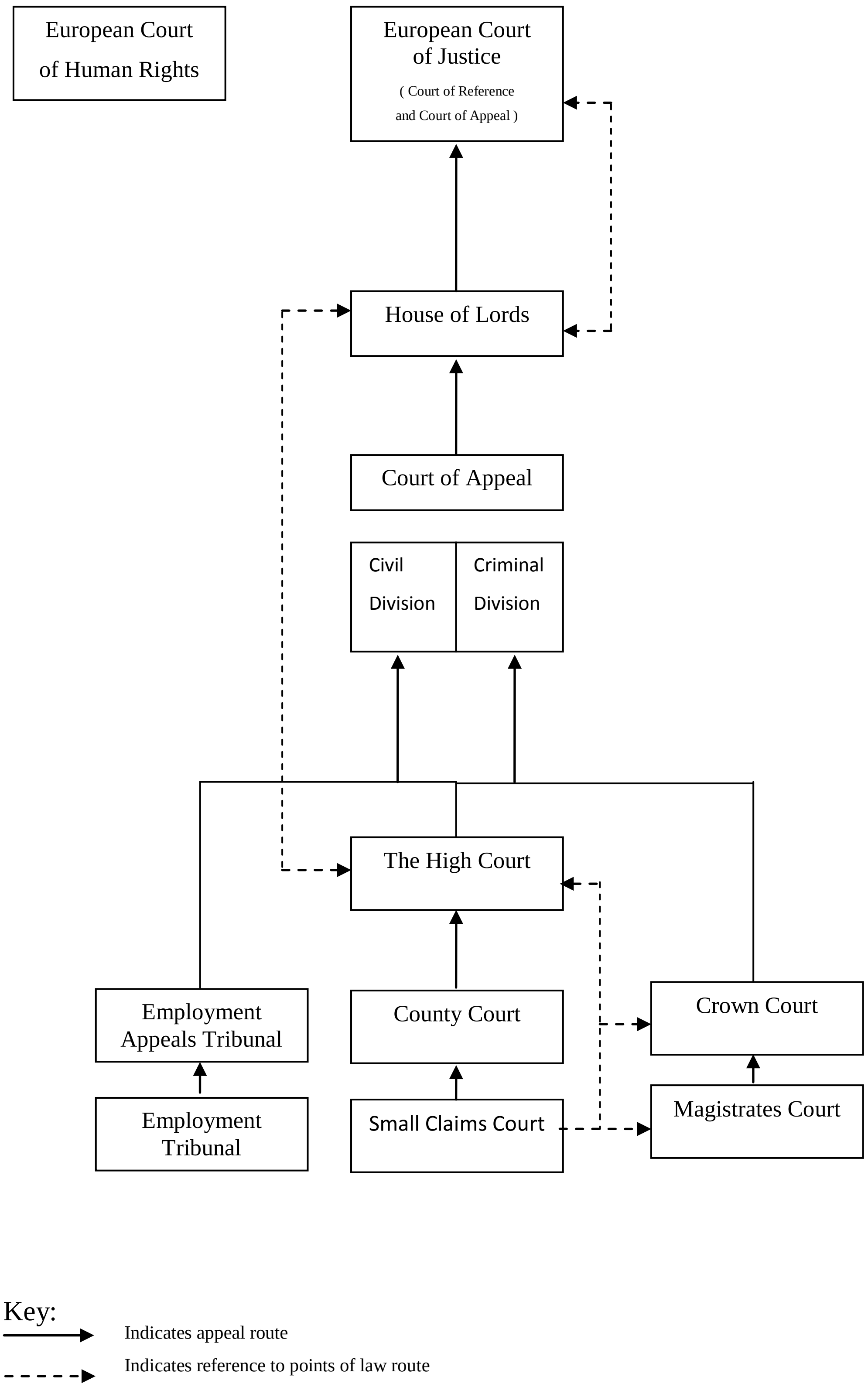

Figure 2.15: The Law Court System, England & Wales (Baker, 2007, p144-146)

2.5.6. Duty of Care

A breach of the duty imposed by health and safety regulations is subject to penalties under the HSWA Section 13. There is also a reverse burden of proof under HSWA section 40 which states that it is for the person or persons under the duty to ensure 'so far as is reasonably practicable' that the steps they took were reasonably practicable (Barber, 2002). Duties of care may exist towards persons other than direct employees and this gives rise to liability for injury, loss or damage suffered by such persons. Prior to HSWA 1974 a breach of duty imposed by health & safety statutes commonly gave rise to civil liability as well as criminal liability. Following the introduction of HSWA, Parliament moved that there is no civil liability for a breach of the general duties. However, individuals may be pursued directly for damages if they personally owed and have been in breach of a duty of care. Civil Law is concerned with compensating injury whilst Criminal Law is concerned with punishing fault (Barber, 2002).

If, in the case of an injured party having suffered injury or loss due to the actions of another party, then under civil law the claimant may bring an action against the defendant for negligence (tort). Where a statutory breach of duty has occurred, the claimant may also bring a case for breach of statutory duty in addition to the claim for negligence (Baker, 2007). However, in order to establish a claim for breach of statutory duty, the claimant must be able to establish in proceedings that:

- The defendant was in breach of their statutory duty;
- The breach caused the injury or loss;
- The claimant was a class of person the statute was intended to protect; and
- The type of injury was of a type that the statute was intended to prevent;

(Baker, 2007, p144-146)

The defendant, in most cases the employer, does have certain arguments to put forward in their defence, but one should always be aware of a most important aspect of negligence, that of the law of 'vicarious liability'. This relates to an employer being liable for the wrongdoings of the employee acting in the course of his or her employment.

2.5.7. Case Law and the Duty of Care

A further important aspect of law is what is referred to as 'Case Law' or Judicial Precedent. This is the result of the decisions made by judges who have laid down legal principles derived from circumstances of the particular disputes coming before them. This doctrine of judicial precedent is known as *stare decisis,* which literally means 'to stand upon decisions' (Ashworth, 2006). In the UK, case law generally sets the principles of whether a duty of care has been breached. Currently the leading case law is Caparo Industries plc v Dickman and others (1990) AC 605 which formulated a single general principle for deciding whether a duty of care existed. This is known as the 'three stage test' for the imposition of a duty of care in tort (Adriaanse, 2005). The basis for the test was that for one party to owe a duty of care to another the following must be established:

- Harm must be a "reasonably foreseeable" result of the defendants conduct
- A relationship of "proximity" between the defendant and the claimant
- It must be "fair, just and reasonable" to impose liability

(Adriaanse, 2005, p253)

Although the case of Caparo v Dickman related to the takeover of a company following the incorrect auditing of the accounts the principles of the duty of care are the same whether it be a personal injury or financial. One of the most significant aspects of the three stage test being; 'is it fair, just and reasonable that the law should impose a duty of care'. Employers would obviously want to test this notion when contesting any action.

2.5.8. CDM Duty Holders

Duty of Care is a common theme running through most of the UK Workplace Regulations. In terms of the construction regulations, the best example of this can be found in the CDM Regulations which comprehensively detail the duty holders' responsibilities (CDMR, 2007). The principal duty holders being:

- The Client
- The Principal Contractor
- CDM Coordinator
- The Designer

The current CDM Regulations came into force on the 6th April 2007 and are structured into five parts with a further five schedules setting out particular administrative requirements. The CDM Regulations are unique in that in all other health & safety legislation refers to the employer as bearing the brunt of the responsibility, whilst CDM uses the term 'Client' as head of the procurement chain (Baker, 2007).

2.5.9. CDM and the Designer

Whilst it is understood that the client has a major part to play in ensuring that each duty holder conforms to the requirements of the CDM Regulations and that matters of health, safety and welfare are adequately addressed, the role of the designer is also paramount. Designers have a key role to play in designing structures that are safer and healthier to build, maintain and demolish (Habilis, 2004). In 2004, the CIC issued their guidelines for designers outlining the duties relating to adherence to CDM 94, which was updated in October 2009. A part of that guidance reads as follows:

> In order to make provision for the safe construction, operation, maintenance and demolition of buildings and structures, designers will need to develop their awareness of the following:
>
> a) Common hazards
>
> b) The construction and demolition processes
>
> c) Requirements for provision of safe temporary works equipment
>
> d) Potential for harm of materials they specify
>
> e) Processes, which can release potentially harmful agents
>
> f) Potential for harm in the activities carried out by others

Without such awareness, it is doubtful whether designers could satisfy the requirements of the CDM Regulations (CIC, 2004 p2-3). Thorpe (2005 p26) states that:

> *Designing for safety is not a standalone consideration, but an integral part of the wider design process. The more widely this is recognized and catered for within design planning, the safer it will become to construct and maintain structures and facilities …everything after the design stage is essentially concerned with meeting design requirements. If the basic design is flawed, the final result will be*

compromised, possibly with far reaching, or even disastrous consequences. It is important that designers do not abdicate their responsibilities and leave things to the contractor, when a little dedicated effort could make a great deal of difference.

How or what the designers ultimate role will evolve into, in securing a safer and healthier workplace, may be determined by the appliance of such as CDM, although adherence to one regulation, or even one concept, will never be enough. The construction process involves a myriad of different disciplines, materials, processes, financial and social aspects that require the input of teams or individuals to bring to fruition the desires and objectives of others.

2.5.10. Contract Conditions

The UK's workplace regulations cascade down from the Health & Safety at Work Act 1974, their main aim being to set down a prescriptive set of rules for employers, employees, the self employed, suppliers of goods and equipment and in some instances owners or managers of workplaces and contract award. It is these latter two points that would seem to be the most misunderstood when it comes down to addressing corporate or individual responsibility. There is little doubt that with the coming of the Construction (Design & Management) Regulations 1994 (CDM) a greater degree of clarity was given to this subject, in that for the first time individuals controlling the demolition or construction process were identified by their roles and their unique responsibilities within that role. For the demolition industry this was a welcome and long awaited statutory instrument, albeit having a number of flaws. CDM, in brief, demanded that the client appoint persons or groups of persons to address the issues of safety, welfare and occupational health on all contracts to which they were placing or managing. In addition, the client had also to ensure that they or their nominated associates produced an adequate and relevant amount of information regarding the project for their contractors to assess any risks and design implications prior to commencement of that project. Up to this period of time those issues were largely undertaken by the individual contractors tasked with each stage of the project and it is not difficult to speculate as to what degree of expertise or success was achieved, particularly given the number of recorded accidents and incidents, over a number of years, attributed to the construction industry.

Following a lengthy review of the CDM Regulations, commencing in 2005 and culminating in their revision in April 2007, they still maintain the closest link of any statutory instrument in stipulating the requirements for individuals to address all issues regarding the health, safety and welfare of all on site. However, as with all regulations there is a degree of ambiguity in the interpretation, despite the level of prescription, and unless the project players are fully aware of all stipulations personal perceptions may vary their execution. Indeed, with the growing awareness for environmental management to be integrated into project terms and conditions the contractor may invariably find that he/she needs to manage this process at his/her own expense and in the time frame dictated by the contract to which it is tied. This is not to suggest that all clients and or clients' administrators offer little or no support in these matters. There are many such supportive institutions that give a great deal of thought to the sustainable agenda. From the number of stakeholders one may identify from the world of academia, commerce and industry, it would seem that the UK is a world leader in moving along the sustainable development strategy path. However, operational experience from a contracting environment would suggest that there are equally as many that do not, offering nothing other than lip service.

The part that individuals, operating within a construction environment, have to play is as large a task as they care to make it. We are reminded, at frequent intervals through press and government sources etc, that the construction industry per se produces around 90MT of CD&E waste each year and that around 50% of that volume is sent to landfill (DCLG, 2005). Therefore, the construction industry has a major role to play in helping to reduce such waste by reducing the volumes created in the first instance and managing the reclamation and recycling of the remainder more efficiently and effectively. One answer to this conundrum is to design, manufacture, build and sustain the buildings and structures of the future to better utilise components and materials and assist in their eventual demolition. This may necessitate a change to the conditions of work e.g. through contract conditions or legislation constraints that demolition contractors, in particular, are subjected to in the allowance of greater flexibility in terms of time and effort regarding meeting sustainable demolition targets.

2.5.11. Risk Management

The elimination or reduction of risk is a prime objective of workplace Acts and Regulations. However, the complete elimination of risk is not desirable from a business risk management point of view where a certain level of risk taking in business is necessary to survive. Instead, it is dependent on how you manage it. Risk is both positive and negative in nature and effective risk management is as much about ensuring that opportunities are not missed, as it is about ensuring that inappropriate risks are not taken (Smith et al, 2006). This particular train of thought was highlighted in the 'Turnbull Report' of 1999 where it was stated that:

> *A company's objectives, its internal organisation and the environment in which it operates are continually evolving and, as a result, the risks it faces are continually changing. A sound system of internal control therefore depends on a thorough and regular evaluation of the nature and extent of the risks to which the company is exposed. Since profits are, in part, the reward for successful risk taking in business, the purpose of internal control is to help manage and control risk appropriately rather than to eliminate it* (Turnbull, 1999, p5).

This is an element of risk assessment that is often forgotten by safety professionals whose main desire is the elimination of risk altogether. However, it is a fine balancing act that is performed by most companies to manage risk taking on the business front whilst eliminating it where possible for personnel activities.

Risk is very much related to personal attitudes. Smith et al (2006) suggest that there are two main categories of people, the risk takers and the risk avoiders; risk takers tend to underrate risk, while the risk averse see all the obstacles and tend to overrate risk. Fortunately, we generally find that people behaving in accordance with both categories are managing and working in project teams or companies. However, in a recent report for HSE it was considered that these two categories may be too stark and that they should be broadened into four more categories particularly when applied to sole traders and micro organisations (Brace et al, 2009, p194):

- Sensation seekers: the adrenalin junkies – they need the 'big stick' approach

- Sensation deniers: ignorant of risk through lack of experience or de-sensitised through continual accepting of risk – they need training, increased awareness and sadly possibly to experience or witness an accident before they will learn
- Sensation acceptors: cope with the ‘fear’ for beneficial outcome – these are the bulk of the sole traders and these are the main challenge that needs to be addressed
- Sensation avoiders: people for whom ‘No risk is worth the risk’ – no action is needed – they are probably not working in the industry in any case

The trick for managers, one may presume, is to identify members of the workforce in relation to these categories. It could be argued that the risk takers amongst the workforce may be less inclined to adhere to the requirements of the workplace Acts and Regulations than their risk-averse counterparts, although there is no evidence to point to this. A key and general objective of the Robens Report was to encourage employers to adopt a more systematic approach to the management of health and safety than had been previously evident. Yet it is debatable whether, without a ‘carrot or stick’, few will go out of their way to uphold the spirit of the law if they only have to do what they are obliged to do under the letter (Humphreys, 2007).

2.5.12. Risk Assessment

The UK workplace regulations are prescriptive by nature generally detailing, only a small amount of the duties expected of the employee in particular, whilst enlarging greatly on the duties imposed on the employer. An example of this can be found under section 14. Employee’s duties, of the Health & Safety at Work Regulations 1999:

> (2) Every employee shall inform his employer or any other employee of that employer with specific responsibility for the health and safety of his fellow employees -
> (a) of any work situation which a person with the first-mentioned employee's training and instruction would reasonably consider represented a serious and immediate danger to health and safety; and
> (b) of any matter which a person with the first-mentioned employee's training and instruction would reasonably consider represented a shortcoming in the employer's protection arrangements for health and safety (MHSWR, 1999 s3(1)).

2.5.13. Worker Participation and Understanding

One of the biggest stumbling blocks to getting the workforce to 'buy in' to safety legislation is the language. The employer, by virtue of overriding duties, must successfully interpret the language and convey that message to the workforce either personally or through a third party. In the event of an accident or incident occurring and the propensity for legal action to follow, ignorance of the law cannot be used as an excuse. HSE are keen to inform all grades of workers that they can expect punitive measures if they are found to be in breach of their statutory duty. However, it is no doubt an alien concept to most employees to report the misgivings of another to either their respective employers or the HSE. Workers who disclose information relating to health and safety matters now have statutory protection of employment rights in defined situations under the Employment Rights Act 1996 Part IVA as inserted by the Public Interest Act 1998 (Barber, 2002). HSE Inspectors, who themselves may have difficulty in conversing with non English speaking workers, for example, are given information on how to proceed via circulars such as OC167/12. This advises on the policy to be adopted to ensure compliance with, in particular but not constrained to, the Race Relations (Amendment) Act 2000. The document reminds the Inspector that:

> An employer has a general duty under HSWA section 2(2)(c) to provide their employees with such information as is necessary to ensure so far as is reasonably practicable their health and safety at work. Regulation 10 of the MHSW Regulations requires employers to provide information to employees which is comprehensible and relevant, i.e. capable of being understood by the person for whom it is intended and Regulation 15 requires certain information to be provided to temporary workers. (HSEOG, 2004).

The document also advises that:

> In the course of inspection or investigation visits, where all or part of the work force are non-English-speaking or have limited knowledge of English, inspectors should enquire how the employer is fulfilling their legal duties to provide employees with such comprehensible information as is necessary for ensuring their health and safety at work. Inspectors should not be concerned because it is a race related issue; it is the same issue as more generally ensuring provision for adequate communication, instruction and training in the workplace (HSEOG, 2004).

This is a very relevant and somewhat emotive subject matter for the construction industry at the time of writing, particularly with the numbers of eastern European workers currently in the industry (estimated to be around 100,000 workers for whom English is the second language in early 2011). The demolition sector is known to employ non-English speaking workers and employers must recognise the potential pitfalls in so doing if they fail to ensure that adequate supervision, information and training is given to these operatives. Current and or potential employers of non-English speaking workers would do well to heed the message embedded in the Management Regulations.

> Risk assessment:
>
> 3. - (1) Every employer shall make a suitable and sufficient assessment of -
>
> (a) the risks to the health and safety of his employees to which they are exposed whilst they are at work; and
>
> (b) the risks to the health and safety of persons not in his employment arising out of or in connection with the conduct by him of his undertaking (MHSWR, 1999 s14(2)).

2.5.14. Risk Analysis

Thorpe (2005) advises that risk assessments can be very subjective. What one person sees as a high risk situation may be seen by another as relatively low risk. Questions that need to be asked are:

- What is the likely effect of the risk? Could it lead to death, severe injury or harm of a minor nature?
- What is the likelihood of the above happening? Is it proportional to numbers of people exposed to the risk, length of exposure time, working environment and so on?
- What is the likely extent of the harm? Could many people be affected or just one person? (Thorpe, 2005)

Panopoulos and Booth (2007) explain that one issue that has been neglected in the literature is that employers may spend more than is strictly necessary on control measures, or squander money on, for example, preventative equipment that is not used in practice. Manifestly, cost-ineffective safety management erodes the business case and Panopolus and Booth (2007, p64-5) go on to suggest some examples of cost-invoking safety management failures (not necessarily susceptible to measurement):

1. Unsuitable and or insufficient risk assessments and accident investigations
2. Less than adequate ‘near miss’ reporting systems
3. Manual handling training that does not deal with the tasks that have to be performed
4. Behavioural safety programmes that provoke staff hostility and fail to reduce human failures
5. Unduly frequent safety inspections, noting also that, where there is a culture of willing compliance with safety procedures, formal inspections are less necessary
6. Successive senior management safety initiatives, often founded on fashionable panaceas, that promote cynicism
7. ‘Talking shop’ safety committees

For the smaller contractor, getting things right and staying on the side of the law can be a daunting or frustrating prospect if contract conditions and or constraints impose too great a burden. However, adopting risk management as part of the management philosophy, as Smith et al (2006) advise, depends very much on the people responsible for maintaining, performing and developing management guidelines. Failure to undertake risk management in an explicit and formal manner as a routine aspect of project management is regarded increasingly as commercially unacceptable.

2.5.15. Summary

Decades of refinement to subsequent workplace legislation has had a lasting impression on attitudes and approach to the reduction of accidents. However, the UK does not have exclusive rights to statutory workplace legislation as there is a significant influence brought about by the introduction of the European Parliament where the common goal is shared between the member states in the form of ‘directives’. The interpretation of the meaning to the directives is still fashioned in the form of ‘regulations’ and because these regulations are generally prescriptive they are often accompanied by ‘codes of practice’ which attempt to make sense of the jargon by giving specific guidance. The UK has also formalised some of this guidance which when intertwined with parts of the regulation has taken the shape of ‘duty of care’ a theme that runs through much of the workplace legislation. This duty of care is often the catalyst to prohibition or prosecution by either the enforcing authorities or public/private law suites taken up by the legal profession. In attempting to interpret the research available on the UK workplace legislation there are diverse opinions from safety professionals and legal experts on the value of the present legislation to adequately address the issues that lead to legal action from infringement of safety legislation. The introduction of the CDM regulations in 1994 and its subsequent revision in 2007 has helped greatly in setting out the responsibilities of the leading players in the construction sector, but has it gone far enough and is it being applied to its full extent?

A simplistic and somewhat obvious question to pose is that; “had not legislation been sufficiently developed to combat bad practice, employer capriciousness, employee indolence and societal attitudes would we not have made the obvious improvements to workplaces, safety culture and general worker wellbeing?” What has been identified is the manner in which these improvements have asked questions of stakeholders and what further improvements can be expected either through better understanding and interpretation of the statutory instruments, codes of practice and guidance documents that exist.

There are a number of other issues that should be addressed namely:

1. Are the current crop of workplace regulations adequate and relevant for today’s working environment given that in general they try to encompass as diverse a number of workplaces as possible?
2. Should new or future regulation be targeted at specific industry sectors, departments, groups of workers and or individuals to focus responsibilities, duties or best practices?
3. Has regulation become so prescriptive that it is irrelevant or useless to most organisations or individuals in managing their daily duties to employees, clients, the enforcing authorities or the public in general?
4. Does the fear of prohibition or prosecution get in the way of organisations or individuals taking a pragmatic or common sense view on safety matters and if so what measures can be taken or adopted to rectify this?
5. Is there insufficient regulation in the workplace, do we need more or should we seek to standardise with Europe?
6. Is the UK too bureaucratic, heavy handed, high minded or insensitive when dealing with organisations or individuals regarding implementation or infringement of the workplace regulations, codes of practice or guidance?

There are three research questions that have arisen from this literature review:

1. How helpful, or otherwise, are the UK's workplace regulations in providing a common framework to improve safety, welfare and health on site?
2. Would statutory regulations specifically targeted at each individual industry sector be of greater benefit than an holistic approach as at present?
3. Does the fear of prohibition or prosecution have an undue influence on an individual's capacity to take a pragmatic or common sense view on Health, Safety and Welfare requirements in the workplace.

2.6 Chapter Summary

This chapter has discussed the UK workplace regulations and what they mean to industry in general, particularly where risk and the duty of care outline working principles within defined parameters. It has also determined a number of causes of accidents to all industry sectors but has identified that waste handling and waste disposal in particular are major causes for concern. The chapter has addressed factors that could be said to have an influence on waste production and the propensity for accidents, such as product and building design, the application of sustainable working principles and the variances associated with the management of risk and risk taking.

3. RESEARCH METHODOLOGY

3.1. Introduction

Chapter 1 provided a general introduction to the thesis and explained the aims, objectives and the justification for the research. Chapter 2 provided the review of the published literature that has helped guide the research objectives and the basis for the research questions. This chapter discusses how the research was carried out to meet the aims and objectives of the study. It explains the various research types and strategies and the reasons for selecting the methods used for this study. Paradigms to the study's underlying philosophical assumptions are based on the literature discussions and a naturalistic approach to research which emphasises the importance of the subjective experience of individuals, with a focus on qualitative analysis (Blaxter et al, 2006). However, little authoritative data is available from within the demolition sector and therefore there was a strong argument to include personal and subjective views, based on the ideographic or social reality approach.

3.1.1. What is Research?

The assumption that research is merely a process of looking for and finding answers to questions is too general and simplistic. Researchers have defined research as many things. Locke et al (1998) states that '*a research report gives the history of a study, including what the researcher wanted to find out, why that seemed worth discovering, how the information was gathered and what he or she thought it all meant*.' A true understanding of research can only come from actually doing it and whilst it is a process of gathering data in a strictly organised manner, it is also a process of testing a stated idea or assertion to see if the evidence supports it or not as well as engaging in planned or unplanned interactions with interventions in parts of the real world and reporting on what happens and what they seem to mean (Davies, 2007). What can be ascertained is that research should be a learning process for the researcher and ultimately any beneficiary of that research. The essential feature of research for a doctoral degree (PhD) is that the work makes an original (even if incremental) contribution to knowledge (Fellows and Liu, 2003).

Research has also been described as a non-sequential, non-linear process with a large degree of ambiguity and serendipity (Leckie, 1996). Leckie also suggests that the expert researcher is relatively independent and has developed his or her own personal information seeking strategy (e.g. a heavy reliance on personal contacts and citation trails). Whilst Head (2007), in a recent American college research project, incorporating discussion groups, described the students using 'tried and true' research strategy for locating scholarly research. This approach focused on accessing research materials from the library web site or course readings rather than the popular assumption that information is mainly obtained via the internet (see Figure 3.1)

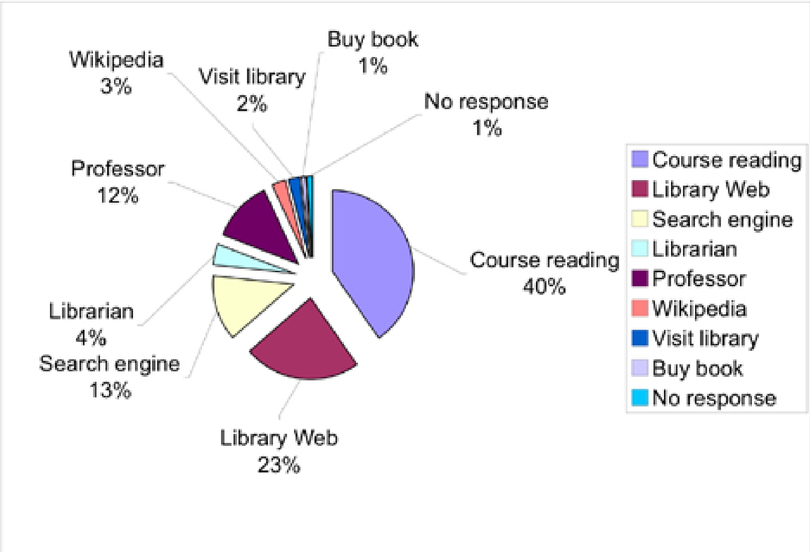

Figure 3.1: What is the first step in the student research process? (Head, 2007)

When discussing different data collection techniques and their advantaged or disadvantages it becomes clear they can complement each other. If used skilfully, a combination of different techniques can reduce bias and give a more comprehensive understanding of the topic under study (Carman, 2004). This process is highlighted in Table 3.1.

Table 3.1: Advantages and Disadvantages of Various Data Collection Techniques

(International Development Research Centre – 2009. Projects – Volume 1. Module 10A)

Technique	Advantages	Possible constraints
Using available information	Is inexpensive, because data is already there. Permits examination of trends over the past.	Data is not always easily accessible. Ethical issues concerning confidentiality may arise. Information may be imprecise or incomplete.
Observing	Gives more detailed and context-related information. Permits collection of information on facts not mentioned in an interview. Permits tests of reliability of responses to questionnaires.	Ethical issues concerning confidentiality or privacy may arise. Observer bias may occur. (Observer may only notice what interests him or her.) The presence of the data collector can influence the situation observed. Thorough training of research assistants is required.
Interviewing	Is suitable for use with both literates and illiterates. Permits clarification of questions. Has higher response rate than written questionnaires.	The presence of the interviewer can influence responses. Reports of events may be less complete than information gained through observations.
Small scale flexible interview	Permits collection of in-depth information and exploration of spontaneous remarks by respondents.	The interviewer may inadvertently influence the respondents. Analysis of open-ended data is more difficult and time-consuming.
Larger scale fixed interview	Is easy to analyse.	Important information may be missed because spontaneous remarks by respondents are usually not recorded or explored.
Administering written questionnaires	Is less expensive. Permits anonymity and may result in more honest responses. Does not require research assistants. Eliminates bias due to phrasing questions differently with different respondents.	Cannot be used with illiterate respondents. There is often a low rate of response. Questions may be misunderstood.
Participatory and projective methods	Provide rich data and may have positive spin offs for knowledge and skills by researchers and informants.	Require some extra training of researchers.

3.1.2. Qualitative and Quantitative Methods

Quantitative approaches tend to relate to positivism and seek to gather factual data to study relationships between facts and how they accord with theories and the findings of any previously executed research/literature (Fellows and Liu, 2003). There are two methods of quantitative research that are related but very different. Survey research and experimental research in which the researcher carrying out the survey will emerge with findings that describe and interpret aspects of current psycho-social reality, while the experimental researcher will be looking for (tentative) proofs – possibly following the introduction of new practices (Davies, 2007).

The word qualitative implies an emphasis on the qualities of entities and on processes and meanings that are not experimentally examined or measured in terms of quantity, amount, intensity or frequency (Denzin et al, 2008). Denzin et al (2008) also state that qualitative research is many things to many people, that its essence is twofold: a commitment to some version of the naturalistic, interpretive approach to its subject matter and an ongoing critique of the politics and methods of post-positivism. Maxwell (1996) suggests that there are five particular research purposes for which qualitative studies are especially suited:

- Understanding the meaning, for participants in the study, of the events, situations and actions they are involved with and the accounts that they give of their lives and experiences.
- Understanding the particular context within which the participants act and the influence that this context has on their actions.
- Identifying unanticipated phenomena and influences and generating new grounded theories about the latter.
- Understanding the process by which events and actions take place.
- Developing causal explanations.

Taking this approach further, Maxwell (1996) advises that qualitative research and quantitative research both need to identify and deal with the plausible validity threats, particularly to any proposed causal explanations. However, Maxwell (1996) states that qualitative research has an advantage in an inductive or open ended strategy to address three practical purposes:

- Generating results and theories that are understandable and experientially credible, both to the people you are studying and to others.
- Conducting formative evaluations, ones that are intended to help improve existing practice rather than to simply assess the value of the program or product being evaluated.
- Engaging in collaborative or action research with practitioners or research participants.

The question of which research method is more desirable has been debated extensively with many pros and cons for each. One method that solves this conundrum is that of triangulation. There are a number of different types of triangulation and by combining multiple observers, theories, methods and data sources, researchers can make substantial strides in overcoming the scepticism that greets singular methods, lone analysts and single-perspective theories and models. Patton (1999) identifies that methods of triangulation often involve comparing data collected through qualitative methods and data collected through quantitative methods, but that it is seldom straightforward because certain types of questions lend themselves to one or other methods. However, it is common that both types of methods are used in a complimentary fashion to answer different questions that do not easily come together to provide a single, well integrated picture of the situation (Patton, 1999).

3.1.3. Underlying Choices of Research Method

The use of both qualitative and quantitative methods would seem to be a logical approach particularly given that answers to questions posed within the research necessitated the analysis of data in numerical, textural and audio format. The diverse range of approaches for both types of research arises from different epistemological and methodological understandings. There is though a strong connection with the qualitative, theory building research approach that allows the researcher to seek connections within the data and to arrive at theories to explain the connections (Phelps, 2007). In general, qualitative data analysis involves engaging closely with the data, in the form of text, audio, and images, to:

- Locate or identify patterns, themes or underlying meaning in the data
- Make comments or notes about what is being implied or said

- Mark or extract segments of data which represent meaningful units, such as a quote, audio clip; and or
- Attach extracts to categories while maintaining a connection to the original source

(Phelps, 2007)

By employing a degree of logical positivism or quantitative research to test hypothetical generalisations, an emphasis on the measurement and analysis of causal relationships between the variables would allow the researcher to familiarise with the problem and to generate hypotheses to be tested. In this paradigm the emphasis is on the facts and causes of behaviour (Golafshani, 2003). Measurement is a process involving both theoretical as well as empirical considerations. From an empirical standpoint, the focus is on the observable response whether it takes the form of a mark on a self-administered questionnaire, the behaviour recorded in an observational study, or the answer given to an interviewer. Theoretically, interest lies in the underlying unobservable (and directly unmeasurable) concept that is represented by the response (Carmines and Zeller, 1979). Carmines and Zeller (1979) also point to the fact that reliability and especially validity are words that have definite positive connotation and are critical to the acceptance of the research outcome. Reliability concerns the degree to which results are consistent across repeated measurements. Whilst validity issues are usually discussed in terms of internal and external validity and they are applied to the interpretation of the results of empirical investigations (Franzen, 1954). Franzen (1954) further advises that threats to internal validity are presented by those events or processes that cast doubt on the reasonableness of the conclusions drawn. Threats to external validity are presented by those events or processes that cast doubt on the generalisation of the results to other populations.

There is therefore a strong argument for taking a pluralist or multi-method approach to this research rather than advocating a single paradigm, be it interpretive or positivist, or even a plurality of paradigms within the discipline as a whole, it suggests that research results will be richer and more reliable if different research methods, preferably from different (existing) paradigms, are routinely combined together and that a research study is not usually a single, discrete event but a process that typically proceeds through a number of phases. These phases pose different tasks and problems for the researcher. However, research methods tend to be more useful in relation to some phases than others, so the prospect of combining them has obvious appeal (Mingers, 2001).

The range of aspects being addressed in this research support a multiple view on social reality and the possibility of using more than one method in the research, given the specific research objectives cited in Chapter 1. Hence, Figure 3.2. demonstrates how research methods have been utilised in this research.

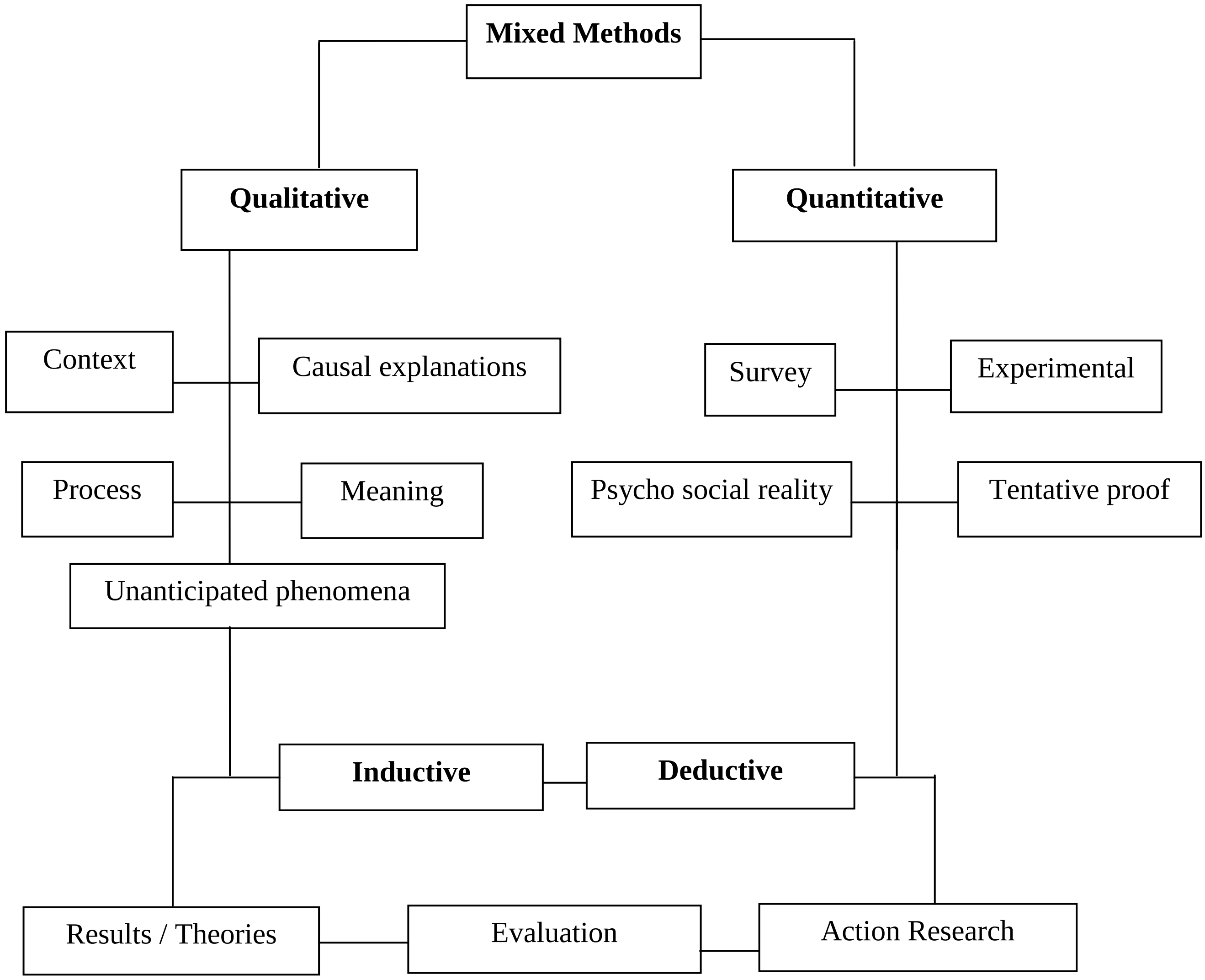

Figure 3.2: Research methods, routes and outcomes

3.2. Adopted Methodology

In choosing a combination of the two approaches for the collection of data, i.e. qualitative and quantitative the author collected data by means of three routes:

- Questionnaire
- Interviews
- Statistical, formal/informal data collection

The reason for this chosen route was as a consequence of poor and or non-existent data being available from within the demolition industry either via technical papers or the expressed opinions of those working within the sector. Any evaluation of gathered data was therefore going to be a mixture of the known works mainly produced for the construction industry at large and data that could be gathered from as many reliable sources within the demolition sector as possible. The author was also aware that the choice of methods is strongly influenced by the situation and context in which evaluation is conducted and that the task facing an evaluator is to provide the most accurate information practically possible in an even-handed manner (Berk and Rossi, 1990; Clark, 1999). Paton (1987) adds that there are no rigid rules that can be provided for making data collection and methods decisions in evaluation. The art of evaluation involves creating and gathering information that is appropriate for a specific situation and particular policymaking context.

3.2.1. Introduction to the questionnaire survey

To gauge opinion on sustainability, demolition practices/operations, accident rates and legislative influences a questionnaire was formulated. This was distributed, at random by selecting five organisations from each of the five regions, to 25 persons who were the principal names shown on the National Federation of Demolition Contractors (NFDC) members list. The questionnaire addressed five topics which were interrelated, consisting of:

- Work practices
- Present and future changes
- Accident / incident reporting
- Recycling and reclamation activities
- Sustainable development knowledge

Each topic contained between 11 and 22 open questions that required either a ‘yes’ ‘no’ answer and/or the opportunity to expand in greater detail.

After a period of three months, none of the respondents had returned the questionnaire to the author. To test out the reasons for this poor response, the author contacted two senior managers of separate demolition organisations and conducted the question and answer session in person. As a result of this exercise the questionnaire was withdrawn and a replacement questionnaire formulated to simplify the process. The revised questionnaire consisted of just ten key questions dealing principally with recycling, accident rates and sustainability within demolition; it was formatted on A4 paper and consisted of closed-ended and open-ended questions. Fellows and Liu (2003) argue that the broader the concept the greater the likelihood that it will encompass underlying dimensions and that sampling should be designed to be sufficiently representative, of the whole population, of which 300 were selected, to obtain results that have sufficient external validity at a given and stated level of confidence. The questionnaire was distributed to 300 members of the Institute of Demolition Engineers (IDE), via email addresses supplied by the National Secretary from the Institute’s data base.

3.2.2. Types of Respondents

When considering the choice of respondent for this study process, the author was mindful of the poor response to the initial questionnaire, from the selected cohort and the rationale that may have affected such a reaction. It was reasoned that to answer the type and number of questions submitted may have necessitated more than one person being involved in the process and that the principal names given by the NFDC as a contact for that organisation were generally the managing director whose time was no doubt at a premium. In addition, there were 158 member companies of the NFDC offering one contact name. By comparison, the Institute of Demolition Engineers gave access to over 300 contacts. Therefore, that study group was potentially a greater source of information and it was deemed logical that respondents for the initial data collection were chosen from the membership of the IDE. Another principal reason for utilising the IDE data base was that the members were all practicing within the demolition industry sector, whether as actual demolition contractors or as practitioners within a supporting role such as asbestos removal, civil or structural engineers and surveyors etc. At the time of the questionnaire distribution the Institutes' membership numbers were 320 members of which 20 had retired or were not contactable, so a total of 300 respondents were targeted.

There were four categories of membership:

- Fellows
- Full members
- Associate members
- Enrolled members

No distinction was made between the grades of membership when sending out the questionnaires as it was considered sufficient that the majority of members of the Institute were drawn from senior management who would have knowledge of, or access to, information needed to complete the questionnaire. The questionnaire was dispatched by email to the respondents over a period of approximately three weeks and after seven weeks seventy five (75) respondents had returned the survey. This represented a response rate of 25% which was considered to be acceptable for an electronic postal survey, although such a low return was not helpful in making generalizations on the answers received. Donaldson et al (1999), in a study of inducements within the medical profession to return questionnaires, identifies that follow-up telephone calls can dramatically increase return rates. However, despite a follow-up email remainder and a number of telephone calls being made, no further responses were received. Indicators of poor response rates can be demonstrated from many previous research projects and low response rates are particularly common in small and medium sized business research (McKeiver and Gaddene, 2005; McPherson and Wilson, 2003).

Response bias and limiting factors within this research section have been carefully considered. One limiting factor is the propensity for respondents to answer questions in a manner that they may consider the researcher would approve of or be inclined to accept as desirable. This was largely countered by avoiding the use of leading questions and assuring those who took part in the questionnaire would remain completely anonymous. A further method that was employed, was to minimize the promulgation of the research project to the respondents community in the belief that responses would be received as a result of the individuals experience and knowledge rather than be biased by any prior awareness of a research topic. The approach to the study and the subsequent report data has purposely used a combination of methods and has attempted to remove bias from the results of the data gathered. However, bias and validity are issues that can be addressed by the use of cross checking and the use of a combination of differing techniques of data collection. Table 3.1 is indicative of the author's approach to the data collected throughout this study.

3.2.3. The Questionnaires

The gathering of data in the form of a questionnaire was considered an ideal study of the variables likely to be drawn from the proposed interview process and to assist in determining the questions for the interview stage. The initial questionnaire proved to be unpopular and excessively long and was refined and shortened prior to full release (refer to Chapter 4 Data Collection & Analysis). The research questionnaire was formulated with a desire to gain a basic insight into the collection of accident statistics, the preference for hand or mechanical working and the propensity for reclamation and recycling in general.

The questions posed were mainly closed-ended questions and were designed with a preference for testing the generalization of traits, actions, abilities, views and attitudes to a larger population (Black, 1999). The recipient was asked to choose one from four possible answers. There were two noticeable exceptions for Questions 6 and 7. In Question 6 the recipient was asked to choose one or more answers from 10 examples and in Question 7 the recipient was also asked an open-ended question if giving a positive (yes) answer to the closed question. A common method of obtaining the results is known as a Likert scale which provides various scales of agreement or disagreement to a given question (Fellows, 1997); questions in the research instrument, in general, followed a 4 point scale (see Appendix C).

The questionnaire was also designed to be as simple as possible and to take the least time or effort to answer. As Fellows and Liu (2003) states, the questions should be unambiguous and easy for the respondent to answer they should not require extensive data gathering by the respondent. The questions fell into two categories:

- Recall of facts, experiences, names dates etc
- Convergent, demanding predictable answers or restricting the respondent to a limited number of choices

(Guildford, 1956; Black, 1999)

As Clark (1999) advises, the questions should be clear, straightforward and jargon free to avoid using vague words or ambiguous or unfamiliar phrases. A good proforma being one that is specifically designed with the nature of the respondents in mind (Clark, 1999; Moser and Kalton, 1983). As the follow on method of data collection, personal interviews were considered to be of a qualitative nature and would bring a balance and validity to the data from the quantitative type of questionnaire; the interviews are described next.

3.2.4. Interview Method

The choice of persons to interview, referred to as the strata or sample, was made from a predisposed understanding of the population. As the data to be collected must be relevant and unique to the research subject as well as of interest to the group chosen, stratified sampling has some advantage over random sampling, as sample sizes could be set to allow separate conclusions about each stratum. This in turn usually delivers a smaller margin of error as the individuals in each stratum are more alike than the population as a whole (Moore, 2001). With this in mind, the strata were chosen as being representative of a cross-section of the demolition industry from small, medium and large organisations. With the exception of two individuals, all were directors of their respective companies as this was considered favourable based on the percentage of responses received from the research questionnaire, the likely knowledge and confidence of the individual to engage fully in the process and the propensity to meet the interview dates. Of the two exceptions, one was a consultant representing a demolition company and the other a senior manager in a large demolition organisation. It was intended to sample between 15 to 20 individuals. However, after interviewing 12 persons it became apparent that a relatively consistent pattern of responses had emerged and that a regime of over sampling might bias consistency in estimation of the population parameter. Therefore the author took the decision to bring the interviews to a close. All interviews were conducted on the interviewee’s premises following pre-arranged meeting times and dates and forwarding of the interview questions to enable the individuals time to reflect on their answers. Bryman (2007) suggests that it is helpful to establish a rapport with the respondent and to ask questions as they appear on the interview schedule. In this respect, the author had the advantage and privilege of personally knowing each respondent which enabled the interview process to be less formal and conducive to providing a frank atmosphere. Great care was taken to read out the pre-formed questions in an even manner and tone to minimise any potential for bias, on the part of the interviewer, which may have been picked up by the respondent. As Kvale (1996) advises, the interview questions here serve to test a hypothesis, employing an interplay of questions, counter questions, leading questions and probing questions. The nuanced description of the phenomena studied, therefore have intrinsic value and constitute one of the strengths of qualitative research.

The interview process was clarified to each respondent by the author who explained the purpose of the interview, the format of the interview, the terms of confidentiality and the expected time frame of approximately one hour. Interviewees were given the opportunity to clarify any other points prior to commencement. The interview times ranged from around 40 minutes to 1.5 hours in duration and were terminated only when each respondent indicated that they had nothing more to add. Each interview was recorded onto a digital voice recorder which was subsequently transferred onto a CD. The CD's were dispatched to an independent secretarial service widely used by Loughborough University, to be transcribed for ease of analysis. The transcriber was asked to record the full text as spoken, omitting only non-grammatical pauses such as throat clearances and inappropriate exclamations.

3.2.5. Interview design

The interviews were conducted by the author following a set number of questions designed from the data collected by the initial questionnaire, the literature review data and the eighteen (18) research propositions, formulated around the four (4) key influences, being:

- Sustainability
- Waste Management
- Accident Causation
- Legislation

Although the interviews were classified as being 'structured', by virtue of the situation in which each respondent was asked a series of pre-established questions, there was ample opportunity for the respondent to answer in any manner they saw fit in order to elucidate and establish their opinion. Denzin et al (1998) suggests that the structured interview proceeds under a stimulus-response format, assuming that if questions are phrased correctly, the respondent will answer them truthfully. In other ways the interview process may also be classified as having an 'unstructured' approach because of the interviewers understanding of the subject and having previously established a rapport with all respondents. The establishment of a good rapport with the respondent may be influential in getting a response to any question posed, but as Denzin et al (1998) point out, the interviewer must guard against becoming a spokesperson for the group and or influencing the report findings. Denzin et al (1998) advise that one way to eradicate this is by way of polyphonic interviewing, in which the subjects are recorded with the minimal influence from the researcher and are not collapsed together and reported as one, through the interpretation of the researcher. In this manner the multiple perspectives of the various subjects are reported and the differences and problems encountered are discussed, rather than glossed over. However, there are difficulties in determining fact from conjecture in all types of interviews and this is even more pronounced where the validity of any statement made is further hindered through a shortage of good quality evidence or literature on the specific subject matter. The respondents were not chosen for their academic abilities but for their long term experiences and management capabilities within, in particular, the field of demolition engineering and waste handling.

Despite the fact that the spoken or written word may have a residue of ambiguity no matter how carefully the questions are asked or the report details, interviewing is one of the most common and powerful ways in which we use to try to understand our fellow human beings. Interviewing is a paramount part of sociology, because interviewing is interactive and sociology is the study of interaction, thus the interview becomes both the tool and the object (Benny & Hughes, 1956).

Purposive paradigms in the form of interviews help to broaden the objectives of the study and in some instances may even develop the theories expounded within the literature review. Fellows et al (1997) refers to bounded and unbounded theories of research where 'bounded' systems tend to be closed and as such are isolated from their environment by an impenetrable boundary. Whereas 'unbounded' systems are open with a highly permeable boundary to allow response and interaction in the environment of the research study. It is questionable as to where one may draw the boundaries of research particularly if answers to human behaviour remain unanswered despite the review of theory and literature. The interview process must therefore be judged as an opportunity to broaden those boundaries to include sociological influences.

3.2.6. Question format: matrix questions

The main source of the data collection for the interviews was the matrix questions derived from the literature review, the questionnaire and the eighteen research proposals (see proforma in Appendix A). The latter of which were important when determining the outcome and validity of the conclusions to the research itself. In total there were 10 matrix questions that were designed to gauge the interviewee's opinions on the four key influences.

It is important for the interviewer to understand that interviews are more personal than questionnaires and that the interviewer works directly with the respondent often probing and or asking follow up questions to seek opinions or impressions (Valenzuela et al, 2003). Throughout the interview process there are a number of factors that have to be taken into account to achieve a successful outcome. McMamara, (1999) points to the following topics to which questions are directed towards:

- Behaviours - about what a person has done or is doing
- Opinions/values - about what a person thinks about a topic
- Feelings - note that respondents sometimes respond with "I think ..." so be careful to note that you're looking for feelings
- Knowledge - to get facts about a topic
- Sensory - about what people have seen, touched, heard, tasted or smelled
- Background/demographics - standard background questions, such as age, education, etc

3.2.7. Statistical, Formal / Informal Data Collection

Statistical and formal data were extrapolated from the research questionnaire and the respondent interviews. Data from the NFDC and HSE was also used by the author. Other data were available as published documents, statistics, industry or authoritarian guidance, public and private sector research documents as well as academic research studies and reports.

Data collection in qualitative studies is typically directed toward discovering the who, what and where of events and experiences or their basic nature and shape, whereas quantitative studies entail interpretation in that researchers set the horizon of expectations for the study, by pre-selecting the variables that will be studied and draw conclusions from the results based on sets of assumptions (Sandelowski, 2000). Denzin et al (1998) remind researchers that "what people say" is very often different from "what people do" and that full sociological analysis cannot be restricted to, such as, interview data. It must also consider the material traces such as analytical data from industry and other research projects.

Blum and Foos (1986) assert that relevant data gathering is the key to appropriate problem solving and correct decision making and that when verifiable data are gathered and analysed, then one approaches the realm and province of science. Blum and Foos (1986) further report that conclusions are dependent upon the findings obtained as a result of data gathering. Such findings are not necessarily easily understood by all readers and that by producing the results of any quantitative research, in particular, through the use of graphs, charts and figures the data extrapolation process can be of great benefit to those readers of the report who do not necessarily understand academia or sophisticated writings. Black (1999) reminds us that many of those reading a report may not be as knowledgeable in the field in which the research is being conducted and that understanding the findings as policy decisions may be based on understanding the study's results. However, as Black (1999) further advises, statistics and statistical tests alone cannot prove causality; they can only provide support in situations of competing variables. Making good use of the data collected is key to evaluating the outcomes and there are a variety of methods which can be employed. Making use of devices such as checklists and rating scales can help to simplify and quantify people's behaviour and attitudes. A checklist is a list of behaviours, characteristics' or other entities that the researcher is looking for, whilst a rating scale is more useful when a behaviour needs to be evaluated on a continuum, i.e. Likert scales (Leedy and Ormrod 2001).

3.2.8. Validity Issues

For the most part, research is concerned with investigating a hypothesized causal relationship between an independent variable and a dependent variable. If such a relationship is found, inferences are drawn about the population and a variety of circumstances in which the relationship may apply beyond those of the particular study carried out (Fellows and Liu, 2003).

Fellows and Liu (2003) reason that such research involves a set of validities (the likely truth of hypothesis) and that they are described as construct, internal, statistical inference and external validity. They describe construct validity, as the degree to which the variables are measured by the research. Internal validity, as where the observed and measured effect is due to the identified causal relationship. Statistical inference validity is where the sample is a good representation of the population and is judged by inference statistical measurements. External validity, being the degree to which the findings can be generalized over circumstances which are different from those of the test carried out (Fellows and Liu, 2003). Throughout this study we make the assumption that validity refers not to the data but to the inferences drawn from them (Creswell and Miller, 2000; Hammersley and Atkinson, 1983).

By employing a mixed or multi-method research strategy it was considered that the accomplishment of the research objectives would be better addressed and that a more diverse data may be achieved. In addition, methodological biases associated with single methods can be avoided since data from one method could corroborate evidence provided by another method and vice versa, forming the basis of the multi-methodology study’s findings (Kheni, 2008).

Creswell and Miller (2000) inform that researchers engage in validity procedures of self disclosure and collaboration with participants in a study. They speak of the use of lens (viewpoint) and paradigm assumptions to create a two-dimensional framework for locating nine different types of validity procedures, as shown in Table 3.2.

Table 3.2: Validity Procedures within Qualitative Lens and Paradigm Assumptions (Creswell and Miller, 2000, p.126)

Paradigm Assumptions/Lens	Postpositivist or Systematic Paradigm	Constructivist Paradigm	Critical Paradigm
Lens of the Researcher	Triangulation	Disconfirming evidence	Researcher reflexivity
Lens of Study Participants	Member checking	Prolonged engagement in the field	Collaboration
Lens of People External to the Study (Reviewers, Readers)	The audit trail	Thick, rich description	Peer debriefing

This study relates closely with some of the validity procedures depicted by Creswell and Miller. It is certainly true to associate the use of 'triangulation', 'disconfirming evidence', 'researcher reflexivity', 'prolonged engagement in the field' and 'thick rich description' as those used at points within the study (Creswell and Miller, 2000, p127-9):

- *'Triangulation' – a systematic process of sorting through the data to find common themes or categories by eliminating overlapped areas.*
- *'Disconfirming evidence' – a search for disconfirming or negative evidence to establish the preliminary themes or categories in the study and to search through the data for evidence that is consistent with or disconfirms these themes.*
- *'Researcher reflexivity' – a report on personal beliefs, values and biases that may shape the enquiry.*
- *'Prolonged engagement in the field' – working for long periods of time in the field of the study with people day in and day out to build trust and establish rapport.*
- *'Thick rich description' – giving deep, dense, detailed accounts to provide as much detail as possible.*

3.2.9. Data Analysis

The use of qualitative and quantitative methodological or multimethod approach in this research has provided a platform in which the variables of data collection have been explored and utilised. In seeking to find answers to a number of questions relating to a number of variables, i.e. what similarities, differences or persuasion could be determined between the four key influences, quantitative data in the form of a questionnaire, which provides essentially an epistemological assumption to the data analysis, was employed. In addition, using a qualitative research method the author was also able to get an 'inside view' of the subject matter and carried out interviews with key informants from the demolition sector. Bryman, (1984) informs that the chief attraction of this type of data collection provides the researcher with an ability to get close to his subjects and see the world from their perspective which often produces 'rich' data with a great deal of depth.

The purpose of the data collected within the survey questionnaire was to allow statistical analysis to be performed regarding the principle topics of recycling, accident rates and sustainability in demolition. The survey was statistically analysed using a four point Likert scale and totalling the responses as a percentage and actual number against the total number of respondents, out of 75, answering each question. Bryman and Cramer (2004) draw on the distinction between measures and indicators, stating that measures constitute direct quantitative assessments of variables, whereas using indicators as a measure may help to capture a respondent's attitude to an issue. This can also have the effect of reducing error by partly offsetting the answer to one question with that of another. This aspect of the data collected from the survey was useful in formulating the open-ended questions used within the interview process and greatly assisted in validating the findings.

The collection of both sets of data, survey and interview, were conducted over a period of four years. However, analysis of the primary data, i.e. the survey questionnaire, was conducted at an early stage to assist in the validity and reliability of later data collection techniques. Hardy and Bryman (2004) advice that both qualitative and quantitative researchers interspace data collection with data analysis and that one should never collect data without substantial analysis going on simultaneously. Whilst Miles and Huberman (1999) are of the opinion that early analysis helps the field worker cycle back and forth between thinking about existing data and generating strategies for collecting new and often better data. They also argue that this permits the production of interim reports that are required in most evaluation and policy studies, advising that interweaving data collection and analysis should be conducted from the start.

The structured interviews data analysis looked at the responses to the ten matrix questions derived from the four key influences of ‘sustainability, waste management, accident causation and legislation.’ The author extracted from the data each respondent’s opinions, observations and recommendations towards the questions as well as comments directed at issues to which the individual respondent considered relevant or pertaining to the subject matter. Key phrases, sentences or words were selected from the transcripts and tabulated against each question, down the left hand column, as ‘Response Issues.’ The table header reflected the ‘change mechanisms’ that the respondents considered necessary to drive through change and a mark was put against each relevant change mechanism pertinent to the response issue. This provided the author with a visual indicator towards how each response issue to the question posed would have a bearing or influence on the four key influences of the research study, the objectives and the propositions.

The analysis of other data collected involved the compilation of officially collected data, i.e. RIDDOR, LFS and NFDC and that which was voluntarily given by nine UK based contractors. Much of this data concentrated on accident frequency although accident types and occupations of injured persons have also been addressed. Analysis of this data were undertaken to measure the fluctuations, rise or fall of accident occurrence over the sample period and to determine if there was any emergent pattern that could be linked to causation or indeed any aspect of the four key influences. In attempting to analyse data that has been collected by ‘official’ means, one is aware that reliability and validity are taken for granted and that they may, in some respects, be considered above reproach. Measurement concerns the problem of linking abstracts to empirical indicants (Franzosi, 1987) and validity is often discussed in connection with measurement error and reliability (Adcock and Collier, 2001). By bringing in the research data and setting it against the official data it was anticipated that any measurement error or bias would be either highlighted or countered against.

3.2.10. Chapter Summary

This chapter has discussed and defended the research strategy and design that has been adopted for the study. The research design discussed within the chapter has described the links between the study's underlying philosophical assumptions, the research methods, the methods of data collection and the process of analysis necessary to meet the aims and objectives of the study.

A multi-methodology approach was employed in the data collection adopting a qualitative approach for data collection with the interviews and a quantitative approach for validation of the questionnaire and other data.

4. CHAPTER FOUR: RESULTS AND ANALYSIS

4.1. Introduction

Having described how the data were collected and analysed in Chapter Three, this chapter presents the data collection and analyses the results systematically. The data collection used three methods questionnaires, interviews and statistical, formal/informal data collection, so these will be considered in turn. Important findings relating to the four key themes of sustainability, waste management, legislation and accident causation will begin to emerge and the chapter concludes with a review of accident statistics gathered from nine demolition contractors, the NFDC, the LFS and RIDDOR.

4.1.1. The Research Questionnaire

The author is aware that access to the IDE data base was made easier by the unique position he held as the President of the Institute and that knowledge of many of the respondents' titles and positions were known or could be verified by the national secretary. This has allowed a breakdown of the individuals who responded, by their position, thereby giving an insight into the various opinions that could be shown across the hierarchy of control within organisations.

Table 4.1: Questionnaire Respondents

	Managing Directors / Directors	Contract / Project Managers	Safety & Environmental Managers	Consultants	Total
Number of respondents	36	28	5	6	75

Having distributed 300 questionnaires, a total of 75 useable survey forms were returned, giving a response rate of 25%, which is considered normal for electronic postal surveys of this nature. A number of respondents wrote additional comments on the questionnaire, in particular to Question 7 that asked for reasons to the answer given. Brief comments were also made for the majority of other questions. These are discussed and evaluated.

4.1.2. Soft Strip Methods (Q1)

This question asked: Do you carry out ‘soft stripping’ of materials by hand and or machine? It related to the general method of soft strip being carried out within the sector to determine to what extent the process was manual or machine based. Although a simple question, the answers have importance in recognizing causation of minor injuries, in particular, to body locations and those operatives most affected by manual handling activities. It was found that (79%, 59/75) of the respondents were in favour of using both hand and mechanical operations, whilst (21%, 16/75) preferred hand operations only. In support of the former method, one respondent stated that he applied 70% of the process to hand work and 30% by machine. Others commented that it often depended on the type of building, what level of recycling was required, the nature of the materials and the health, safety and environmental implications.

Table 4.2: Q1 – Soft Strip Methods – By Hand or Machine

Always by hand	Sometimes	Never	A mixture of both	Total (n)
16	0	0	59	75

4.1.3. The Value of Materials Prior to Stripping (Q2)

This question asked: Do you take into account the value of any material before you soft strip? It was designed to evaluate if there was any account taken of the value of the soft strip or other materials present within the building prior to stripping activities. This, it was assumed, would be irrespective of what stripping method was preferred, i.e. hand or mechanical. Figures 4.1 and 4.2 are included here to give an indication of what types of materials may be encountered during the soft strip process, which could be reclaimed for re-use.

Figure: 4.1: Reclaimed bricks (Dorton) **Figure: 4.2: Ceramics and stone (Dorton)**

The overall majority, (65%, 49/75), said they would always take the value of materials into account, whilst the second largest group, (29%, 22/75), sometimes took this into consideration. The remainder either never thought about the value or would only do so if asked. As to the reasons given for such a stance, several respondents pointed to the fact that one should always look at the value of the materials and in addition, take into account any negative values. A further respondent suggested; one would always take the value into account otherwise there is too much 'pie in the sky' thinking relating to achieving re-use/recycling rates which are neither financially nor environmentally productive. A common theme throughout the research was that of a tight programme of works and lack of opportunity to take advantage of any recyclable materials present.

Table 4.3: Q2 Do you Value the Materials you Strip Out?

Always	Sometimes	Only if asked	Never	Total (n)
49	22	1	3	75

4.1.4. Increasing Salvage where Markets are Available (Q3)

This question aimed to determine the extent to which the respondents would consider increasing salvage if opportunities were greater through freely available markets. This is an often mentioned subject amongst the demolition fraternity which bemoans the lack of commercial markets for many recycled materials. The author is aware that where markets are either unavailable or are 'saturated', landfill is still a cheap option for all but secondary aggregates. It was therefore gratifying to record that (95%, 70/74) of respondents would salvage more where market conditions were right and or freely available. Two respondents gave their comments alongside their answers with one admitting that salvage was only possible if it was cost effective. The other posed a rather different scenario and asked the question: are we not re-using and recycling as much as the market can (wants to) presently take?

Table 4.4: Q3 Would you Increase Salvage if the Markets were Available?

Absolutely	Possibly	Only if pushed	Never	Total	No response
39	31	3	1	75	1

4.1.5. Salvage and the use of Machine Attachments (Q4)

This question asked: Do you think that machine attachments used today make it harder to salvage materials? It was aimed at raising the subject of machine attachment use in salvage/recycling activities where there has been suggestions, from some exponents of the demolition process, that hard edged equipment such as shears, pulverisers and grapples may cause undue damage to materials thus reducing their recyclable value. Figures 4.3, 4.4 and 4.5 are included here to give an indication of the types of machine based attachments that are available for use within a demolition environment.

Figure 4.3: Selector grab (Dorton)

Figure 4.4: Steel shear (Dorton)

Figure 4.5: Concrete pulveriser (Dorton)

Table 4.5 shows that the majority of respondents to the research questionnaire, (56%, 41/73), do not agree that attachments make it harder to salvage, although a significant proportion, (42%, 31/73), think it definitely, or could possibly, make it harder. A further 1% admits to not knowing. This would suggest that attachment use is subjective and of personal preference as to its mode of operation and the outcome of the tasks they are put to. Comments received with the questionnaires point to the various types of methods employed to separate and segregate materials and that the range of attachments now available should assist in making the process simpler. One respondent pointed to the fact that smaller robotic machines can almost provide a near manual level of soft strip.

Table 4.5: Q4 – Do Attachments make it Harder to Salvage?

Yes	Possibly	No	Don’t know	Total	No response
15	16	41	1	73	2

4.1.6. Notifiable Accidents over Ten Years (Q5)

Question five asked: How many notifiable accidents have you had over the last 10 years?
In asking this question it was assumed that all respondents understood what was meant by 'notifiable', i.e. absence from work for 3 days or more being reportable under RIDDOR 95. There were two main reasons for asking such a question. Firstly, the reporting regime within the industry sector, amongst NFDC members predominantly, is poor and the gathering of any accident data proved to be difficult. Secondly, over 3 day accidents generally mean that some form of incapacity for work has arisen and this could necessitate a change in operational procedures. Collecting accurate data on accidents has continued to frustrate data analysts over a number of years. Traditional collection routes such as RIDDOR and the Labour Force Survey (LFS) have well documented inadequacies as have many other modes. One reason for a poor reporting response may be that contractors do not wish to highlight the number of accidents occurring for fear of non compliance or failure to qualify for work opportunities.

Table 4.6: Q5 – How many Notifiable Accidents over the last 10 Years?

Over 10	5 or more	Less than 5	None	Total	No response
5	5	42	21	73	

Therefore in answering this question, (57%, 42/73) of respondents stated that they have recorded less than 5 over 3 day accidents and (29%, 21/73) said they have had no notifiable accidents in the last ten years. A smaller group, (7%, 5/73), admitted to having 5 or more and the same number admits to having over 10 notifiable accidents in this period. Against what would appear reluctance to being candid, one of the respondents, a Safety and Environmental Manager freely admitted to recording over 10 three day accidents and more than 5 major injuries. A further respondent identified that over 80% of accidents in his organisation were as a result of slips and trips causing bruising and sprains. Whilst it may be questionable as to the overall accuracy of the reporting, the answers given in this questionnaire appear to be fuller than for those given within the NFDC mandatory members annual return, refer to Chapter 4 (Section 4.3) and certainly comparable with figures recorded through the RIDDOR regime for all demolition companies, again refer to 4.3.

4.1.7. Accidents Most Frequently Recorded (Q6)

Question 6 asked: What kind of accidents (all accidents minor or major) are the most frequently recorded? This question was devised to ascertain the types of accidents occurring on site and to whether those injuries could have any correlation with those generally attributable to manual handling. Although this type of questioning was reliant on a good standard of accident reporting it was considered viable and reasonable to ask given that most demolition contractors would be using the HSE F2508 form to record accidents on which details of the injury are noted. The results from the 71 respondents indicate that (51%, 58/113) injuries are from 'cuts and abrasions'. Whilst the second largest (21%, 24/113) of injuries are from trips, with slipping injuries coming in a distant third. Interestingly, injuries from falls are well down in fourth place although these types of accidents account for the most fatalities recorded for the construction sector per se. Injuries from burns come in at fifth place, whilst striking by plant, falling or moving objects is the sixth largest, which according to the national accident statistics for the construction industry accounts for the second largest number of fatalities. Entrapment, collision and other accidents are recorded as being low, with several respondents failing to return any statistics at all.

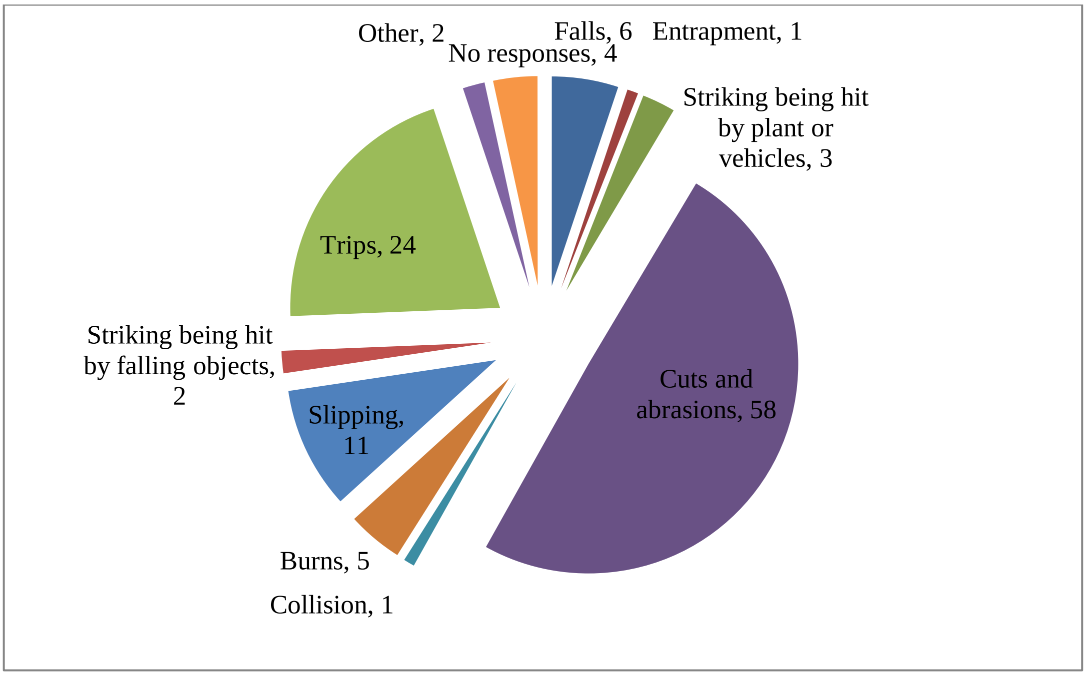

Figure 4.6: Q6 – The Types of Accidents Most Frequently Recorded

4.1.8. Frequency of Accidents Occurring

Question 7 asked: On your sites, have the numbers of accidents (minor or major) risen over the last 10 years? It attempted to determine the frequency of accidents occurring on site. This is considered to be one of the more important aspects of the research as it may help to identify trends in accident causation as well as when they have occurred. Such periods in time, according to RIDDOR accident data, (refer to Section 4.3), show a marked rise in over 3 day and major accidents for the demolition sector.

Table 4.7: Q7 – Have the Number of Accidents on Site Risen?

Noticeably	Slightly	No change	Fallen	Total	No response
1	12	22	35	70	5

However, despite the RIDDOR statistics identifying this rise, (50%, 35/70) of the 70 respondents who answered this question reported a reduction in accidents over the last 10 years. A further (31%, 22/70) said there had been no change, with (17%, 12/70) of respondents identifying a slight upward change. Only 1 person had noticed a significant upward change in the number of accidents and (7%, 5/70) failed to return an answer. This anomaly is not as surprising as it would at first seem. Both RIDDOR and the LFS identify a gradual decline in construction related fatal, major and over 3 day accidents from the 1999 base line onwards. If a similar trend is reported, via this limited snapshot of the demolition sector, from the research questionnaire, one may conclude that many of the recorded accidents occurring within the demolition sector are either to those employees outside of the NFDC companies or to individuals who have been misrepresented, i.e. having an accident thought to be related to demolition activities.

In addition to indicating the changes, if any, of the number of accidents occurring, the respondents were also asked to give their reasons for these changes. A little over (18%, 13/70) of respondents reported a slight or significant upward rise in accidents and although they were in the minority regarding the rise in the number of accidents, they were certainly in the majority when it came to writing a response. There were many reasons given for this rise including lack of training and supervision, behavioural attitudes, lack of concentration, better reporting procedures, increased workload and decrease in program times, lack of skilled indigenous workers and a poor understanding of language in foreign workers. Several respondents picked up on the increased propensity for recycling and reclamation which required an increase in manual handling and manpower, where machines had previously replaced such activities. One respondent claimed; there is too much health and safety ruling and advice that has stopped operatives thinking for themselves to a large degree. They expect to be made aware of all hazards and no longer feel it is necessary for them to check. In addition, the employment agencies and departments make the job of getting work easier for school leavers and unemployed persons but the demolition industry ends up employing these people who are below average skill.

The majority of respondents reporting no change or a reduction in accidents put it down to an increase in training, safety awareness and better safety systems in place. Several state that improvements have been noticeable through the increased use of mechanical methods and the minimization of labour requirements. One respondent states; the decrease in accidents is down to a less labour intensive use of ‘bob cats’ and ‘mini diggers’ equipped with attachments and large demolition rigs equipped with selector grabs etc.

4.1.9. Waste Management and Sustainability (Q8)

Question 8: Have you as a company or individual made an effort to get to know all the issues regarding waste management and all the sustainability issues affecting your workplaces? This question changed the focus to waste management and sustainability issues and asked the respondents to qualify their awareness and understanding of the subject. The reasons behind this type of questioning were two-fold. Firstly to determine whether these issues were considered and secondly to gauge if they may have any bearing on how demolition methodology is derived, particularly for soft strip and handling of materials. As can be seen in Table 4.8 all respondents had acknowledged some understanding of these issues with the greater number, of the 63 who responded (76%, 48/63) stating a full understanding of waste management and sustainability issues. This is of course an encouraging sign, but nevertheless, not unexpected given the degree of waste handling that all demolition contractors have to manage. No other comments were received but 12 people chose not to respond which perhaps suggests a lack of engagement with these issues.

Table 4.8: Q8 – Have you Made an Effort to Understand Waste and Sustainability?

Fully	Partly	Only when necessary	Never	Total	No response
48	25	0	0	63	12

4.1.10. Reclamation, Recycling and Re-use (The Three R's) (Q9)

This question asked the respondents to give their opinion on the insistence or otherwise of their clients towards the reclamation, recycling or re-use of materials arising from a project. This is a question that many researchers have consistently failed to ask. During a detailed investigation of the available literature on the three R's, the overriding principle by many researchers is that the construction industry plays a large part in achieving reclamation, recycling and re-use targets. This is an assumption that is propagated but is not necessarily substantiated from this research. What is certainly unquestioned is that the majority of demolition contractors do manage their waste in a more sustainable manner than many other trades and can point to achieving recycling rates of over (90%) (NFDC, 2010). Therefore, in giving an answer to this question, the majority of the respondents could only state that clients sometimes insisted on the three R's with an almost equal number of (10%, 7/71) and (9%, 6/71) respectively admitting that clients only insist if pushed into it or that they always insist on it.

Table 4.9: Q9 – Does Your Client Insist on the Three R's?

Always	Sometimes	Only if they are pushed	Never	Total	No response
6	57	7	1	71	4

Those respondents who commented further added that many clients either had to be advised on the opportunities available or that they had no interest in the issue if it cost them time or money, or equally, if there was no value or credit return to them. Two respondents did admit that the insistence by clients on recycling was on the increase but that it usually only involved secondary aggregates.

4.1.11. Demolition Contractors and Sustainability Targets (Q10)

The final question, Question 10 asked: Do you think that demolition contractors have a major role to play in improving sustainability target results? It provided an opportunity to gauge the respondents' reaction to the role that demolition contractors may have in improving sustainability targets. It was hoped that the answer to this question would have been in the positive and would highlight the importance that sustainability has on how waste management and the handling of secondary materials is undertaken. With the UK Government's call for a significant reduction in landfill by 2012 it was gratifying to note that of the 73 respondents who answered this question (79%, 58/73) 'absolutely' agreed that demolition contractors have a major role to play and that the remainder, barely (16%, 12/73) believe they 'sometimes' have a major role to play.

Table 4.10: Q10 – Do Demolition Contractors have a Major Role to Play?

Absolutely	Sometimes	Not sure	Not ever	Total	No response
58	12	3	0	73	2

In terms of the comments received to this question there was criticism directed at clients who should accept that there may be a potentially higher cost in order to maximize recycling and that client involvement was critical; with regard to the time allowed for projects where the achievement of higher sustainability targets will require more time in the programme, which clients are reluctant to accept. Another respondent (a senior manager in a nationally operating company) stated that the demolition sector is way ahead of construction. Another added that demolition contractors have been reclaiming and recycling as it has always been financially rewarding. However, recording the fact has always appeared to be an issue.

4.1.12. Summary

The results of the questionnaire indicate that hand demolition for soft stripping is still very much in existence and, although attachment use is on the increase, there would appear to be a wide difference of opinion as to whether their usage makes the process of soft stripping easier or harder. Salvage and the value that materials may have is still an importance issue but indications that change is happening is clear.

In terms of accident reporting, over 50% of the respondents stated that they had recorded less than 5 over 3 day injuries in the last ten years and that of all injuries, cuts and abrasions were by far the most frequently recorded. Most respondents also believed that accidents had reduced over this period. The respondent's knowledge on waste and sustainability issues would appear to be good but as far as recycling initiatives and interest from clients where concerned, there would appear to be little desire.

4.2. Interviews

In this section, the responses received from the 10 questions posed to each interviewee have been analysed. A detailed analysis of the interview transcripts are discussed further in Chapter 5, leading to conclusions reached from all data collected.

4.2.1. Interviewees

The strata consisted of 12 individuals drawn from ten organisations that were practicing demolition companies within the United Kingdom. The Table 4.11 indicates the size of the organisation and the respondent types that the samples were taken from and in which the respondents (interviewees) were based.

Table 4.11: Interviews - Sample Derivation

Strata / Sample	Large Company 100 to 200 persons	Medium Company 50 to 100 persons	Small Company 1 to 50 persons
Managing Director 1	1		
Managing Director 2	1		
Managing Director 3			1
Managing Director 4		1	
Managing Director 5			1
Managing Director 6		1	
Consultant 1			1
Director 1		1	
Director 2	1		
Director 3	1		
Director 4		1	
Senior Manager 1	1		
Totals	5	4	3

4.2.2. Interview Data

There were in total 10 matrix questions (refer to Appendix C) that were designed to gauge the interviewees' opinions on four key influences. Namely:

1: Sustainability

2: Waste Management

3: Accident Causation

4: Legislation

The responses received by all interviewees were varied, but the same underlying belief, values and interpretation for each subject was immediately apparent and although the author found that adherence to the questions, in the strictest sense, was interpreted differently by each individual, the answers received were considered to be full and honest. There were also a number of overlapping answers that were given for previous questions and this was largely interpreted as a result of the individual's keenness on a subject or because there was a genuine belief that one mirrored the other closely.

The interview data has been presented in two formats. First, to address the four key influences; and secondly, to bring together the findings to address the four specific objectives. These objectives were determined to broaden the field of research within the four key influences and to explore the contextual issues associated with work in construction and more importantly, the association with demolition activities. Each objective has sufficient scope to expand outside of the remit and therefore put down indicators for further research as may be necessary. Together, these answers will also assist to address the 18 propositions derived from both sets of questioning, interviews and questionnaire, as well as the data collected via the literature review

4.2.3. Sustainable Demolition

Sustainability is a broad subject but the fundamental purpose of this research was to establish if there is any correlation between sustainability and a rise in accidents, in the demolition sector. It was also an opportunity to gauge the opinion of demolition contractors on their interpretation of sustainability particularly around the area of product and building design, as well as secondary materials usage.

Question 1 asked: "It has been suggested that there is a need to improve design and/or use of sustainable products and materials in the new build process. What new initiatives, processes or procedures could be implemented or adopted to achieve this?"

Of the twelve respondents, half believed that there is a real and genuine reluctance, on the behalf of clients, designers and constructors in general, to use secondary materials or products in any new build project. In terms of what needs to be addressed to combat this, the following points were raised:

- The lack of design of buildings to facilitate reuse, either as components within the frame or as products arising from the structure.
- The types of materials or products used within the structures that were unsuitable or impossible to re-use or recycle and peoples' lack of perception or disregard to the problems currently encountered in recycling and reclamation.
- Planning and the need for improvements in the process that take account of all aspects and impacts whether environmental, social or fiscal.

Almost all respondents agreed that reuse in modern day structures was impractical and that the best that could be achieved was recycling of materials, i.e. concrete, brick and clean timber. Rather surprisingly, changes to legislation or regulation was not considered to be a major factor as it was thought that changes to design and materials stipulation should take precedent. Table 4.12 lists key issues, together with the necessary action or change needed to drive forward implementation of that change broken down into five main categories (as determined by the interviewer).

Table 4.12: Q1 Key Response Issues and the Change/Action Implementation

Response Issues	Planning Improvement	Design Changes	Legislation & Regulation	Materials Use	People Perception (education)
More information about what is in the building	x	x		x	
More emphasis on improvements for design	x	x		x	x
More off site fabrication	x	x		x	x

Certification for sustainable buildings		x	x	x	x
Financial incentives for sustainable product use			x	x	x
End of life building directive		x	x	x	
Better education	x	x	x	x	x
Eradication of blame cultures	x		x		x
Whole life costing	x	x		x	x
Improvement in attitudes		x			x
Improvements in materials handling and recovery techniques	x	x		x	x

Question 2 aimed to tease out any alternate improvements or initiatives not addressed in the previous question. The response to this question was all the more surprising given that it was so similar and clearly illustrates the depth of feeling. It asked: "Given that there is an almost universal call for greater use of secondary products or materials either in the new build process or on the open market, how can improvements be made or initiatives driven to accomplish this?"

One of the consistent themes that came over clearly within answers was peoples and organisations 'perception' and 'attitude' to the use of/or specification of secondary products/materials. In the opinion of the contractors the reasons for such a poor perception or attitude to the use of secondary products/materials was split between commercial considerations, over specification, i.e. building regulations, inconsistency in quality, potential insurance claims, liability issues and importantly a lack of education or knowledge about the production and use of secondary materials. The majority of respondents were also of the opinion that improvements or changes to legislation and regulation could have a major role. Two respondents, 'senior manager 1 and managing director 4', stated that they would welcome an increase in the landfill tax and an introduction of some form of fiscal penalty to designers or developers who specified exclusive use of virgin materials when secondary materials were available for that function. All respondents were in agreement that the legal definition of waste was inaccurate and unhelpful and required change. Equally, all expressed concerns regarding their clients' intransigence in allowing sufficient time to recover all materials. Several commented on the use of poor quality screws in timber (that necessitated damaging the product to separate) and glues on composite products (that were impossible to take apart). Improvements in building and product design were repeated as was changes to planning laws, particularly a relaxing of the stringent requirements for setting up recycling centres and regional collection points.

Table 4.13 lists the key response issues arising from Question 2 with the necessary action or change needed to drive forward implementation of that change broken down into five main categories, as previously explained.

Table 4.13: Q2 Key Response Issues and the Change/Action Implementation

Response Issues	Planning Improvement	Design Changes	Legislation & Regulation	Materials Usage	People Perception (education)
Introduction of fiscal penalties for use of virgin materials		x	x	x	x
Measures needed to encourage use of secondary materials		x	x	x	x
Improvements to building and product design	x	x		x	x
Reduce over specification of secondary materials		x	x		
Change the legal definition of waste			x		x
Stop use of poor quality fixings that impedes recovery	x	x		x	x
Changes to planning laws and increase in MRF's and regional collection centres	x		x		
Ban production of single life products		x	x	x	x
Stop use of insulation that damages or makes recovery of materials difficult		x		x	x
Put pressure on clients who do not allow sufficient time to recover materials			x		x
Increase landfill taxes further			x		

Question 5 is included here as it addressed the strategy and regulatory side of waste management and recycling. Additionally, it attempted to bring out any further response to the design criteria, having considered the legislatory influences. The purpose of interchanging the questions in this way was to try to determine if the respondents had forthright opinions on the mandatory principle of the design element and what, if any, difference this may make to how the designer views his or her role. Q5 asked: “If design at all levels can have a major influence on how we manage our activities, do you think it should be obligatory for designers to accept a greater level of responsibility than they may do at present?”

The respondents were of the opinion that design and designers have a significant role to play in increasing recycling, re-use, reclamation and recovery of products and materials at end of life and that in general they are failing to apply sustainability solutions in their design. Three respondents, ‘managing directors 2 and 5 and director 4’, took the argument a little further suggesting the responsibility should not sit with the designer but should be shared with others engaged in the construction process. In particular the end of life process where expertise could be offered and designers could be advised on sustainability techniques and learn. Safety in design was cited by two of the respondents who believed that although the CDM Regulations addressed the subject there was no correlation with recycling and or recovery and therefore was not adequately challenged. One respondent agreed that buildings should be designed to be operated safely, used safely and taken down safely but because of the products and materials used and the time frames involved in a modern buildings life, i.e. 25 to 100 years, he questioned the need, or indeed, the desire that may exist for any use of those products and materials after that period. Another respondent suggested that designers could ensure that pre-cast concrete units could have features cast into them that made dismantling easier; he also suggested that pre-formed holes could be made in those structures that would clearly require controlled explosive felling. This would eliminate the risk of hand arm vibration experienced from drilling to create the charging holes.

Many of the comments also mirrored those given as answers to the previous questions. The most common being use of difficult or impossible to recycle materials in new build, changes to legislation and planning to incentivise people and better education to change perception and attitudes to secondary materials use. Table 4.14 lists the key response issues arising from question 5 with the necessary action or change needed to drive forward implementation of that change broken down into five main categories.

Table 4.14: Q5 Key Response Issues and the Change/Action Implementation

Response Issues	Planning Improvement	Design Changes	Legislation & Regulation	Materials Usage	People Perception (education)
Designers to look at whole life consequences		x	x	x	x
Better information and consultation given to the contractor at tender stage	x	x	x	x	x
Imbed features to improve dismantling at fabrication stage of pre-cast units	x	x		x	x
Stop use of composite / foam/ polystyrene products		x	x	x	
Designers should learn from other parts of the world		x			x
Change attitudes and perceptions by legislation or regulation if necessary	x	x	x	x	x
Changes to planning laws to make greater dependency on sustainability solutions	x		x		
Include sustainability and recycling requirements in the CDM Regulations		x	x	x	x
Government to offer tax breaks for eco-friendly designs		x	x		x
Put pressure on clients to question their architects etc on design criteria		x	x		x
Balance affordability with sustainability and carbon usage	x	x		x	x

4.2.4. Legislation and Waste Management

Question 3 was intended to capture opinions on waste strategy and waste handling whilst maintaining the ethos of a sustainable approach to demolition and the arisings created by the process. It asked: "What, in your opinion, are the greatest barriers to implementing a sustainable waste strategy in the demolition sector and how can these be best broken down"?
As previously noted in answers to other questions, the reference to the lack of time given on projects and the increased cost to operating an efficient and effective waste strategy, where all considerations for recycling are taken onboard, came out as a high concern. Both these

constraints are born by the contractor as generally the client is unlikely or unwilling to shoulder any of the burden. In addition, the majority of the respondents made reference to the legal definition of waste and how this was unhelpful to any waste strategy undertaken by the demolition sector. Further reference was made to environmental permitting and the constraints imposed on producers of secondary products or materials. One large London based contractor gave an example of having to send soils to Belgium for remediation and ship them back for re-use, because of the cost and time element in complying with UK waste licensing laws. Other barriers to a good waste strategy included impositions on site, over specification of secondary materials use, management risks, lip service by clients, the throw away societal attitude and the lack of investment into materials recycling facilities.

Table 4.15 lists the key response issues arising from question 3 with the necessary action or change needed to drive forward implementation of that change broken down into five main categories. On interrogation of Table 4.15, the order of preference for changes/actions needed to be implemented is equal for all issues except for column 3 where there is an overall agreement that the best way forward is for Government to impose the conditions necessary for change by applying legislation or regulation. This is somewhat surprising given that many of the respondents blamed a good proportion of the missed opportunities to apply a sensible waste strategy on the intransigence of the Environment Agency, who incidentally, are controlled by DEFRA. Of the changes/actions required to break down the barriers to implementing a sustainable waste strategy, five key considerations were identified. These were; giving products/materials an inherent value to increase recovery; specifying a 'whole life cycle' strategy as mandatory at planning stage; eradicating time and cost constraints where there is a clear demand or reason to operate a waste strategy; bringing influence to bear on plant and machinery manufacturers to produce equipment with integrated systems fitted to enhance recycling and recovery techniques, i.e. crushers fitted with integral screens and belts, shredders with primary and secondary cutters etc or a change to the legal definition of waste and making planning applications for opening waste recycling centres friendlier.

Table 4.15: Q3 Key Response Issues and the Change/Action Implementation

Response Issues	Improvements in LA Mind Set & Planning	H & S and Management Risks	Legislation & Regulation	Improve Materials Spec's	People Perception (education)
Time and cost constraints		x		x	x
Lip service given by clients and designers to a proactive waste strategy		x	x	x	x
Lack of planning and imposition on planning for MRF's	x	x	x		
Inconsistency of approach by Local Authorities	x		x	x	
Cartels operated by the big '5' aggregate companies to keep quarry tax low	x		x		
The legal definition of waste and the EA's intransigence to call all demolition arisings waste		x	x	x	x
Environmental permitting constraints	x		x	x	
Lack of regulatory/legislator control	x		x	x	
The Building regulations	x	x	x	x	x
Increased risk to health & safety		x	x		x
Specifications for secondary products/materials and the hierarchy of waste	x	x	x	x	x
Impositions on site	x	x			x
Lack of investment by contractors and stubbornness of regulators to relax constraint on movement of materials	x		x	x	x
Management risks, i.e. insurance, finance, licensing		x			x

Moving on, the purpose of Question Four was to determine if the interviewees saw the present day legislation as a hindrance or an asset to 'waste' utilisation and management and what changes may be needed if any for improvement. It asked; "Could regulatory/legislatory changes or a relaxing of the present regime make a significant difference to waste handling and utilisation"?

The answers given were a confusing mixture of opinions on a number of topics, some related to the question, others not so. Many of the remarks made within the interviews had little to do with a change to legislation and therefore specific feedback to regulatory controls was limited. However, the depth of feeling regarding what is classed as waste was aired by all respondents. Many made the point that they do not consider any demolition arisings to be waste until such time as all efforts to either convert what they have into a saleable commodity has run its course, or they have run out of avenues of opportunity to process or move on the materials and only then will they deem the remainder to be waste. Respondents 'director 2 and 3 and manager 1' gave examples of how the waste licensing regulations have made it unprofitable or impossible to take such as clean excavated soils straight to another site because of the environmental permitting regime. One contractor in particular, 'director 2', sited an example of the constraints imposed by the regulations, in that a site half a mile from the demolition site wanted to take the material as fill, but because of the legislatory restriction, they had to take it eight miles out of town to process it and bring it back the same distance to deliver to the new site. Several of the contractors stated that landfill is still a tempting alternative to having to drive up to 70 miles to a recycling centre with the more difficult waste materials such as that generated by the 'soft strip' process. Respondent 'manager 1', on the subject of the regulatory regime, was convinced that the UK suffers from over regulation and that with every new regulation that is brought out, two old ones should be repealed or squashed.

In order of importance, the interviewees were firmly of the view that regulatory/legislatory changes or a relaxing of the regime would make a substantial difference to waste handling and utilisation. Improvements to secondary materials/products specification criteria was considered to be the next best step with an improvement in people's perception and better involvement at local authority level coming in close behind. Table 4.16 lists the key response issues arising from Question 4 with the necessary action or change needed to drive forward implementation of that change broken down into five main categories

Table 4.16: Q4 Key Response Issues and the Change/Action Implementation

Response Issues	Improvements in L A Mind Set & Planning	H & S and Management Risks	Legislation & Regulation	Improve Materials Spec's	People Perception (education)
The legal definition of waste is misleading, unhelpful and inaccurate and needs a radical overhaul	x		x	x	x
Landfill charges are helpful in increasing contractor recycling habits and the separation of waste at source	x		x		x
Increase landfill tax and quarry tax	x		x	x	
Need for a relaxation on the restrictions for moving clean, inert, hazard free soils and aggregates	x		x	x	x
Need for better liaison between officers of the EA in the interpretation of materials as a waste or usable commodity		x	x	x	x
Review of specification standards of secondary aggregates to curb over specification and to improve grading	x	x	x	x	x
Abolish the 'stigma' associated with use of secondary materials/products	x	x	x	x	x
Create tax 'off sets' for recycling activities			x	x	
Review and change the Building Regulations to accommodate use of secondary materials/products	x	x	x	x	x

4.2.5. Accident Causation and Sustainability

In Question Six, there was an opportunity to determine whether any significance had been attached, or concern raised, as to the increased health and safety risk of using a manual approach in opposition to mechanical means. Sustainability verses commercial viability was also a factor. It asked: “If the significant risk of an accident occurring is increased by the introduction of the man into the workplace, is it reasonable to expect that the recovery of building components take second place to efficient and effective work methods where safety factors may be increased and sustainability initiatives be decreased”?

The principal messages that emanated from the interviewees’ answers were that the recovery of materials would always take second place to health and safety and that the more man hours spent on site, the greater the increase in risk. The majority of respondents took a pragmatic view to the recovery of products, citing cost and time as major drawbacks. Many preferred to pull down a structure and ‘cherry pick’ the salvageable items as opposed to putting men at height or increasing the labour force on site. Several of the respondents referred to unsafe practices carried out by unscrupulous contractors who would blatantly disregard health and safety measures, such as scaffolding, to reclaim features like roofing slates with a high salvage value. One interviewee, ‘consultant 1’, expressed concern that there was too much emphasis on the recovery of an item for re-use in its original form, when the safest and easiest way was to recover and re-use in a different form, i.e. bricks, slates and tiles as hardcore, a door as wood chip, a steel beam as scrap etc. Another contractor, ‘managing director 6’, questioned the integrity of one particular client’s health and safety manager when he was advised that salvaging the roof slates on a site building would not be possible in the interests of his operatives’ safety as he would be required to work at height. He was later instructed to take off the slates when it was thought that bats could be nesting in the roof, thereby causing a potential for a substantial delay in the project programme if the cladding was not removed to discourage habitat. Contractor ‘managing director 2’, mentioned the modern style industrial cladding that has been constructed of steel profile sheeting with a cfc- or hcfc- blown foam inner layer (an ozone depleting substance that should not be subjected to direct sunlight). It has been suggested that there is growing concern within the industry that they may be pressurised into taking down this cladding by hand, thereby greatly increasing the risk of accident and injury. Table 4.17 lists the key response issues arising from this question with the necessary action or change needed to drive forward implementation of that change broken down into five main categories

Table 4.17: Q6 Key Response Issues and the Change/Action Implementation

Response Issues	Improvements in Client Mind Set & Knowledge	H & S and Management Risks	Legislation & Regulation	Improve Design Spec’	People Perception (education)
There is a perceivable tension between H & S and recycling	x	x			x
More men equals more cost, more man hours, more risk and stripping for recovery doesn’t always add up financially	x	x			x
We recover what we can using machinery and where that doesn’t happen it’s just too bad		x		x	x
We have a tendency to wrap ourselves in cotton wool and do not look at the common sense things	x	x	x		x
It’s a question of refocusing to decide if a skirting board is only that or is after all just a piece of timber cut to a particular shape	x	x		x	x
Putting people back into a building will increase accidents and this is disproportionate to the recovery rate	x	x	x	x	x
Generally the cost of a scaffold to remove roofing materials outweighs the salvage value	x	x			x
The bonafide contractor will always be at an economical disadvantage to the unscrupulous contractors	x	x	x		
Design for deconstruction is the key to safe working	x	x	x	x	x
If you have ten men on a job you have ten times the risk of something happening	x	x			x
The recovery of materials will always take second place to safe working	x	x	x		x
There must be a happy medium but it seems at times that more emphasis is put on commercial aspects	x	x			x

rather than the safety requirements					
Effectively there is nothing more expensive than an accident and one accident is not worth all the bricks in a building	x	x	x		x

4.2.6. Accident Causation and Legislation

Question 4 addressed the regulatory regime and its position on waste management. Question 7 was intended to test the helpfulness or otherwise of the regulations in terms of site safety and welfare. The overall impression was that UK regulations were well received and doing a good job, albeit with some reservations. Question 7 asked “How helpful, or otherwise, are the UK workplace regulations in providing a common framework to improve safety, welfare and health on site”?

Whilst there was a resounding ‘thumbs up’ for the UK workplace regulations, some respondents did not think these went far enough and one ventured that they sometimes went ‘over the top’. Many were sceptical of the role played by HSE and almost half of the respondents believed that policing of the regulations was poor. CDM received some criticism and although in general, they were well received, it was thought that their interpretation by clients, main contractors and CDMC’s, in particular, did not properly address the issues in a demolition environment. All the respondents who mentioned site welfare agreed that standards had dramatically improved. Several respondents alluded to the fact that demolition sites are safer places today, but the same cannot be said for many construction/building sites where standards are poor and are a breeding ground for accidents. Table 4.18 lists the key response issues arising from Question 7 with the necessary action or change needed to drive forward implementation of that change broken down into five main categories

Table 4.18: Q7 Key Response Issues and the Change/Action Implementation

Response Issues	Improvements in Client Mind Set & Knowledge	H & S and Management Risks	Legislation & Regulation	Improve Working Practices	People Perception (education)
I am certain that sites are safer places to be now	x	x	x		x
I think we have some of the most thought out and grown up H & S legislation in the	x	x	x		x

world					
We are definitely world leaders in Occupational Safety and Health		x	x	x	x
The UK workplace regulations are a good framework for improving safety and the general wellbeing of people	x	x	x	x	x
The standard of welfare has improved over the last ten years with our workforce demands		x	x	x	x
There are not enough inspectors to police the system and the unscrupulous take advantage of this fact	x	x	x	x	x
If regulations such as CDM were better understood by clients and some main contractors they could make a huge impact	x	x	x	x	x
CDM is really designed for building and not demolition and dismantling	x	x	x	x	x
Many CDMC’s have no demolition experience and it’s become something of a joke	x	x	x	x	x
There seems to an attitude in HSE that all they want to be is policemen and not advisors		x	x	x	x
There are requirements within the workplace regulation that are difficult to achieve or comply with because they are not specific enough		x	x	x	x
In our industry sector we have largely managed to design the man out of the workplace	x	x	x	x	x
There are times when you wonder if it’s all worth it when fly by night contractors win jobs because they have little regard for legislation and good practice	x	x	x	x	x

4.2.7. Legislation

Question Eight was born out of a need to test the views of the individuals on the current workplace regulations and their relevance to the demolition industry. The reactions to this question were interesting with the answers given from a practical viewpoint. Four of the respondents were in favour of specific regulations targeted for the demolition sector whilst the remainder were of the view that what was in place was adequate, although two of the respondents repeated an earlier view that they should be policed better. Question Eight specifically asked: "Would statutory regulations specifically targeted at each individual industry sector be of greater benefit than an holistic approach as at present"?

For the majority of the respondents there appeared to be an air of frustration regarding the inevitable cross over between construction and demolition activities. Although it was agreed that many of the workplace regulations adequately addressed construction activities they didn't fulfil the needs of the demolition sector, citing the challenges that new technology is addressing. In that respect, there was a majority agreement on the need for specifically targeted legislation. 'Managing director 6' was a lone voice who would prefer to see more Approved Codes of Practice (ACOP's) as opposed to more regulation. He was also of the opinion that ACOP's worked better with improvements and advances in new technology. CDM also came in for more criticism with, in particular, reference to unqualified CDMC's, poor implementation and policing, misinterpretation of the duty holders and a disregard for the ethos of the regulations by some clients. Respondent 'director 4' gave an example of this when the CDMC and an asbestos consultant were asked to leave the meeting whilst the price for the job and the commercial issues were discussed. The policing of the regulations, with CDM principally being mentioned, was a moot point with the main issue being the low number of HSE Inspectors available to cover the whole of the UK. Table 4.19 lists the key response issues arising from question 8 with the necessary action or change needed to drive forward implementation of that change broken down into five main categories.

Table 4.19: Q8 Key Response Issues and the Change/Action Implementation

Response Issues	Improvements in Client Mind Set & Knowledge	H & S and Management Risks	Legislation & Regulation	Improve Working Practices	People Perception (education)
I am of the opinion that we have to have our own regulations as at present we		x	x	x	x

are trying to apply the construction regulations to an industry sector that does just the opposite					
The present regulations are more construction led and demolition is quite unique. If we had regulations tailored for our needs everyone would be happier	x	x	x	x	x
We need a stronger stick in our sector. We are continuously dictated to by people who have never done our job	x	x	x	x	x
We have to apply so many regulations and rules that have never really fitted us. We are just tagged onto the back of the construction boys	x	x	x	x	x
For myself I would prefer more codes of practice not regulations. It's easier to move forward with technology using ACOP's		x		x	x
CDM regulations are good but they are not policed enough		x	x	x	
Too many CDMC's know nothing about demolition and are not fit to coordinate our operations	x	x	x	x	x
I don't believe that improvements to H & S would work by splitting up the regulations, you would end up with confusion over who owns responsibility		x	x		x
It would probably cost ten times the amount we spend on HSE to see specific regulations per sector		x	x	x	x
We are not big enough to get our own regulations			x		x
I believe the number of regulation we have are sufficient as there is a catch all in the H & S at Work Act and nobody gets past the Act			x		x

Question Nine went on to interrogate the theory that decisions on health and safety issues are taken by individuals or companies, through a fear of being exposed to prohibition or prosecution if they failed to take any kind of action. The answers received were varied and came from many different viewpoints, but the responses seemed to agree with the context of the question. It asked: “Do you believe that the fear of prohibition or prosecution could have an undue influence on an individual’s capacity to take a pragmatic or common sense view on health, safety and welfare requirements in the workplace.”?

A number of responses received made reference to the HSE’s attitude towards demolition operations on site and either their ability, to see the obvious challengers facing the demolition contractor, or their inability or unwillingness, to understand what is the deciding factor on prohibition or otherwise. Inevitably, the CDM regulations were mentioned again but one could associate this with the fact that they are by far the most talked about of all the workplace regulations and when policing, or more frequently the lack of policing, is mentioned it has involved CDM. Several respondents were displeased with situations that arise, as a specialist contractor working for a main contractor, where their health and safety team will, in their opinion, needlessly impose constraints on certain work activities, usually from a lack of understanding of industry practices and a desire to ‘cover their backsides’, or where they have ‘incorrectly identified a potential for risk’. A comparison was made between ‘health and safety’ by respondent ‘managing director 6’ who pointed out: “*that what most people worry about is safety because that is instant, if they get it wrong the consequences are felt immediately. However, health tends to be longer term and the fear of being legally affected is less so it doesn’t get attended to as much”*.
On another point, respondent ‘manager 1’pointed to the fact that every day was different on a demolition site: “*If one looked at the two issues of a factory production worker and the man whose working in a demolition environment. The man who is working in the demolition environment is the spaceman, he is the man who’s going to the moon every day, whereas the factory worker is on the Clapham Omnibus”*. Other issues aired centred around the issue of a prohibition notice and what that could mean to an increase in insurance premiums, an ability to get more work and how it could affect ones judgement on how to do the job. Equally topical was the blame culture that tends to exist today, although not necessarily within the demolition sector, where people shy away from accepting responsibility and when an accident or incident happens, the ‘no win no fee’ lawyers are called in to push for vicarious liability to absolve their client from the ultimate blame.

Table 4.20 lists the key response issues arising from Question 9 with the necessary action or change needed to drive forward implementation of that change broken down into five main categories

Table 4.20: Q9 Key Response Issues and the Change/Action Implementation

Response Issues	Improvements in Client Mind Set & Knowledge	H & S and Management Risks	Legislation & Regulation	Improve Working Practices	People Perception (education)
I have told the HSE to their faces that they are removing a person's ability to think for themselves and as a result we see stupid accidents occurring		x	x	x	x
The problem is that most people don't understand H & S legislation so it's as much a fear of prohibition and prosecution as it is people claiming through insurance liability	x	x	x	x	x
The way the regulations are written means we mollycoddle people and it is inevitable that stupid accidents are going to happen	x	x	x	x	x
A lot of these things are built on a negative fear and not on a positive feel.	x	x	x	x	x
Developing a good H & S culture is a better way to go than fear of prohibition or prosecution		x		x	x
I believe that amongst quality contractors the fear of prohibition and prosecution and the bad name that results because of it, does assist in the drive for high H & S goals	x	x	x	x	x
In England I believe that HSE take the view that if someone doesn't know to wear a hard hat, vest and boots on site, then they are not fit to be there		x	x		x
If we jump in my car to go to the cafe and the police		x		x	x

stop us because you are not wearing a safety belt, they don't fine Mercedes, me or my company, they fine you as an individual					
The majority of prohibitions I know about have been based on the text book and not the practical aspect		x	x	x	x
Too many people pay lip service only to the regulations			x		x
People need to be sensible and pragmatic about H & S and its up to those of us in the know to guide others			x	x	x

4.2.8. Legislation, Sustainability, Waste Management and Accident Causation

Finally, Question 10 gave the respondents an opportunity to gather their thoughts on what had been said previously and to elucidate on that or comment further on any other matter. Some of the comments that were made mirrored previous thoughts and it would have been unusual if this were not the case. However, what did emerge was that some of the comments received at this point were given by individuals who although expressing them for the first time, actually mirrored the previously aired opinions of others. This further supports the validity of the data. Question 10 asked: What if any changes or initiatives would you like to see implemented or developed that could improve health, safety, and welfare and environmental practices in the workplace.

There were of course a number of issues raised for Q10 and some of them had a recurring theme, i.e. the role of the HSE, licensing for demolition, duties of designers and the improvements needed to such as CDM. Several of the respondents were unhappy with the role undertaken by the client and were of the opinion that as long as the price was right, they didn't give much consideration to anything else. Respondent 'managing director 2'finished off his interview by stating: *"one of the more interesting things about our industry is that we can never afford the time, or be able to relax on a day to day basis, because there is always something to address and there are always improvements to be made. Whether that's from a regulatory perspective or whether from self implementation, you try to look at things that don't look right to you and you try to address it; and I suppose that's what makes sure you get up in the morning and go to work".*

Table 4.21 lists the key response issues arising from question 10 with the necessary action or change needed to drive forward implementation of that change broken down into five main categories

Table 4.21: Q10 Key Response Issues and the Change/Action Implementation

Response Issues	Improvements in Client Mind Set & Knowledge	H & S and Management Risks	Legislation & Regulation	Improve Working Practices	People Perception (education)
What is needed is an expansion of the role played by HSE in guiding people and helping them		x		x	x
HSE could do more to address the issues within our industry and be more specific to our needs by meeting with NFDC and IDE regularly	x	x		x	x
I would like to see an enforcing body that deals exclusively with the demolition and recycling sector, who could write and apply specific regulations		x	x	x	x
I would like to see demolition become a licensed activity to drive out the unscrupulous from the industry			x	x	
An improvement to the CDM regulations in terms of awareness and responsibility	x	x	x	x	x
I would like to see a regulation that stipulates, in a format that can be better measured than CDM allows at present, exactly what the client has done and achieved before the demolition contractor is involved	x	x	x	x	x
More usage of common language that workmen can understand			x	x	x
More improvement in welfare arrangements to ensure they are top class		x		x	
Moving forward as a more open society that does	x	x	x	x	x

things through consensus and changes in attitude rather than regulation					
More direction from trade bodies				x	x
Make industry training cheap enough and available for all and remove any inconsistencies				x	x
A universal KPI to be developed that enables one to benchmark against all standards		x	x	x	x
Better survey's of buildings, prior to demolition, undertaken by the client	x	x		x	x
Outlaw immediately the concept that lowest price always wins	x	x	x	x	x
More direct liaison at design stage	x	x		x	x
A change of attitude of designers to consider properly whole life consequences of what they are designing, the materials they use and specify		x		x	x
Give buildings a rating on sustainability to use taxation or legislation to make things financially viable		x	x	x	
A change of attitude towards re-use and recycling	x	x		x	x
A real drive and ambition to make electricity out of all the waste we have dumped into landfill			x	x	
To get major contractors to practice what they preach	x	x	x	x	x

4.2.9. Summary

The interview process has resulted in an abundant amount of data from a small group of individuals who displayed a powerful and emotive series of opinions over a cross-section of questions. The main areas of interest or concern that have been highlighted feature:

Legislation, either the lack of it, too much of it or the wrong kind of legislation particularly where regulations address construction needs but fall short of addressing specific demolition activities. A clear message of frustration and disappointment was given by the majority of the respondents regarding the unhelpful legal definition of waste, the ignorance and apathy displayed by civil and building contractors, designers, developers and others towards the use of secondary materials and the time and cost constraints imposed by clients when there is a clear demand or reason for reclamation or recycling on the site. Some respondents cited a fear of prohibition or prosecution, ignorance and a total lack of knowledge towards the demolition process as an excuse to impose unrealistic safety demands on what would be considered as low risk activities by demolition contractors. Five points in particular stand out:

- Give products and materials an inherent value to increase recovery
- Specify a whole 'life cycle' strategy as mandatory at the planning stage
- Eradicate time and cost constraints where there is a clear demand or reason to operate a waste strategy
- Bring influence to bear on plant and machinery manufacturers to provide equipment with integrated systems fitted to enhance recycling and recovery techniques
- Change the legal definition of waste and make planning applications for opening recycling facilities friendlier

4.3. Regional Accident Data

Data on all non-fatal accidents recorded within individual demolition companies between 2003 and 2008 were sampled from nine organisations spread across the UK. The organisations were chosen for their diversity of operations in demolition, asbestos removal and recycling activities. The purpose of this research exercise was to explore the correlation, if any, of the types of accidents being recorded against the types of work activities and those groups of workers involved in demolition activities or their satellite operations per annum.

The data were recorded within an Excel spreadsheet that enabled charts to be produced. The data consisted of the types of information as depicted below. However, not all respondents chose to follow the remit and submitted their accident data in their own format. Whilst this created some difficulties, the author was grateful for the time taken by the organisations to respond positively to the request for information. The requested data were:

Injuries to parts of the body

- Hand/arm
- Torso
- Legs/feet
- Head/eyes

Injuries by employment

- Demolition operatives
- Asbestos operatives
- Yard operatives
- Drivers
- Sub-contractors

4.3.1. Sample Description

Organisation 1

Sample 1 was taken from a north east of England contractor whose average labour force was approximately 300 employees during the study period. The organisation carries out a variety of operations ranging from earthworks, quarrying and demolition. This contractor's accident records show that the largest number of injuries occur to demolition operatives, with drivers of HGV vehicles running a close second. With a fleet of over 100 trucks, drivers are the second largest group of employees with demolition operatives in the ascendency. Hand and arm injuries are the most common injuries recorded, whilst injuries to legs and feet are around 14% less. Both types of injuries are persistently higher than others, although it is interesting to note that in year 2003 hand/arm and head/eyes shared top spot, whilst the following year injuries to legs/feet far outstripped that of the others. The total number of accidents recorded for this period was 85.

Organisation 2

Sample two was taken from a large London based contractor who, on average, employed approximately 150 site based staff. The organisation has a head office in London with satellite offices around the UK and operates on a national basis. This organisation has traditionally employed sub-contract labour gangs to supplement its own directly employed operatives. The highest number of injuries has been recorded to asbestos removal workers who it would appear are twice that of the demolition operatives. However, one may assume, based on the historical knowledge of the researcher, that the majority of the sub-contractors were demolition operatives. This would narrow the margin somewhat if this were fully substantiated, which it cannot. There are several interesting factors emerging from the data with the most telling being a gradual reduction in hand/arm injuries over the research period, although, it is significant that these injuries are significantly higher than for any other. The total number of accidents recorded for this period was 91.

Organisation 3

Sample 3 was taken from a medium sized organisation that employed approximately 100 operatives engaged in a variety of operations ranging from demolition, asbestos removal, scrap and waste handling and reclamation. The organisation kept detailed accident data although did not differentiate between the occupations of the various employees. Although this changed the reporting criteria somewhat, enquiries made by the researcher after the data were submitted has revealed that of the 100 operatives employed in that period the average employment consisted of:

45% demolition operatives
13% asbestos removal operatives
12% drivers
8% scrap metal workers
6% reclamation yard operatives
17% sub-contractors
12% waste handling operatives

The detail of the accident data were over and above that which was requested but was nevertheless welcome as it assisted greatly with the identification of trends and occurrences for each employment. The data indicates that hand/arm injuries are the most prolific followed by legs/feet. The data also identifies that manual handling is a significant cause of injury with slips, trips and falls edging out cutting and being hit by stationary or moving objects. The total number of accidents recorded for this period was 79.

Organisation 4

Sample 4 was obtained from a nationally operating company based in the West Midlands, specialising in demolition, asbestos removal, waste handling and excavations. The company employed an average workforce of 85 persons over the research period. The company did not identify individual's employment roles against the recorded accidents, but a breakdown of those employed in this period was available. However, in 2009 they have recorded the accident causation and body locations. The total number of accidents recorded over the study period was 55.

<u>Organisation 5</u>

Sample 5 was taken from a medium sized organisation employing around 60 site based operatives during the study period. The organisation is based in the West Country operating predominantly down the west coast of the UK from South Wales into Cornwall and along the M4 corridor. Sub-contract labour has been drawn from demolition, asbestos, fencing and scaffolding suppliers. Data collected from this sample identifies that demolition operatives have been recorded as receiving a significantly greater number of injuries than other workers, with a three year period between 2005–2007, as being particularly high. The cause of this high number of recorded injuries is not clear, although the researcher has personal knowledge of an expansion of operations in this company during this period and the employment of an independent HSE consultant whose reporting regime could have been substantially superior to an in-house regime. These factors may account for the increase in reporting. Of those injuries recorded, hand/arm injuries were appreciably higher, with legs/feet approximately 35% lower. The total number of accidents, in this period, is recorded as being 124.

<u>Organisation 6</u>

Sample 6 was taken from an SME based in the north of Northern Ireland whose operations are divided between demolition, civil engineering and plant hire. This division of work is common in the Province amongst contractors. However the SME has separated the recorded accidents to the demolition wing from those of other activities. The sample indicates that the number of most recorded accidents occurs to the hand and arm with legs and feet the second most recorded. The overall number of accidents recorded is low and although the SME gives no indication of the reason for this, the researcher has to presume that even with an average of 28 employees, over the study period, safety systems were working efficiently and effectively. There is no evidence in place to support any theory of under reporting or failure to record all injuries occurring. The total number of accidents recorded during this period was 6.

Organisation 7

Sample 7 was collected from an SME that employed on average, over the sample period, 25 site based staff, employing sub-contractors for fencing and scaffolding work only. The area of operation for the organisation was predominantly within the South East of England and along the South Coast. It is clear from the data that there are two emergent factors. Firstly, the majority of accidents occurring at this organisation, during this period, were to demolition operatives and secondly, the majority of accidents that have been recorded were predominantly to the hands and arms. The total number of all accidents recorded in this period is 42.

Organisation 8

Sample 8 was taken from an SME based in Northern Ireland with a trading history of over 50 years in operation, employing an average of 16 site based persons over the study period. The organisation specialise in demolition, asbestos removal and waste management. Accident records had not been kept over an extended period of time and until recently were not recorded for the purpose of investigating trends or as a measure of the effectiveness of safety systems. However, accident records are available for years 2006 to 2008 of the study period. The sample would indicate that hand/arm and legs/feet injuries were the most prolific over a two year period. However, it is also interesting to note that injuries to the torso equal the number of reported injuries to hand/arm and legs/feet over the 3 year period. A substantial part of this contractors operations are within waste management and as injuries to the back fall into the torso category it is not unreasonable to speculate that the majority, if not all, of these recorded injuries were as a result of manual handling during waste handling. Without the extended data being available it is not possible to identify a trend between the different groups of employees, although the data collected for the 3 year period puts the total number of accidents recorded at 23.

Organisation 9

Sample 9 was taken from a small demolition, asbestos removal and plant hire organisation based in the south west of Scotland. The organisation employed approximately 10 site operatives, on average, within the research study period. The number of recorded injuries by this Scottish SME show that demolition operatives receive the greatest number of injuries at a rate twice that of the combined total for all other operatives. The sample would also indicate that the greatest number of accidents occurring is to the hand/arm, which is twice that for other bodily injuries combined. The total number of accidents recorded was 10.

Table 4.22: Aggregated Total of Employees from Samples

	Org 1	Org 2	Org 3	Org 4	Org 5	Org 6	Org 7	Org 8	Org 9	Total
Average number of employees (2003-08)	300	150	100	85	60	28	25	16	10	744

4.3.2. Injured Employee Category (2003-2008)

Table 4.23 and Figure 4.7 show the number of injuries recorded against the category of workers employed in the nine companies. For Organisations 3 and 4 the numbers have been estimated as no account was recorded by the companies of those individuals employment. However, the numbers employed are known and the accidents have been averaged out against the percentage numbers employed. For Organisation 8, no accident details are available prior to year 2006 so the average for the three years submitted has been averaged out and added to the total. The grand total of all accidents for the nine organisations, between 2003 and 2008, is 515 which equates to 69.2% of employees having recorded being injured at work during the study period.

Table 4.23: Employee Injury by Organisation (2003-2008)

	Org 1	Org 2	Org 3	Org 4	Org 5	Org 6	Org 7	Org 8	Org 9	Total
Demolition Operatives	37	21	35*	30*	76	5	25	7^	5	241
Asbestos Operatives		45	10*	6*	6		6	6^	1	80
Yard Operatives	13		12*	3*	6	1	6	8^	2	51
Drivers	34	9	9*	3*	12		3	2^	2	74
Sub-contractors	1	16	13*	13*	24		2			69
TOTAL	85	91	82	55	124	12	42	23	10	515

* estimated

^ reduced reporting period so figures are averaged out

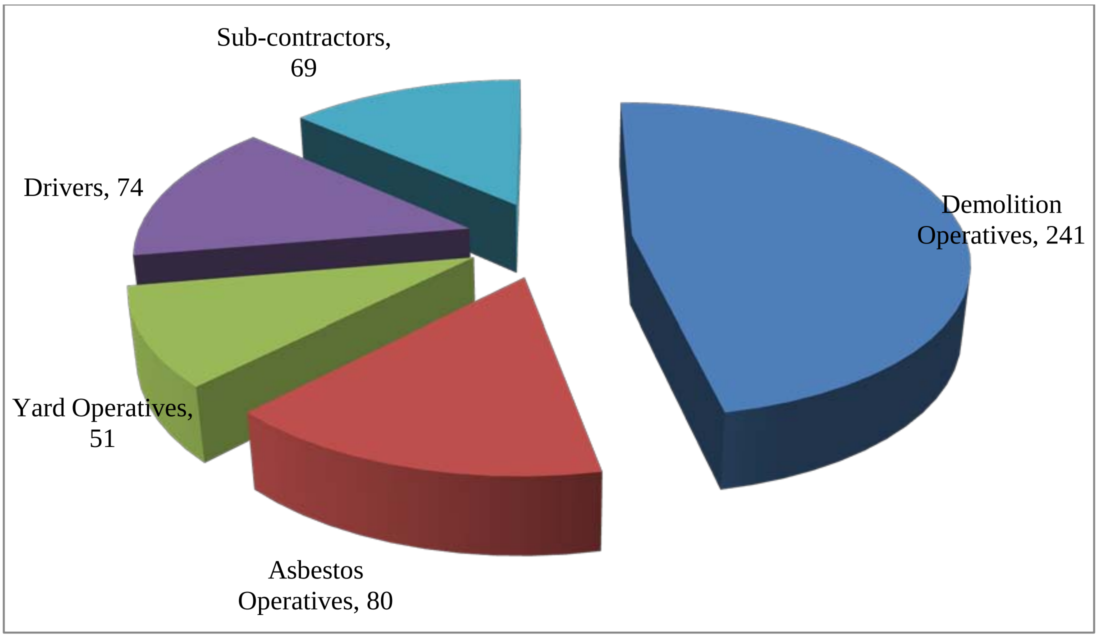

Figure 4.7: Employee Injury by Worker Category (2003-2008)

The data recorded in Figure 4.7 identifies that demolition operatives, at 46.7% of the total, as having had the most accidents, followed by asbestos operatives at 15.5%. Drivers are shown to be the third highest at 14.3% of the total although one must be guarded in assuming that this figure is fully representative of all HGV drivers employed in the demolition sector as these figures may have been artificially swollen by one sample from Organisation 1.

Sub-contractor injury is also an interesting aspect because many demolition companies use sub-contract labour gangs for stripping out and also for asbestos removal. However, for the latter category, one could be fairly confident that the majority of asbestos removal work will relate to non notifiable work, i.e. which does not require licensed asbestos removal contractors or 14 days prior notice to the HSE. Therefore, both these types of operations will generally be undertaken by demolition operatives. This realization does of course increase the number of accidents attributed to demolition operatives and may be as high a percentage as 60.1% of the total accidents recorded.

Interrogation of the data taken from individual organisations, illustrated by Figure 4.8 provide evidence that the larger the organisation the greater, proportionately, the number of accidents they record. There are however, some anomalies to this fact in that Organisations 5 and 7 have recorded a proportionately higher number of accidents to demolition operatives as has Organisation 2 for asbestos operatives.

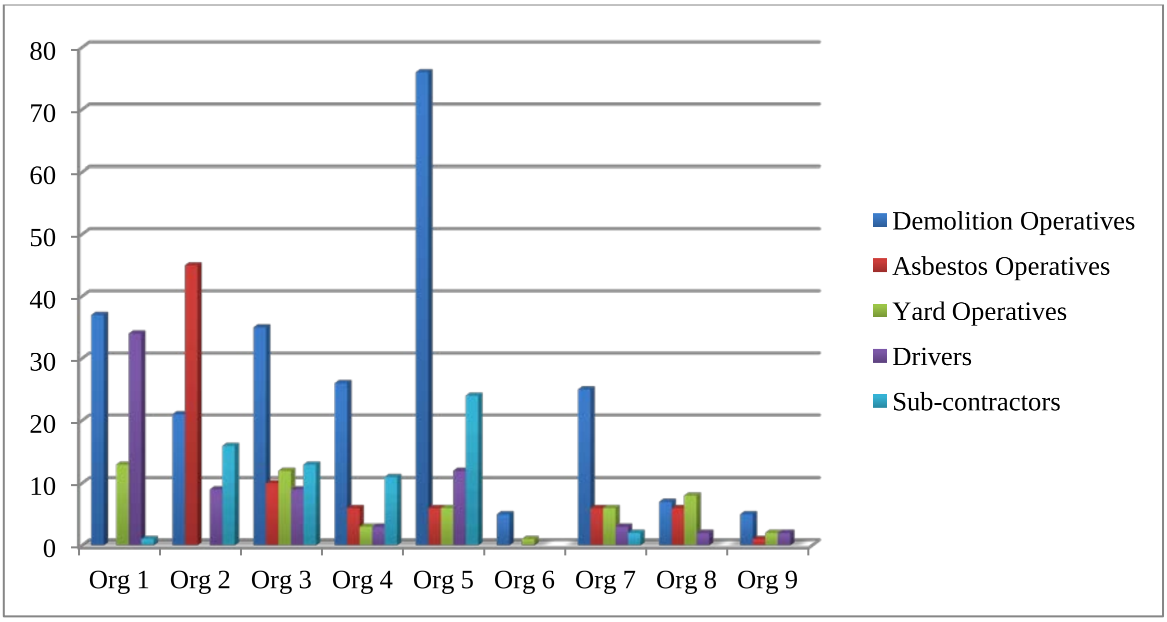

Figure 4.8: Employee Injury Category (2003-2008)

There could be several explanations for this type of anomaly, although one would be tempted to explain it as those organisations having a better reporting regime than others, particularly when set against figures given to NFDC in the members annual return (see Section 4.3.7 to 4.3.8). Where Organisation 2 has recorded an unusually high number of asbestos operative accidents, the explanation may be simple in that such accident occurrences may in fact have happened whilst removing non notifiable asbestos materials. In which case, it could have been demolition operatives to which the accident should have been noted. One is therefore left to speculate if this was a reporting error based on the type of work being carried out rather than who carried out the task.

Table 4.24: Injuries by % of Employee Types for all Organisations

%	Org 1	Org 2	Org 3	Org 4	Org 5	Org 6	Org 7	Org 8	Org 9
Demolition Operatives	12.3	14	35	30.5	126.6	17.8	100	43.7	50
Asbestos Operatives		30	10	7	10		24	37.5	10
Yard Operatives	4.3		12	3.5	10	3.5	24	50	20
Drivers	11.3	6	9	3.5	20		12	12.5	20
Sub-contractors	0.3	10.6	13	12.9	40		8		

When determining the likelihood of an accident occurring by a % point, the larger organisations would appear to fare better than the smaller organisations, as proportionally we can see the percentages rise as we move across the table from left to right (see Table 4.24). Although this could be said to be a common mathematical occurrence, it is nonetheless disconcerting to know that one's chances of having an accident are, in some organisations, more likely to occur than in others.

4.3.3. Injury Types

Table 4.25 shows that hand/arm injuries account for nearly double that for injuries to other body locations even allowing for estimated numbers in Organisations 4 and 8. Hand/arm injuries account for 39.4% of the 502 injuries recorded over the study period. Injuries to Legs/feet are slightly higher than for the Head/eyes at 21.3% and 20.7% respectively. Injuries to the Torso are only marginally lower at 18.5%. Figure 4.9 is included here to highlight the differences in these categories.

Table 4.25: Injury Types per Organisation (2003-2008)

	Org 1	Org 2	Org 3	Org 4	Org 5	Org 6	Org 7	Org 8	Org 9	Total
Hand/arm	37	21	32	15*	58	4	18	8*	5	198
Torso		45	11	15*	11		2	8*	1	93
Legs/feet	13		20	15*	35	2	12	8*	2	107
Head/eyes	34	9	16	8*	23	1	9	2*	2	104
TOTAL	84	75	79	53	127	7	41	26	10	502

*estimated

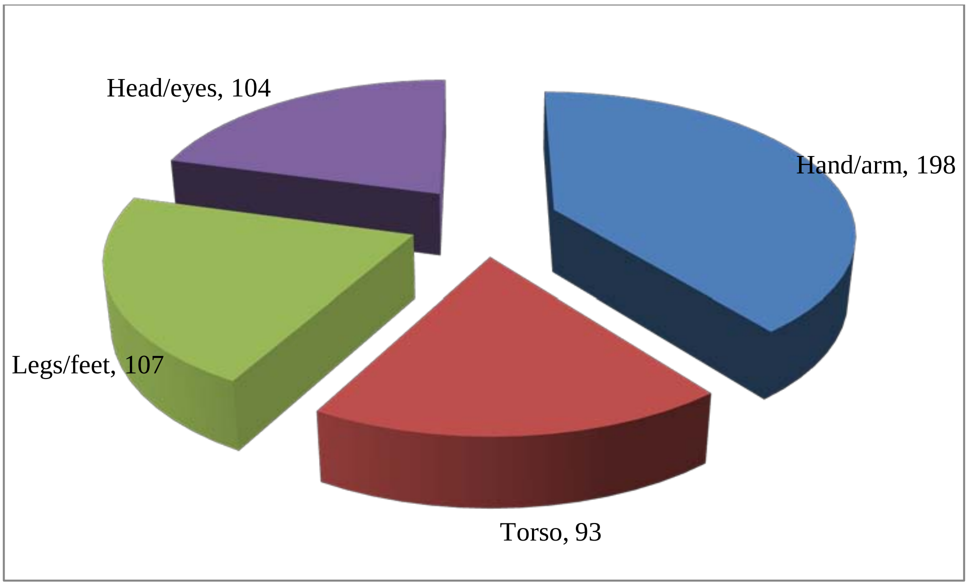

Figure 4.9: Injury Types for all Organisations (2003-2008)

4.3.4. Change Over Time

The data has also been evaluated to identify the number of accidents occurring in each year by category of accident, as displayed in Table 4.26. The highest number of all injuries occurring, at 23% of the total recorded, is shown to have occurred in 2005, whilst the lowest recorded at 11.8% of the total, are in year 2003. Years 2006 and 2007 account for 19.4% and 18.5% respectively, with 2004 and 2008 coming in at 14.6% and 12.7% of the total injuries recorded.

Table 4.26: Injury Types by Year (2003-2008)

Organisation		2003	2004	2005	2006	2007	2008	Total
Hand/arm	1	7	4	5	7	3	4	30
	2	16	14	14	12	10	7	73
	3*	1	1.5	6.25	5.75	1.5	3.75	20
	4*	2.5	2.5	2.5	2.5	2.5	2.5	15
	5		5	20	13	16	4	58
	6		1		1	1	1	4
	7	2	1	4	6	1	4	18
	8#	1.3	1.3	1.3	4			8
	9	1		1		2	1	5
Torso	1	2	2	2	2	5	1	14
	2	2	1	2	2	1		8
	3*	1	1.5	6.25	5.75	1.5	3.75	19
	4*	2.5	2.5	2.5	2.5	2.5	2.5	15
	5		1	3	2	4	1	11
	6							
	7			1	1			2
	8#	1.3	1.3	1.3	2	1	1	8
	9					1		1
Legs/feet	1	4	7	3		2	1	17
	2	1	2	1	1	1	2	8
	3*	1	1.5	6.25	5.75	1.5	3.75	20
	4*	2.5	2.5	2.5	2.5	2.5	2.5	15
	5			12	6	15	2	35
	6	1	1					2
	7	1	2	1	1	2	5	12
	8#	1.3	1.3	1.3		4		8
	9	1			1			2
Head/eyes	1	7	2	3		2	1	15
	2							
	3*	1	1.5	6.25	5.75	1.5	3.75	20
	4*	1.3	1.3	1.3	1.3	1.3	1.3	8
	5		1	8	3	7	4	23
	6				1			1
	7		3		3	2	1	9
	8#	0.33	0.33	0.33			1	2
	9			1			1	2
TOTAL		60.3	75.3	119.3	99.8	94.8	65.8	508

*estimated

averaged over the period (1-2% error)

4.3.5. National Accident Data

The collection of accident data from the demolition sector has been made possible by two avenues of opportunity. First, through interrogation of the RIDDOR data which has been made available by HSE and secondly, through the annual members reporting regime of the NFDC. However, information supplied by NFDC, from its members, is largely unsubstantiated and does not seem to agree with evidence gathered through other channels. Accident data for the whole of the construction industry is available from the Construction Statistics Annual. This is based on the findings of the Labour Force Survey and some of this data has been presented in Section 4.3.9 together with some comments.

4.3.6. RIDDOR Accident Statistics 1996 – 2007

Accidents recorded under RIDDOR for the demolition sector have been extracted from the main data base, by HSE, using the Bomel data extraction tool (Tunnicliffe 2010). Table 4.27 depicts the fatalities, major, over three day injuries and the total recorded for the years 1996 to 2009. Fatalities in the demolition sector appear to have fluctuated within the RIDDOR reporting timeframe rising as high as 8 in 1997/98 and dropping to a low of 3 at the end of the reporting period. Major injuries show an overall rise of 93% from 1996 levels to 2009, peaking in 2004 and 2007 respectively at 118% and 143% greater. Whilst over three day injuries have increased by 18% from 1996 levels to the year 2009, peaking in 2004 at 30% greater. All injuries within the sector have increased by around 43% during this study period.

Table 4.27 Demolition Accident Statistics via RIDDOR

Year	Fatal	Major	Over 3 day	Total
1996/97	3	44	67	114
1997/98	8	44	43	95
1998/99	2	38	43	83
1999/00	4	32	43	79
2000/01	7	49	40	96
2001/02	2	38	54	94
2002/03	7	83	80	170
2003/04	5	77	83	159
2004/05	3	96	87	186
2005/06	2	92	75	169
2006/07	3	73	83	159
2007/08	2	107	86	195
2008/09	3	85	79	167

When one interrogates the RIDDOR data there is an unmistakable connection between the data collected from the 9 regional contractors, (see Section 4.3.4) and that derived from RIDDOR, in particular for years 2005-2007. This is clearly shown on Figure 4.10 between years 2004-07 where the correlation is clear in the rise of accidents.

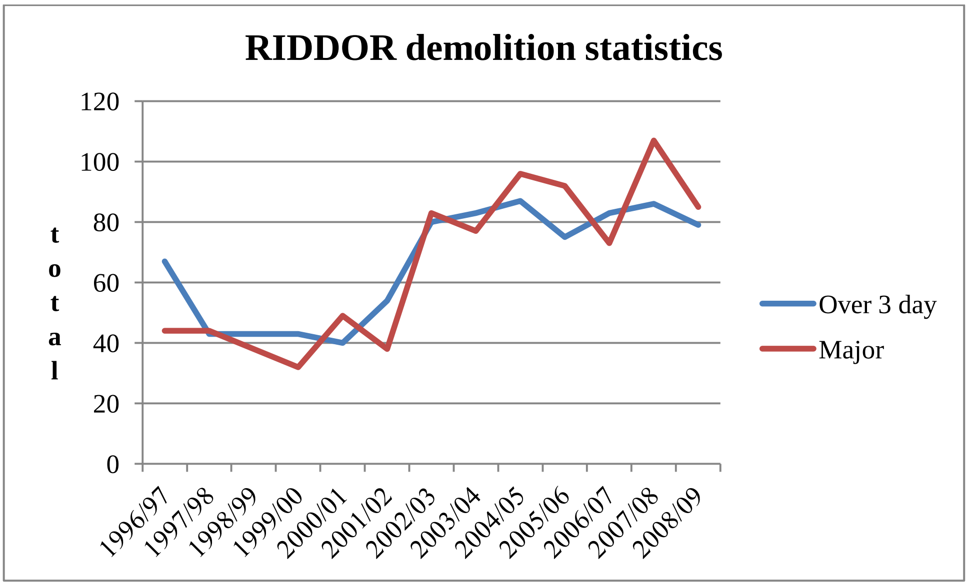

Figure 4.10: Demolition Major and Over Three Day Injuries 1996 – 2009

4.3.7. NFDC Accident Statistics 2000 - 2002

Despite the mandatory requirement to furnish annual accident and waste record returns, by member companies of the NFDC, the regime is notoriously lax and difficult to police because of the time and cost to appoint staff to oversee the system. Although such a reporting system is desirable and needed, it does not receive the attention which it merits. This is unfortunate, as one has to rely on RIDDOR or the Labour Force Survey, which have well known drawbacks and is not fully representative of an industry sector that has its fair share of detractors when it comes down to health and safety performance. It would not be fair to report that all members companies fail to return their annual accident and waste statistics, although it is questionable as to the accuracy of some of those returns, given the size of the organisations and the diversity of work carried out. In years 2000 to 2002 an effort had been made to identify trends and the types of accidents occurring in each region. It is unfortunate that this has not been repeated for subsequent years as the data embodies the principle, although not precisely, within the research study on regional accident statistics for years 2003 to 2008. Figure 4.11 shows the data in the format collected by NFDC for years 2000 to 2002.

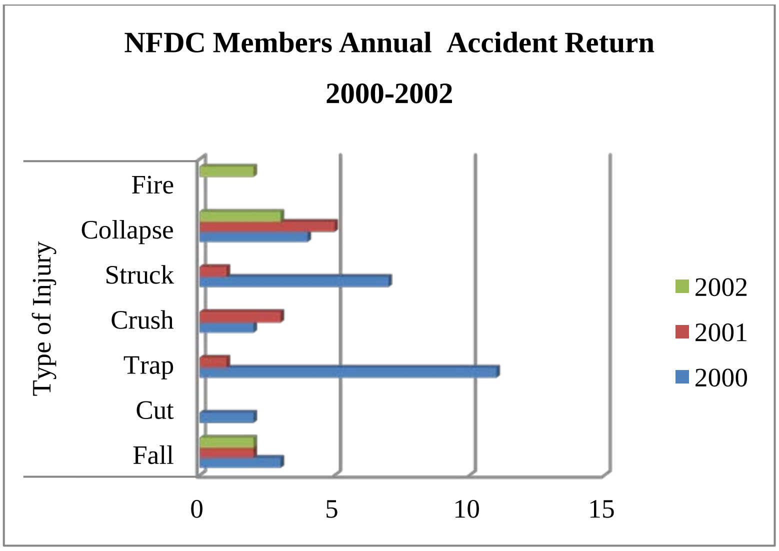

Figure 4.11: NFDC Accident Statistics

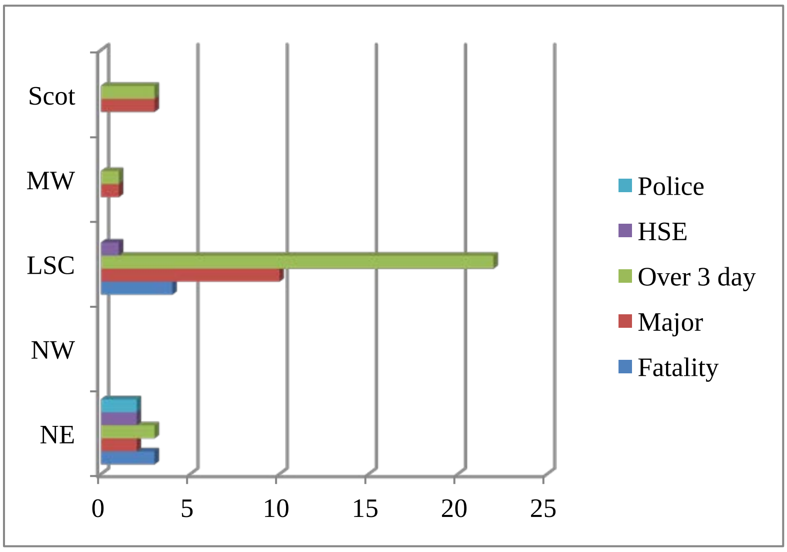

Figure 4.12: NFDC Regional Reporting

The NFDC membership is divided into 5 regions. These are:

NE = North East

NW = North West

LSC = London & Southern Counties

MW = Midland & Wales

Scot = Scotland and Northern Ireland

The data, as submitted, also identified the individual region to which the accident had been attributed. However, there are a number of issues arising from the data, not least the absence of any data submitted by the North West region which numbered approximately 20 companies. The following observations however, can be made:

- It is unclear as to whether the recorded major injuries are also listed as being an ‘over 3 day’ injury or whether they constitute another injury. For the purposes of this exercise they have been counted as another injury.
- The number of fatalities correspond with that reported under RIDDOR for year 2001-2002
- Major injuries are recorded as being 16 for years 2000-02, although RIDDOR records show 87. Therefore, NFDC members account for 18.5% of major injuries in that period.
- In year 2000 LSC region recorded 11 cases of trapping with one fatality. No other cases were recorded for 2001 or 2002 by LSC and no other region recorded any such injuries for the whole period.
- HSE action and police involvement are registered for two fatalities in the NE region in year 2002 and for an over 3 day injury to a member of the public in year 2000 in the same region. HSE action was recorded for a major and an over 3 day injury in year 2000 for the LSC region. However, the data suggests that for four fatalities occurring in year 2001 in the LSC region and one fatality in year 2000 in the NE region, there was no HSE action or police involvement which seems extraordinary.
- The highest number of injuries have been as a result of trapping and collapse (12 each), the second highest being struck (8) and the third highest from falls (7). One would need to ascertain whether there is a correlation between falls and collapse as there is a propensity to associate the two and assume some or all of the recorded falls may have been as a result of a building or structural collapse.
- Striking and crushing injuries number 13 as do trapping injuries. Is this to be regarded as a coincidence, or is there a fault in the reporting process?
- Fire and cuts injuries are relatively low compared to others reported. Whilst it may be expected that the former would be low one must question the low reporting of cuts injuries in an environment where manual handling is common. A further anomaly is the discrepancy between the data collected from the questionnaire which has

identified 58 cases of cuts and abrasions, reported by 75 respondents, which was significantly higher than other reported injuries.

4.3.8. NFDC Accident Statistics 2003 - 2009

For 2003 and onwards the NFDC reporting system and its annual return form was changed. Regrettably, the reason for such change is not known as those members of the NFDC staff employed at that time are no longer in post. However, what is apparent is that the reporting of accidents and dangerous occurrences was encouraged using the RIDDOR reporting process which favoured sending in copies of the completed F2508 accident form submitted to HSE at the time of the incident or injury. Whilst these forms are formatted to extract the bulk of the information, such information is reliant on the person filling out the form to give a full account of the incident. The following data have been appended in as close a format to the regional research data as possible.

Table 4.28: NFDC Annual Accident Data by Employment – 2003 – 2009

	2003	2004	2005	2006	2007	2008	2009	Total
Demolition operatives	1	1	4	3			7	16
Asbestos operatives	1	1				1	2	5
Drivers								
Yard operatives							2	2
Sub-contractors							1	1

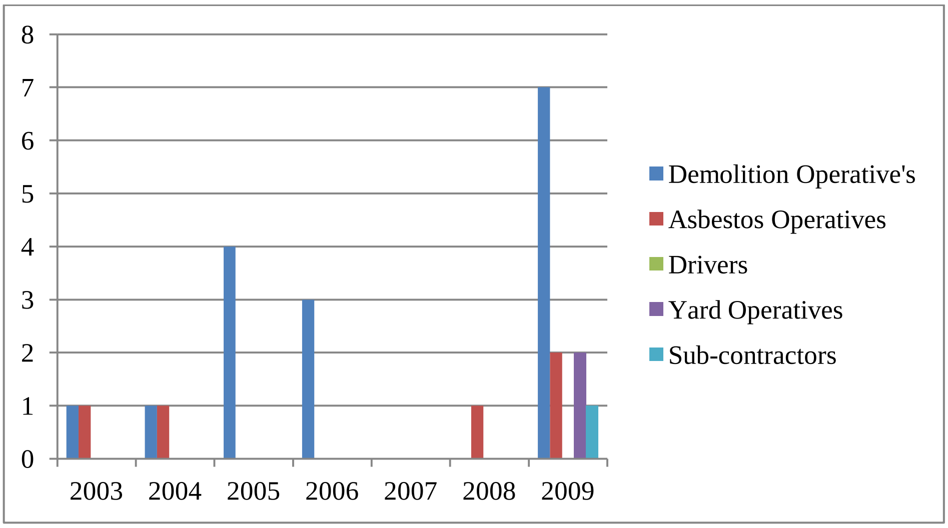

Figure 4.13: NFDC Annual Accident Data by Employment – 2003 – 2009

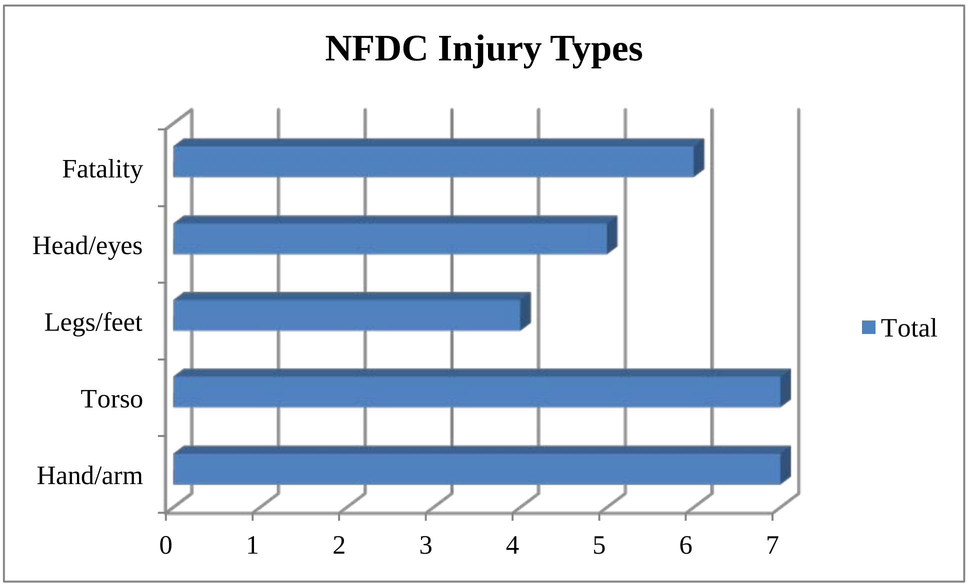

Figure 4.14: NFDC Total Injury Types 2003 – 2009

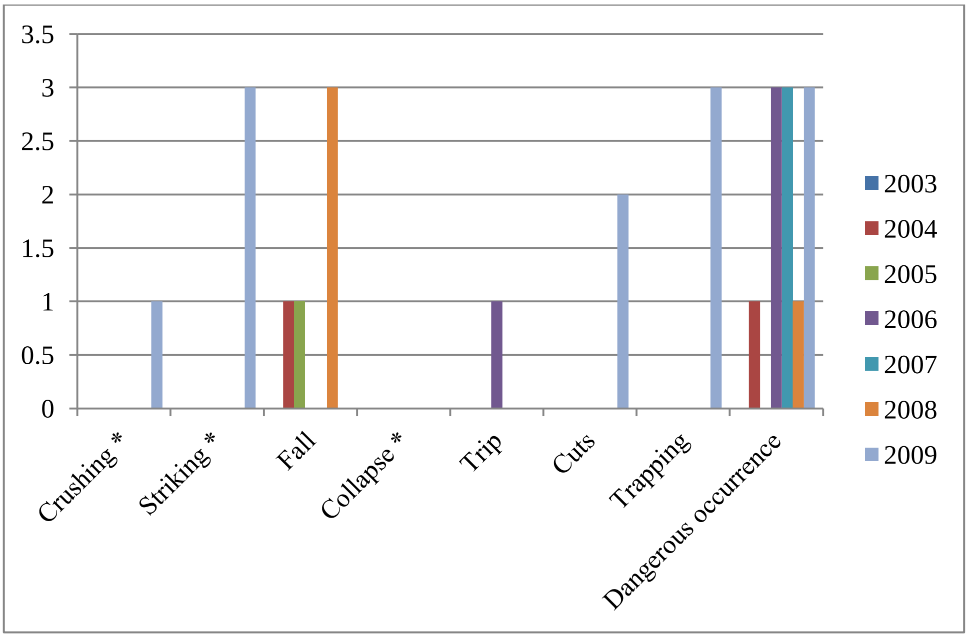

Figure 4.15: NFDC Cause/result of Injuries 2003 – 2009

When one examines the data collected in years 2000-02 against that collected for years 2003-09, one is struck by the considerable difference in the number of accidents reported. The former period reporting a total of 48 and the latter a total of only 24, over a period of time twice as great. Indeed, for year 2007 no accidents of any kind were recorded and for 2008 one accident only was reported to an asbestos operative. Comparing this data with the nine regional respondents that returned their accident statistics as part of this study, the frailty of the NFDC system and its inability to provide a true account of the sector's accidents is exposed. The regional respondents reported a staggering number of 515 persons who had received an injury of some kind between years 2003-08. RIDDOR statistics for the industry sector up to the end of 2008, reported 1,063 accidents in total from 2003-08. These facts would suggest that NFDC need to dramatically improve their accident reporting regime if they are to have any meaningful value. In addition, it would appear that there is a substantial underreporting within the RIDDOR scheme given that NFDC membership totals 152 (at end of 2010) companies, but according to the Office for National Statistics, there are at least 1,430 registered demolition companies, employing around 13,600 people in the third quarter of 2008 (ONS, 2010).

4.3.9. Construction Industry Accident Statistics 2003 – 2008

Table 4.29 has been derived from the Labour Force Survey (LFS) administered by the Vital Statistics Division of the Office for National Statistics (ONS) on behalf of the Statistical Outputs Group of the ONS (ONS, 2010). Unlike RIDDOR, the ONS carry out sampling from randomly selected households/persons (usually 60,000) on a continuous quarterly basis within England, Scotland and Wales. Confidence intervals are estimated to be at 95% (i.e. estimate + or – 1.96 standard error) (ONS, 2010). Taking the figures for 2006/7 we can determine that the LFS reports a total of 12,649 injuries, which equates to around 1% of the total construction industry workforce at that period (see Section 2.4.5).

Table 4.29: Labour Force Survey of all Accidents in the Construction Sector 2003-2008 (ONS, 2010)

Employees	**2002/3**	**2003/4**	**2004/5**	**2005/6**	**2006/7**	**2007/8**
Fatal Injuries	56	52	55	43	54	54
Non-fatal major injuries	4,031	3,978	3,768	3,706	3,730	3,764
Over 3 day injuries	8,949	8,256	7,540	7,555	7,161	7,446
All reported injuries	13,036	12,286	11,363	11,304	10,945	11,264
Self-employed						

Fatal Injuries	14	19	14	17	25	18
Non-fatal major injuries	690	750	728	766	727	703
Over 3 day injuries	629	739	748	829	754	702
All reported injuries	1,333	1,508	1,490	1,612	1,506	1,423
Members of the public						
Fatal injuries	5	4	8	4	7	3
Non-fatal injuries	263	180	200	200	191	197
All reported injuries	268	184	208	204	198	200
Totals						
Fatal Injuries	75	75	77	64	86	75
Non-fatal major injuries	4,984	4,908	4,696	4,672	4,648	4,664
Over 3 day injuries	9,578	8,995	8,288	8,384	7,915	8,148
All reported injuries	14,637	13,978	13,061	13,120	12,649	12,887

HSE, on their web pages for statistics related to construction activities, report an overall downward trend in fatal, major and over 3 day injuries from 1999 onwards. Taking 2006/7 as an example, RIDDOR figures for all construction accidents are put at approximately 10,800 (HSE, 2010) a significantly lower figure than suggested by the LFS. In terms of injuries measured per 100,000 workers, RIDDOR statistics are considerably lower than the LFS estimated rates, as shown in Figure 4.16.

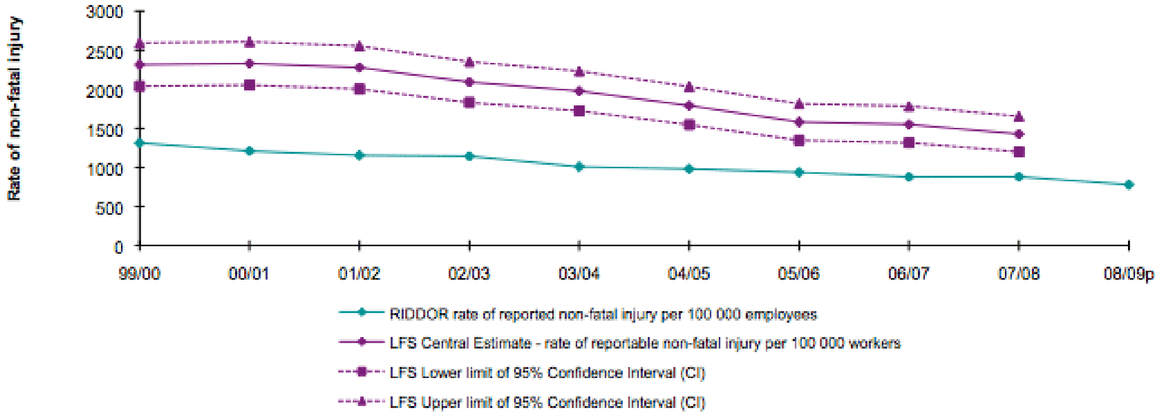

Figure 4.16: RIDDOR and averaged LFS rates of reportable injuries in construction 1999/2000 - 2008/09 (HSE, 2010)

The discrepancy between the estimated LFS rates and those reported under RIDDOR are less than helpful in determining exact accident rates and one suspects that unless the process of reporting is made mandatory, which is backed up by a legislatory regime for all offenders of the system, it will continue to be flawed. The HSE (2008) states that non-fatal RIDDOR reports are subject to significant under-reporting and that the true level of accidents in the construction industry are around 30,000 per year as opposed to the 4,600 majors and 8,000 over 3 day injuries. Even the LFS reporting levels are only about 50% with self-employed levels very low at 5% (HSE, 2008). Despite this obvious irregularity, HSE are confident that overall the rate of accidents within the construction sector are falling and this can be seen from the results depicted in Figure 4.16 and Table 4.30 presents HSE's rationale for this statement.

Table 4.30: Downward Trend in Accident Occurrence for Construction (HSE, 2008)

Fatal injuries	The rate of fatal injury to workers is 28% lower in 2007/08 compared to the base year in 1999/00 following the decrease from 3.9 to 3.4.
Reported major injuries	The rate of reported major injury to employees shows a clear downward trend, despite the small increase in 2007/08. The rate in 2007/08 is 23.5% lower than in the base year.
Reported over-3-day injuries	The rate of reported over-3-day injury to employees has increased somewhat in 2007/08, having fallen steadily over the previous 7-year period from 1999/2000. It is nearly 35% lower in 2007/08 than in the base year.

Reporting levels.	Levels of reporting for non-fatal injury to workers (as measured by the LFS rate) have increased from 52% in 1999/2000 to around 57% by 2005/06-2007/08. Although there is no clear improvement in reporting rates, recent trends in LFS support the reduction in reported injury rates

Despite the flaws in the reporting regimes the insistence by HSE on a tangible reduction of accidents occurring in the construction industry is encouraging. However, it doesn't appear that the same can be said for demolition alone. If we consider the data shown in Figure 4.10 we can see that the rate of accidents has steadily increased from around year 2000 up to 2006/7 with a slight tailing off in 2007. This trend is also corroborated by the regional data, collected as part of this research study, as shown in Table 4.26 Section 4.3.4. This substantial increase in the number of accidents occurring in the demolition sector cannot simply be explained away by an increase in activity or manpower as this should also be reflected in the overall accident rate for construction per se, which would appear to be going in the opposite direction. The number of hand/arm injuries in the demolition sector is nearly double that for those recorded in other body locations, suggesting that manual handling activities may be a prime causation. Coupled with the fact that demolition operatives are the group most at risk and that activities such as 'soft strip' are still largely undertaken by hand, it is indicative of a problem area that has not been solved by technological or cultural advances

4.4. Chapter summary

In this chapter, the results show that the preferred mode of operation for soft stripping is by hand, despite the increased use of mechanical equipment and that this type of operation is likely to result in more injuries. However, the general feeling from those respondents taking part in the research questionnaire was that accidents were being reduced when other data collected from the nine regional contractors and that separated from RIDDOR by HSE clearly indicates that accidents would appear to be on the increase.

The majority of those respondents taking part in the research interview had strong views on the legitimacy of the 'legal definition of waste' citing that it did not assist the demolition sector in increased resource efficiency. Whereas clients, in general, had little appetite for recycling initiatives and put undue pressure on demolition contractors to complete within tight time frames at reduced cost. The general perception towards the workplace regulations was that they were adequate for the construction sector but failed to address some specific needs for demolition activities. The HSE came in for some criticism regarding how it policed the workplace regulations, whilst there was opinion expressed towards client contractors, in particular, that the fear of prosecution or prohibition often led to unrealistic safety demands where demolition contractors considered the perceived risk to be low.

5. CHAPTER FIVE: DISCUSSION

5.1. Introduction

This chapter brings together the knowledge derived from the literature review, the research questionnaire, respondent interviews and all statistical formal and informal data collected. The purpose of which is to show that this data has met the research objectives and propositions including highlighting recommendations for change or efficiency in sustainable demolition and safety systems.

The research methodology involved the use of qualitative and quantitative data collection, employing the ‘triangulation’ method, which when used in a complimentary fashion to answer different questions that do not necessarily come together easily, can provide a single well integrated picture (Patton, 1999). Data collection took the form of an emailed questionnaire sent out to 300 members of the Institute of Demolition Engineers, of which 75 were returned, a response rate of 25%; a programme of structured personal interviews with 12 senior practicing demolition professionals; an electronic data collection of individual companies accident statistics derived from nine organisations spread throughout the United Kingdom; an interrogation of the National Federation of Demolition Contractors members annual accident returns; and data supplied by RIDDOR, LFS, HSE and the ONS.

Accident data were collected from nine UK wide demolition companies, the NFDC, HSE and from RIDDOR and LFS published statistics, covering in general, a period between 2003 and 2008. There was an importance placed on identifying those operative categories most at risk and to what types of injuries were most prevalent. This would also give some indication as to the methodology in place, i.e. mechanical or manual and which if any year of the research period indicated higher or lower levels of incidence.

Interviews were conducted with 12 senior figures of demolition companies practicing in the UK. The interviewees were all known to the author and the organisations that each represented were corporate members of the NFDC. This last point was considered important as the members of the NFDC are purported to undertake the greater majority of demolition, dismantling and its satellite operations of asbestos removal and waste handling carried out in the UK each year (Button, 2007; CRW, 2008). The 10 questions for the interviews were designed to address the research objectives and the propositions and allowed sufficient scope for each interviewee to put forward their views in as forthright a manner as they saw fit.

The Objectives of the research were:

- To evaluate the importance that both design and designers have on the ability to provide a safe working environment to reduce significant hazards and therefore risk, which in turn may influence human characteristics or traits
- To examine the interactivity between sustainable demolition activities and the propensity for an increase in accidents or incidents
- To question the need for small or radical changes in UK safety regulations and workplace policy in order to simplify and make relevant the demands for work in a demolition environment
- To identify efficient ways in handling and disposing of secondary materials or products liberated from the demolition process with a specific emphasis on the reduction of accident or incident

5.2: Accidents and Injuries

5.2.1 Frequency

The collection of data on accident periods is generally intended to advise on trends, i.e. an increase or decrease or a change corresponding with an action or initiative etc. It is also useful to note those trends that appear to be moving in opposing directions to the general or national trend. This is a phenomena that affects accident data from the demolition sector which seems to indicate that, whereas in all industries and in particular the construction industry accident rates are falling, those extracted from RIDDOR using the Bomel data extraction tool indicate a rise in demolition accidents over the research period. This is also highlighted in the data from the research cohort of nine UK wide organisations (see Section 4.3). Both sets of data, RIDDOR (demolition stats) and the nine selected organisations, show an unmistakable peak in years 2005 to 2007 which is in conflict with the LFS and RIDDOR statistics for the construction industry in the same period. However, what is unmistakable is the considerable rise in the reported demolition orientated accidents recorded under RIDDOR, see Figure 4.10 from 2000 onwards.

Of the nine UK organisations sampled, as part of the regional data collection, they employed 744 staff. Of these employees it was identified that the largest category of worker was the demolition operative and that those operatives also recorded the greatest number of workplace accidents by a significant amount. An equally significant fact was that around 62%, or 515 persons, of the sampled workforce had recorded having had an accident at work during the research period. In the same period, the LFS identify that there were, in total, 65,695 injuries for the construction industry (ONS, 2010), whereas HSE state that 872 injuries were recorded for the demolition sector at this time (Tunnicliffe, 2010), meaning that those injuries accounted for around 1.3% of all injuries received in the construction industry.

Three of the ten questions asked within the research questionnaire centred on the number and frequency of accidents and those most commonly recorded. Although one is constrained by the context that the question dictates, one is obliged to recognize the accuracy of the answers received in that they are supposedly given in good faith. Of the 75 respondents, all representing their organisations and all but six full contracting members of the NFDC, 59 had reported having between 1 and >10 accidents during the research period. However, during the same period the NFDC recorded only 24 accidents occurring for all 158 corporate member organisations (refer to Section 4.3.8).

Whilst the number of demolition related injuries may appear to be relatively low it is worth considering that in the third quarter of 2008 the total number of persons employed in demolition accounted for a mere 1% of the construction industry numbers employed (ONS, 2010). Extrapolating further, ONS report that in 2008 there were 13,600 people employed in the demolition sector, therefore this research cohort represented a mere 5.4% of the total employed, but may account for up to 59% of the total accidents returned via RIDDOR reporting which seems somewhat curious. Although the interrogation of the accuracy, or otherwise, of the various reporting regimes was not a research objective, it is nevertheless important that there be confidence in the veracity of the data gathered, as this is a further indicator of the misguided reliance placed on the RIDDOR reporting process.

5.2.2 Types

The research cohort and data gathered from the NFDC members annual returns identified that demolition operatives, with at least a two thirds majority, were most at risk of incurring injury at work. Of the types of injury most prevalent the research cohort established that injuries to hand and arm were most significant, being almost double that of the next largest category, legs and feet, although injuries to the torso and head and eyes were of similar numbers. NFDC by comparison, put injuries to hand, arm and torso on an equal rating followed by head and eyes and legs and feet respectively. However, one is inclined to view the NFDC injuries data with scepticism regarding its accuracy considering that over the research period of six years the members' annual accident returns recorded 24 accidents against the research cohort reporting of 515 accidents and 1,039 under RIDDOR during the same period.

Reporting anomalies aside, the data identified that cuts and abrasions were the most prevalent followed by trips, slips, burns and falls respectively. It also identified that accidents were perceived to have decreased by nearly half of the respondents during the research period, whilst an equal number either recorded no change or a slight rise. Both the LFS and RIDDOR have reported a consistent fall in serious and over three day accidents for the construction industry but figures extracted from RIDDOR, utilising the Bomel data extraction tool, for the demolition sector alone, suggest an overall rise during the period. Whilst the value of construction work undertaken has steadily risen over the research period up to the fourth quarter of 2008, as has that for demolition, accidents have decreased for construction but have increased for demolition (ONS, 2009).

These variances in reporting paint a confusing picture as to what is really the true situation. Duffy et al (2003) state that '*the path to the present is littered with the mistakes and errors of the past, most of which we did not foresee or simply did not believe could happen*'. Shaw, (2002) and Haslam et al (2003) found that accidents studied had arisen from problems related to worker actions with the latter adding that this is a trend likely to increase in proportion to the reliability and probable sophistication of the hardware tools. This last point should be one that the demolition sector takes into consideration when determining methodology and any decision on manual operations as opposed to machine only.

5.2.3 Causation

Whilst legislation ranked high on the list of priorities to reduce accidents at work, the demolition sector appear to be aware of the main threats to accident causation and have devised methodology that largely removes the man from the workplace, by introducing the machine. However, this does not appear to include soft strip operations in all cases.

The one question within the interview process that specifically addressed the potential for accidents occurring where 'man' was introduced to the workplace met with a strong response. The two main principles raised were that; first, putting people back into the building will increase accidents disproportionately to the recovery rate; and secondly, that design for deconstruction is the key to safe working.

There is a general reluctance to put operatives at height or in positions where falls are possible. This is not based purely on health and safety principles, but at its core has a fundamental ethos of efficiency, expedience and cost reduction, although risk reduction is very definitely something that all the interviewees mentioned. The predisposition for using mechanical plant as opposed to manual labour is strongly emphasized. One interviewee summed up the man hours debate by adding; " *more men equals more cost, more man hours, more risk and stripping for recovery doesn't always add up financially*". Although this is a common theme throughout the interview stage, nevertheless 21% of the respondents from the research questionnaire said they preferred hand stripping of internal materials during demolition; the change to a wholly machine based process is therefore not universal. However, the author's knowledge of the respondents' organisations points to the establishment of a more mechanical-based approach by the larger demolition companies and either a combination of manual and mechanical or wholly manual for the smaller organisations. One is bound to conclude that there is likely a division of work that takes a somewhat naturalistic approach to size, i.e. smaller organizations take on smaller projects which could include such as private housing where soft strip material is prevalent and makes up a large percentage of the arisings, whereas large organisations are more likely to take on the heavy industrial projects where such materials are in low quantities and therefore the buildings lend themselves to mechanical reduction.

It is also tempting to question whether risk management and risk taking may have a bearing on the size of the organisation or the general view of the contractor on work methodology. Trimpop and Wilde (1994) have suggested that people willingly take risks and that those who consider human error to be the principal cause of accidents tend to advocate safety measures that will reduce the likelihood of nasty surprises. Duffy et al (2003) advise that accident losses are by definition a consequence of taking risks and that the more risks a person takes the greater, on average, the losses. The results of the data collected from the Regional Accident Data (see Section 4.3) would suggest that the smaller organisations have recorded a higher percentage loss in accidents than the larger organisations, although this fact in itself is not significant or conclusive towards an argument for mechanical or manual applications as this question was not posed. What is known is that despite the rhetoric surrounding a preference for mechanical operations, this research has found no evidence that this is the case in reality and that accidents continue to happen at alarming rates, mainly through handling of the arisings.

As Thorpe (2005) suggests, what one person sees as a high risk situation may be seen by another as a relatively low risk. When one combines an individual's assessment of risk with that of risk management the propensity for 'over the top' control measures are increased. Turnbull (1999, p5) advised that: '*a company's objectives, its internal organisation and the environment in which it operates are continuously evolving and as a result, the risks it faces are continuously changing. A sound system of internal control therefore depends on a thorough and regular evaluation of the nature and extent of the risks to which the company is exposed.*' Panopoulos and Booth (2007) counter-argue that employers spend more time than is strictly necessary on control measures or squander money on preventative equipment that is not used in practice.

Risk taking, in the correct context, can be a rewarding exercise but it can also be a morally unacceptable action. Education and instruction on the dangers of risk taking, where personal accident may be a consequence, can be driven by legislation but getting people to listen and learn is very different. Conceptual thinking by the demolition contractor's clients and construction managers is an area that may need extensive education to eliminate ambiguity and advocate better relations.

The HSE Construction report of 2008 brings together the findings of several independent research projects on accident causation concluding that the most common and therefore most prevalent, are from slips, trips and low falls; manual handling and carrying (HSE, 2008). Similar causes of injuries are determined by the Bomel report for the waste industry (Bomel, 2004). The occurrence of injuries, in the demolition sector, from these types of causation can generally be attributed to carrying out activities such as 'soft strip' and salvage of reusable items. This generalisation is made possible by the data collected from the research study (see Section 4.1) which points to a propensity for the use of mechanical based methodology interspersed with manual operations for such as soft strip and salvage activities, where necessary or desired. However, there appears to be a consensus of opinion regarding the necessity for manual stripping of buildings given the poor quality and quantity of the reclaimed materials, with mechanical operations using specialist attachments in the ascendency. The use of mechanical equipment, i.e. excavator based demolition machines, can be traced back many years and the reasons for such an application may presumed to be for reasons of efficiency, cost and manpower reduction, although this research can offer no further tangible evidence to prove or disprove this theory.

5.2.4 Legislation

Inevitably, legislation is a key topic as it permeates into every aspect of the workplace. The penalties for infringement or deliberate abuse can be varied but all are designed to give the legislators control and the powers to suspend, prohibit, confiscate or prosecute. The responses received from all interviewees regarding the relevance of the current workplace safety regulations to demolition activities was almost universal in their accusation that regulations aimed at the construction industry do not adequately reflect the needs of the demolition sector (see Section 4.2). Many of the respondents were annoyed at being dictated to by construction practitioners who knew little or nothing of the demolition process, with CDMC's attracting specific criticism. Whether this is a fact borne of ignorance or apathy may be debatable, but there appears to be a groundswell of opinion within the demolition fraternity that change in some form is necessary, but that change should be targeted at the demolition sector and not across the whole of industry.

Although the comments received during the research interviews regarding workplace safety regulations and their relevance to the demolition process were lucid enough, there was a great deal of generalization with no specific or individual areas identified as being good or bad. The general view being that people did not either understand health and safety legislation, had an inherent fear of prosecution or that the legislation was designed to impart fear rather than positivism. Other comments reflected the fact that the regulations tended to overprotect people thus taking away an individual's natural instinct to avoid hazardous or risky situations. This may of course work in a reverse manner through the fear of prohibition or prosecution, in that people unnecessarily over-specify control measures and constrain actions or operations. The question of the relevance therefore of any particular health and safety legislation to any one particular industry sector may be irrelevant if the message is lost in the interpretation.

The UK workplace regulations are generally considered, by HSE, to be 'goal setting' rather than prescriptive. It was therefore interesting to note that almost all the respondents (eight from twelve) considered that the workplace regulations were adequate although CDM was thought to need more attention to make it relevant to the demolition sector. CDM is in itself a unique piece of legislation in that it speaks of the 'client' bearing the brunt of the responsibility as opposed to all other regulations which use the term 'employer'. Many contractors working in the demolition sector believe that policing of the CDM regulations by HSE is poor, which was borne out by comments received during the interview process. The interviewees firmly believed that if they were better understood by clients and others they could make a huge impact.

Of the seven key change/actions needed to be implemented as highlighted in Table 4.18, three of those points concern CDM, one cites the lack of inspectors, one applauds the UK workplace regulations, a sixth points to the bad practice of some contractors and the last advises that the demolition industry has largely managed to design the 'man' out of the workplace. It is this last point that merits the most attention as it provides a unique insight into how an industry sector has moved forward on an initiative, without legislation, in order to reduce their exposure to risk.

5.2.5 Waste Management

There would appear to be an inconsistency in the perception of what waste is and how to deal with the multitude of materials derived from the demolition process. The ICE 'Demolition Protocol' speaks of dealing with those materials in a hierarchy of reclaim, recycle and landfill as the last resort (ICE, 2008). The European Commission's Environmental Action Programme Waste Strategy viewed waste in negative terms as a problem, a cost and a pollutant. Yet they admitted to a gap opening up between the perception of waste as a significant environmental problem and the increasing evidence that it can be a resource to be exploited (EU, 2005). Powrie et al (2006) advises that sustainability principles require that resources are used with maximum efficiency whilst they are within the human part of the cycle and that they should be returned to the environment in a way that enables them to be extracted and used again. These are but a few of the multitude of words written on behalf of waste and resource efficiency. One cannot help but question as to what exactly is meant by waste. We are informed that as far as the Waste Framework Directive is concerned anything that has been discarded, intended to be discarded or is required to be discarded is waste. However, as far as the many waste strategies and protocols are concerned the word 'discarded' is never used and the word waste is often enough supplemented with words such as materials, products and arisings. The reclamation and subsequent recycling of secondary aggregates by the demolition sector is well in excess of 90% (Button, 2007; CRW, 2008) and is by far superior to the record shown by the construction industry per se. Where non-aggregates arisings are concerned the record is not as good unless a waste transfer station (WTS) is used. The Construction Resources and Waste Platform report of 2008 informs that at least 20%, by weight (tonnage), from all construction sites (includes demolition) is taken to a WTS and that of that waste material 76.9% was recycled and the remainder sent to landfill. These are encouraging figures for the demolition industry in particular whose preference it seems for mechanical applications in their methodology does nothing to detract from improvements for exceeding the UK Governments projected recycling targets.

Although there was not a universal consensus (on the part of the interviewees) on how UK legislation could improve waste management, there was a firm view that the UK Government should take the initiative rather than leave it up to industry and if that meant changes to regulation etc these should be brought in. Improvements to materials and products specifications as well as people's perception seemed to strike an accord with DEFRA's view in that ‘we must break the link between economic growth and waste growth, so that products should be re-used or their materials recycled with the recovery of energy where possible, even if a small amount of residual landfill is necessary’ (DEFRA, 2007, p9). This theme was certainly apparent in that eight out of the twelve taking part in the research interviews were in favour of using a WTS or MRF, to send those demolition arisings that were difficult to separate, which also had the added advantage of improving recycling rates, reduced landfill and cheaper gate fees.

5.2.6 Sustainable Demolition

The research questionnaire identified that 76% (48/63) of those engaged in managing the demolition process, which includes the management of waste, were fully or partly aware of waste management and sustainability issues. However, the respondents’ reaction to whether they considered their clients had given enough thought to sustainable demolition and the recycling, reclamation and reuse of materials from the process was vague. Several intimated that unless it concerned secondary aggregates, clients had no interest, particularly if time and cost had a negative effect. With the many UK Government-led initiatives on sustainable solutions for construction activities and efforts by WRAP to reduce waste going to landfill and to increase the recycling and reclamation targets, the answer from the demolition contractors would appear to suggest that the rhetoric is some way ahead of the action. Despite this, it was almost unanimous (79%, 58/73) that the respondents agreed that demolition contractors had a major role to play in improving sustainability targets although how that role will be developed in the future remains a matter of conjecture at this point.

Three questions, in particular, targeted the contractors views on ‘sustainable demolition’ with the most common response being better education, information and a change of attitudes and perceptions brought about by a change in legislation or regulation if necessary. Other notable comments included banning single life products, stopping use of poor quality fixings and improvements to building and product design. This last point is also the subject of much discussion and features in many reports for the construction industry on how to improve resource efficiency. However, despite goodwill and earnest efforts aimed at this topic, this research can offer no tangible evidence that designers, or those who engage designers, either in product design or build design are heeding the message for the greater number of materials used and structures built. We are informed that the Construction Products Association has embedded sustainability thinking within its organizational objectives and that both Government and industry will need to collaborate to consider what additional tools and mechanisms are needed to promote increased use of sustainable materials in construction and improvements in materials themselves (BERR, 2008). Osmani et al, (2007) advise that 33% of all waste generated on a construction site could be designed out if architects maximized their influence and accelerated the pace of change. The WRAP report on the efficient use of materials in regeneration projects aims to persuade designers to include the demolition contractor when planning the feasibility of on-site reclamation and recycling, at the design stage (WRAP, 2008). None of these considerations were picked up on by any of the interviewees; indeed, perceptions of their clients' attitudes towards the value of sustainable demolition was almost universally poor.

There is no doubting the good intentions of most demolition contractors regarding resource efficiency. All 12 interviewees recognised the commercial advantages of managing the various waste streams in as efficient a manner as possible. Almost all were of the opinion that time and cost stopped them from achieving better or more productive recycling rates, blaming client intransigence mainly (and to some extent the unhelpful legal definition of waste). Almost all thought that it was necessary to make changes to people's perception of secondary materials by better education which may need improved legislation or more regulation. Only three of the interviewees mentioned safety in design at this stage of the interview process. However, what would constitute sustainable demolition activities for environmentalists would differ greatly from the views of the contractor who, one gets the impression when this is discussed, that sustainability refers mainly to the recovery of materials for recycling only; and whilst there was the occasional reference to salvage and re-use one was left with the feeling that in commercial terms there was no added advantage nor desire to pursue this.

The consideration given to the value of salvage and reclamation of materials on all demolition projects was a surprisingly low two-thirds majority in favour, with around a third of the respondents admitting that it was sometimes favoured and even if market availability increased they would only possibly consider salvaging materials. If transferred across the whole of the sector, this would represent a dramatic reversal of work practices from say 20 years ago when it could reasonably be argued that all demolition contractors salvaged the maximum possible to supplement low contract fees and increase cash flow (Quarmby, 2010). If this is indeed a true indication of the pattern of thought towards reclamation, in particular, it is also symptomatic of the types of materials in use in the construction supply chain today. Many of those materials are extremely difficult to recycle or reclaim and have an intrinsically low value at the end of their life cycle. This was also acknowledged by those who took part in the research interviews.

Data gathered from the literature review would suggest that society very much favours reclamation and recycling, but as Pearce et al (1993) state, until such time as non renewable resources are replaced with readily renewable resources they should be used in such a way that their environmental effects are fully accounted for. Reid (2006) reminds us all that the overall objective of government policy on waste is to protect human health and the environment by producing less waste and by using it as a resource wherever possible. One of the respondents from the structured research interview went as far as to question the value of any reclaimed materials in 50 to 100 years time, given the nature of the products in use today. Therefore, one may infer that it is reasonable that an increasing number of demolition contractors are beginning to question the value in spending time, effort and money on trying to recoup materials of low value on the second hand markets when wholesale transfer of arisings, other than aggregates, can be dispatched to Materials Recycling Facilities for efficient processing. It may also be argued that with less emphasis on selectivity of materials during the soft strip process, by hand, the less the risk of personal injury.

All of the respondents were familiar with the phrase, 'design for deconstruction' (dfd) but none could recall any project, present or past, where this had been initiated or such a structure had been taken down. The question of dfd has arisen many times over an extended period of time. CIRIA attempted to guide designers and others, who could be said to have a responsibility for sustainability of the environment, into moving from a linear to a closed loop process (Addis and Schouten 2004). However, this and similar projects do not seem to have made the kind of lasting impression that requires such a move. A common belief amongst the respondents to the interview process, regarding building design, was that in general no apparent consideration has been given to how a building will be demolished or to what waste streams will be generated and how these will be managed. The UK Government's stance on construction design is: "*the overall objective of good design is to ensure that buildings, infrastructure, public places and spaces are buildable, fit for purpose, resource* *efficient, sustainable, resilient, adaptable and attractive... good design is synonymous with sustainable construction*" (BERR, 2008, p16). What is apparent from this statement is that the demolition element of a building or structure does not appear to be viewed in as equal a degree of importance as its erection. Designing for deconstruction needs to become an integral part of the process, possibly as early as the planning stage and that resource efficiency should include end of life.

5.2.7 Plant or People?

If the demolition sector were to increase the use of mechanical attachments to assist in the soft strip process, rather than hand stripping only, it would be reasonable to expect that injury rates would decrease. This particular notion was aired by 51% of the survey respondents and 8 of the interviewees. The reasons given for this are many and in line with the answers received from the interview stage suggest that tight work programmes, negative value returns on materials removed, health and safety considerations and diminishing markets were some of the foremost reasons offered. In terms of attachment use making the process of materials recovery harder, the majority of survey respondents agreed that it did not, but it was a close run argument with 41% opposing that belief. In all, 79% of the survey respondents agreed that they used a mixture of both processes although there was a further suggestion that there is a 70-30 split in favour of machine applications. Whilst these facts may appear to be relatively unimportant or a pointer towards personal preference, they do signify that mechanical applications are on the increase and that the careful removal of individual elements within a building or structure may not have the importance it once had. This is also an indicator that the demolition fraternity has identified that the most efficient and effective way of handling secondary materials liberated from the demolition process is by mechanical applications on the majority of occasions, supplemented by hand removal only where necessary.

The research questionnaire provided a unique insight into how a cross section of the demolition industry viewed the importance of mechanical applications in such as soft strip, salvage of materials and recycling opportunities, the causation and incidence of accidents and an elementary understanding of sustainable targets for waste reduction. However, the research interviews provoked a surprising reaction to the importance placed on the recovery of building materials which are known to have a high commercial value. For example, roofing slates and clay tiles still command good fiscal returns in the used market and are not difficult, in terms of technical ability, to remove. However, with the advent of enhanced safety restrictions on work at height, in particular, there is a strong reluctance by many contractors to undertake such works where it means employing scaffolding and other expensive access arrangements. Other features such as timber floor boards and joists which once formed a large percentage of the reclaimed materials market are largely ignored as a resalable item and are mainly segregated for processing as clean chipped timber or waste for energy fuel. This was viewed as a straightforward and natural evolution to improving both safety factors and the re-use of building components.

5.2.8 Towards an Action Plan

The literature review concentrated on four key aspects of industry; sustainability, waste management, accident causation and legislation. The construction industry, in particular, is the UK's largest employer. It also records the greatest number of workplace fatalities (HSE, 2010) and is a major driver in delivering sustainable products and the built environment (Jones and Clements-Croome, 2004). The information available on the activities of the construction industry is vast and is presented in many formats across the spectrum of the written word and visual images. However, what is clear is that some specialist groups operating under the umbrella of the construction industry do not have a plethora of such information to hand. One such group, of particular interest to this research is the demolition sector. One can find passing references to the sector and to some of the activities concerning a particular process, but there is little in the way of detailed historical data on all the activities concerning the sectors management and its procedures. The demolition sector may be a small cog in the supply chain, but is invariably the catalyst that sets in motion the remainder of the process, particularly on 'brownfield' site developments and inner city regeneration.

There are however, some indications that such a deficit of information may not continue to be the case in perpetuity as sustainability continues to grow in society's psyche. Where the phrase 'resource efficiency' is used it generally involves a process of waste management (something that the demolition sector is particularly good at). NGO's such as the BRE and CIRIA and industry interest groups such as the Institute for Sustainable Construction do recognize that the demolition sector has a vital role to play in offering their expertise and knowledge in handling and managing waste streams, in particular and in the types of methodology and plant utilised to deal with simple and complex structures. These types of organisations do engage with the demolition sector from time to time and are a source of data, albeit it small and fairly ad hoc.

Whilst there is an obvious frustration in not being able to unearth specific data to carry forward an argument or viewpoint, the review of available literature has highlighted this anomaly which will need to be addressed in the future. Access to good information is a necessity for any research and whilst there are many ways in which such information may be interrogated there needs to be corroboration of evidence to formulate a reasonable view. In terms of looking at demolition accident statistics the data can be extremely difficult to collect as no research project has been undertaken to date. Information and data gathering in the waste industry fares little better, with the exception of Bomel Limited, whose 2004 research report is significant and has therefore been quoted fairly extensively in this research.

A review of the literature concerning sustainability and its constituent parts will reward the researcher with an overabundance of information by comparison, particularly the connection with construction activities and the UK Government's efforts to drive forward initiatives concerned with the many aspects of sustainability. One will find no shortage of references to sustainable management and green thinking for local authority and the communities. Even the waste industry has its share of sustainable ideals and has a large environmental lobby driving forward initiatives. However, little progress has been made through academia to highlight the obvious advantages of engaging with the demolition sector where resource efficiency has its beginnings in the process of selectivity of waste streams at the point of generation. With the exception of the WRAP protocols, i.e. 'The Quality Protocol for the production of aggregates from inert waste', which look almost exclusively at aggregate recovery, there is little else in the way of developed sustainable solutions for the millions of tonnes of materials generated by the demolition industry each year.

When industry accident statistics are required, the most notable source of data and information is the Health & Safety Executive (HSE) which provides Government and NGO's with data on all industries' health and safety performance. HSE use a number of variants to collect and collate such data working in conjunction with pan-industry bodies to produce reports, codes of practice, guidance and other information sources. In addition, another major source of accident data is the Labour Force Survey (LFS) which is managed and produced by the Office of National Statistics (ONS, 2010). This is a quarterly sample of households in Great Britain using internationally agreed concepts and definitions based on a systematic random sample of 60,000 private households. Data gathered during the literature review has highlighted an anomaly between the LFS accident statistics and that derived from RIDDOR in the magnitude of around 14% variance for at least one year in particular. Indeed, if the data gathered from the nine regional demolition contractors is taken into account, which has identified 515 injury's, over the research period between 2003-08 and the 1,063 reported under RIDDOR, the efficiency and accuracy of all data gathering is questionable.

There is therefore a need to instigate and carry through an action plan, over a realistic timeframe of say five years, to bring recognition to a small but important industry sector whose activities over the coming years will influence how resource efficiency is managed. This action plan should be agreed and implemented by key industry stakeholders, i.e. NFDC National Council and IDE Council of Management. Within that management structure, action should also be targeted at improving the reporting regime for accidents and their causation at national and individual organisation level to provide information and guidance to regulators and those tasked with influencing industry decision making. This in turn may help to create awareness of potential changes in environmental and safety trends through a change in traditional industrial processes, which should ensure that the future advancements of sustainability in demolition are not at the expense of those advancements already made to improve health, safety and environmental qualities.

5.3 Evaluation of the Research Objectives

5.3.1 Objective 1:

'To evaluate the importance that design and designers have on the ability to provide a safer working environment to reduce significant hazards and therefore risk, which in turn may influence human characteristics or traits.'

In 1994 the CIC issued guidelines for designers in relation to their duties under the new CDM regulations. As part of that guidance they instructed designers to make provision for the safe construction, operation, maintenance and demolition of buildings and structures (CIC, 2004).

Kind (2006) however, points to a lack of clarity about what health and safety design requirements fall exclusively within CDM and are not contained within other regulations. It has been stated that re-use and recycling of materials will only happen if designers and manufactures can find ways of constructing buildings that will make deconstruction of them commercially favourable (CIRIA, 2004). WRAP suggest that introducing good practice in the efficient use of materials involves effective design, efficient procurement and recycling of site arisings (WRAP, 2007), whereas an alternative argument is that designers have a key role to play in designing structures that are safer and healthier to build, maintain and demolish (Habilis, 2004). In a research project carried out by Haslam that focused on the possible contribution of design in the analysis of accident study, it was found that of the four types of designer to which the research centred on, the risk of having an accident could have been reduced by at least 36% in three cases and 60% in a fourth (Haslam. 2003). Carpenter (2006) calls into question the competency levels of individual designers and corporations to recognize in particular; potential hazards related to the work (or equipment) under consideration, to detect any technical defects or omissions in that work (or equipment) and to recognize any implications for health and safety caused by those defects or omissions and to be able to specify a remedial action to mitigate those implications (Carpenter, 2006).

This last point is particularly relevant to demolition activities where there is no scientific and few predetermined patterns to follow on the behaviour of a building as it is being demolished (controlled explosive demolition excepted). The safety of the operations on site are largely dependent on the skill of the management and workforce to recognize tell tale signs in a structure and to determine the best load paths down through the building. Where it has been recognized that designers can make a big contribution is the principle of design for deconstruction; Addis and Schouten (2004) speak of getting designers to move from a linear thinking process to one of a closed loop in which presumably designers will incorporate end of life principles at the inception of the building design. In this way buildings may still be futuristic in their shape, rather than the image of boxes on top of boxes, but will incorporate lifting points, easily disconnected node points or even pre-drilled charging holes for controlled explosive demolition, as one research interviewee suggested. In addition, the reduction of waste products by use of re-usable or reclaimable elements which can be reclaimed using mechanical based operations will greatly reduce the need for manual operations. Equally, if building materials and products are specifically designed to be classed as waste which are either recyclable or destined as bio-fuel but are fitted into the structure in such a manner as to be easily removed by mechanical application, there would be little need to engage people to manhandle the arisings. Where such a realization becomes common place the necessity and or the habit to use manual labour will diminish, which in turn will reduce risk.

It is said that accidents can be regarded as any unplanned event that resulted in injury, ill health of people, or damage to property, plant, materials or the environment or a loss of business opportunity (HSE, 1997). A further argument is that an accident is an unmotivated event, that it is as unpredictable as it is unique (Green, 1997). Trimpop and Wilde (1994) take an opposing view to risk taking, which constitutes a large proportion of accident causation, in that trying to eliminate risk which can be highly rewarding in certain circumstances, is illogical. However, one major drawback to adopting these sentiments is to accept that accidents are inevitable or that risk taking cannot be totally eliminated. This may or may not be true but as far as demolition operations are concerned, tackling a structure or building that has a design element aimed at assisting in the process to make mechanical reduction easier and to separate the waste products more productively will almost certainly reduce risk and influence people's decision making. In taking account of the views of the research interviewees and the weight of evidence derived from the Habilis (2004) and more importantly the Haslam (2003) research reports, one would be minded to agree that designers do have a key role to play and that through their input into the design of a structure and or its contents they can indeed shape the outcome of the decisions made by others.

5.3.2 Objective 2:

'To examine the interactivity between sustainable demolition activities and the propensity for an increase in accidents or incidents.'

If one is to interpret the messages emanating from those persons who took part in the research questionnaire and the interviews, they conflict with that sent out by NGO's and Government alike, on the subject of sustainable demolition and the drive to increase reclamation and re-use of building products. Conversely, recycling of demolition arisings and the future growth of an industry sector that will handle, process and supply for re-manufacture is certainly assured.

This research has determined that demolition contractors prefer to employ mechanical applications as opposed to manual and that this process makes it unlikely that the recovery of individual elements of a building, in a condition for re-use, will be possible. There are many reasons that have been given for taking this stance, amongst those most prominent are: that taking the man out of the workplace reduces risk; mechanical operations are more efficient, cost effective and easily managed; that salvage and reclamation is commercially unviable; that safety considerations and constraints preclude putting men at height or in positions of risk.

The demolition sector is being encouraged by NGO's and Government, in particular, to increase resource efficiency by increasing reclamation rather than purely recycling materials. However, there does not appear to be sufficient consideration to the reverse outcomes of such a policy and to recognise the conclusions that have already been reached by demolition contractors. They perceive that with an increase in manpower on site (necessary to take down or dismantle structures for reclamation), there are increases in the risk of accidents and incidents occurring. Equally, there is also the cost of using more labour, providing extensive access equipment, lifting facilities, transport and storage. None of which are generally required where wholesale recycling of waste materials will take place.

Rainey (2006) reminds us that sustainability outcomes are those that balance the performance objectives of the present with the needs and expectations of the future. This is starkly illuminated when interrogation of the demolition sector's accident statistics shows that major and over three day injuries have risen in excess of 100% from the year 2000 to the present date. These injuries appear to be mainly from exposure to manual handling activities such as soft strip and salvage, with demolition operatives most at risk by a factor of around 2:1 against other disciplines. Why such an increase has happened and is continuing to happen is somewhat subjective but may be linked to a desire to either salvage and reclaim more or to provide as clean a product for recycling as is possible. Green (1997) argues that there are no absolute ways in which to measure the success of accident prevention, as gains in reducing accidents may be offset by losses in other prioritized areas of health or emotional well being, but that there is some evidence that engineering and enforcement strategies can be a major way to prevent accidents. If the use of mechanical equipment lessens the productivity of salvage operations and reduces the risk of accident to people, the offset may be a gain in recycling and a reduction of overall cost.

5.3.3 Objective 3:

'To question the need for small or radical changes in UK safety regulations and workplace policy in order to simplify and make relevant the demands for work in a demolition environment.'

The UK safety regulations and workplace policies are designed to tackle the multitude of potential hazardous scenarios and decisions made on behalf of all workers irrespective of their type of workplace and conditions. Some of these regulations are designed to be workplace specific, i.e. CDM but most can be applied to all work environments.

Specific questions on the relevance of the workplace regulations or their influence were posed to the research interview cohort who, in the main, agreed that the UK had the most thought out and mature set of safety regulations to be found anywhere. However, the CDM regulations came in for particular criticism as the majority were of the opinion that they were misunderstood, poorly policed, badly implemented and largely ineffective as a guide to clients for the demolition process and that the role of the CDMC for demolition activities needed a radical overhaul. Although it was agreed that the regulations adequately addressed construction needs, it was recognised by most that the demolition sector had to try to adapt rather than immediately adhere to many of the requirements of the construction orientated safety regulations, although this point was not elucidated upon. Most were in favour of workplace safety regulations that were specifically targeted at demolition activities although equally, all doubted that this would happen in the short term if at all.

One must also be aware that a prime function of the workplace safety regulations is to reduce or eliminate risk and therefore the success of this policy will rest on the interpretation of the requirements to conform to or exceed the minimum requirements. If there is ambiguity or conflict in the interpretation, the regulation will fail to be effective. Where potential conflict may arise in a regulation that seeks to eliminate risk is where risk is a natural process in business. Smith et al (2006) argue that risk is both positive and negative in nature and effective risk management is as much about ensuring you are not missing opportunities, as it is about ensuring you are not taking inappropriate risks. What employers need to concentrate on is those employees, whether at site or management level, whose personal appreciation of risk may be different from the company's policy. Risk takers tend to underrate risk, whilst the risk averse do see all the obstacles and so tend to overate risk (Smith et al, 2006). In wanting specific regulations for demolition, the industry sector may find that the prescriptive impositions detailed in such legislation may be more of a constraint to efficient and effective working than the present crop of safety regulations. It could be that risk takers amongst the workforce are less inclined to adhere to the requirements of the workplace safety acts and regulations than their risk averse counterparts. It is also debatable whether without a 'carrot or stick' few will go out of their way to uphold the spirit of the law if they only have to do what they are obliged to do under the letter (Humphreys, 2007).

It therefore remains a point for debate as to whether any changes in the current workplace regulations would greatly benefit the demolition sector.

5.3.4 Objective 4:

'To identify efficient or effective ways in handling and disposing of secondary materials or products liberated from the demolition process with a specific emphasis on the reduction of accidents or incidents.'

The key to determining an outcome for Objective 4 is to take many of the ideas offered for Objectives 1-3 and to weave them into other considerations and deliberations. For example, designers can certainly help to make demolition workplaces safer; where their designs incorporate new processes, technology and innovation they will invariably influence human traits and decision making. Sustainability in demolition can be targeted in many ways to reduce risk and increase salvage output where safe and practical to do so, but on all other occasions settling for a safe, efficient and productive recycling policy is definitely achievable. Where UK safety regulations are concerned, there is little doubt that they are both logical and effective, with the exception of the CDM Regulations which it was thought needed some attention. However, striving for specific safety regulations to address demolition alone may be a step too far and may not even be achievable in practice. It could also be a case of getting what one wished for and finding that it's not what one wanted at all.

The research questionnaire identified that almost 79% of the cohort were in favour of using both hand and mechanical operations, with a further 23% favouring hand operations only to carry out activities such as 'soft strip.' However, it was also intimated that those in favour of using both types of operation split the process 70-30 in preference to hand work. Therefore one may conclude that a very large percentage of the strip out of a building is traditionally undertaken by hand and that presumably mechanical applications are mainly used to load the waste arisings and remove the larger and heavier elements. RIDDOR accident statistics for the demolition sector show a 100% rise in accidents from the year 2000 to the present date. This increase is also indentified by the data received from the research study which concentrates on all injuries whether notifiable or not. The data further intimates that demolition operatives are the most at risk of injury and that hand arm injuries are the most prevalent. We may draw conclusions from this data that the most significant cause of such injuries occur during handling of demolition arisings.

Whilst there is undoubtedly a synergy between manual handling and personal injury, one must also consider other reasons for a possible increase in accidents within the demolition sector. From the year 2000 to the last quarter of 2008 (within the study period) the value of work undertaken by the construction industry had almost doubled. The value of work carried out by demolition contractors had almost quadrupled and the labour force had more than doubled (ONS, 2010). One may naturally conclude that an exponential rise in work and manpower would also see a proportional rise in accident or incident as a natural progression. However, both RIDDOR and the LFS show that construction related accidents have fallen in this period despite the increase in construction activity. Therefore, why hasn't demolition followed this trend? There may be several reasons, but predominantly it has its roots in the traditional approach undertaken by the majority of contractors to stripping out and pre-weakening of buildings and structures. Despite the responses given by the interview cohort to an increased use of mechanical equipment there is little doubt that manual handling remains the preferred work mode for soft stripping and the clearance of non aggregate based materials from buildings. It would also appear that the disinclination to salvage and reclaim has no tangible benefits in the reduction of injury although it may contribute to a reduction in the overall risk. Sustainable demolition is, above all, about recycling and the segregation of waste streams to identify the commercial and fiscal opportunities and to reduce expenditure for all difficult or hazardous waste disposal. Therefore one is inclined to discount, though not forget, the apparent importance placed on 'taking the man out of the workplace' by the survey and interview respondents, who also intimated that this was a common theme throughout the sector. This particular sentiment may be true when it comes to the physical reduction of the shell but it is certainly not true regarding the interiors.

In order for the industry sector to greatly reduce its accident rate, there needs to be a step change that will dramatically reduce the number of people employed in handling arisings and in the manner that building contents are designed and fitted. In the short term, it is difficult to see how this may be achieved, particularly for the smaller contractor whose plant and equipment may not be adequate or plentiful to move from a manual based operation to one of full mechanization. The biggest problem to overcome on all sites would appear to be the segregation of the materials as ultimately the desire is to end up with clean hardcore and concrete (aggregate arisings). This is where the soft strip process is so important in that the majority of non aggregate materials are removed prior to any mechanical reduction. Despite what can now be identified as a major cause of injury, this process is still regarded as the most effective and efficient and although there are many micro machines on the market (as shown in Section 1.2) and in operation on demolition sites they have yet to replace manpower. Technological innovation may yet provide further opportunities if protective garments and or powered tools can be developed to be worn and operated by individuals. Although this may appear to be a futuristic concept, there are many examples of gloved tools in use today in the nuclear and medical fields which could cross-over into demolition.

For some demolition contractors, the opportunity to segregate materials at source is not an option, where the demolition work is undertaken in city centres or confined working spaces. In general, the methodology that would apply in these instances will involve a mechanized approach from day one to reduce the building or structure with all interiors intact. The resulting mixed debris is loaded and dispatched to another site or taken straight to a waste transfer station (WTS) for sorting and processing. In this way, recycling of usable materials is carried out and landfill waste is reduced to a minimum. Should such a methodology be adopted across the board by all demolition contractors, the accident rate would presumably fall by virtue of the absence of the soft stripping gangs. The downsides, which may be unpalatable for some, would be little if any salvage of materials for re-use, potential longer journeys to a WTS and the possibility of contaminated hardcore requiring hand picking of unwanted debris. A small price to pay, some may agree, to reduce accidents at work. However, having spoken to many demolition contractors over the period of this research study, the author has knowledge that the use of WTS and MRF is particularly widespread for the disposal of mixed and difficult to recycle waste arisings and that although there is a gate fee on the waste acceptance it is comparably cheaper than landfill.

Stating that Objective 4 has been answered fully and that a solution to the problem of injuries derived from the soft strip process has been determined cannot be justified without tangible evidence that accidents at work, within the demolition sector, are being reduced. The fact that accidents do not appear to be falling and that traditional methods of soft strip continue, despite the introduction of certain innovative tools and equipment, means that there is a wide gap between efficiency and effectiveness. Whilst it would certainly be true to state that employing mechanical tools and equipment to carry out soft stripping may be effective, efficiency levels will vary depending on how clean or pristine one desires the secondary aggregates and or the mix of organic from inert materials to be. Therefore the dichotomy will continue one feels until technology improves the protection to hand working.

5.4 Propositions

5.4.1 Propositions 1-2

In Brief. *'Designers of products and buildings are unwilling or indifferent as to their importance to sustainability ideals and the procurement process.'*

Clients and procurers of the products and the built environment need to incorporate their aesthetical demands with ease of dismantling, re-use and recycling principles. The evidence that this is common place is not easily found and whilst there may be some evidence that sustainability principles are gradually being incorporated into the design of some buildings being constructed recently, it is certainly not true to state that demolition, dismantling and waste separation are always considered. Therefore, the propositions would appear to have some foundation.

These propositions are less than complimentary to designers of products, buildings and structures and those who requisition design. The UK Government in their 'Strategy for Sustainable Construction' document stated that product design should take on an holistic approach incorporating excellence, cost effectiveness, efficiency, safety in use and re-use/recycling ability (BERR, 2008). In fairness to designers they are tasked with finding solutions not just to the basic problems but those with an increasing complex nature and always with an eye on cost and efficiency. Product design no doubt, is evolving constantly and would seek, we presume, to provide a cost and build ability benefit, meet building acts and regulation standards as well as longevity in a structures life. To an untrained eye, we merely mostly see the aesthetics of the product when fitted. However, from a resource efficiency view point at the end of life cycle, the demolition contractor is faced with segregation of the products/arisings and determining any salvage value or recycling opportunity. Designers who apply the Building Research Establishment Environmental Assessment Method (BREEAM) may move in a sustainable manner towards energy and eco-friendliness but may fall short of considerations for end of life evaluations.

5.4.2 Propositions 3-5

In Brief. *'Unrealistic targets are being set by Government and NGO's regarding recycling and reclamation of materials and products. Waste from construction and demolition could be reduced by better design and technological innovation to realise its full potential.'*

Within these propositions lie the fundamental barriers to the placement of a truly sustainable demolition process. In order to reclaim and recycle to maximum effect there needs to be a consistency and longevity of markets for the arisings created. To identify and efficiently process these arisings they need to be separated at source or along the route to final disposal, in the most expedient and cost effective manner, which would include all health, safety and environmental considerations. To greatly assist in this process of recovery it is desirable that all building products lend themselves to a productive process of waste reduction, resource efficiency and ease of capture.

These barriers begin with poor product design that largely negates the opportunity for salvage and re-use, whilst recycling of many waste materials is constrained to an end use as either bio-fuel or fuel for energy rather than re-manufacturing in its original form. The difficulty in separating out the many products arising from the construction or demolition process adds to the degree of complexity as well as requiring manpower that invariably increases risk of injury. If the separation of arisings does not make economical sense because the end user or market is unreliable or unavailable it is inevitable that the process will be flawed. Whilst there are many good examples of efficient and effective recycling, reclamation and re-use projects around the UK, the evidence that this is widespread, for C & D waste in particular, is unsubstantiated despite the increase in the number of MRF and WTS springing up or in use. It is tempting to denigrate the UK Governments efforts to increase the amount of reclamation of materials and products arising from construction and demolition activities, if only for the very fact that there is a feeling that the 'cart is being put before the horse'. Demolition contractors, in particular, have a long history of success in the recovery of materials from their on site activities. However, if the standard or suitability of the arisings is insufficient for recovery by virtue of their poor composition and design, it is impractical to expect that such a success story can continue. Therefore the propositions have a ring of accuracy about them and are difficult to argue against particularly where present efforts to maximise resource efficiency is relying on fluctuating markets whilst trying to juggle the rising cost of handling and disposal.

5.4.3 Propositions 6-10

In Brief. *'Better product design, technology advances and design for deconstruction must be better placed to improve health and safety and reduce accidents at work. Do procurers and those with design responsibilities need to be legislated against to improve sustainable development and resource efficiency'?*

The Construction Products Association advises that many construction product manufacturers and suppliers are responding to the challenges of sustainable development and are spending large amounts of money on innovation and design; becoming more energy efficient, reducing carbon emissions, using natural resources more efficiently, cutting waste, training workforces whilst remaining viable and competitive in business (CPA, 2007). However, with the exception of those products which easily lend themselves to re-use and recycling, i.e. concrete, steel and brick, the vast majority of products used in the construction process remain difficult to recover, re-use and recycle without a good deal of effort, time and cost being applied. The desire to improve product design is no doubt a continuous process but it would appear that the greater emphasis is directed towards energy efficiency and the reduction of carbon usage than looking at end of life principles. Equally, this research can find no tangible evidence that product design takes into account deconstruction and whilst the onus may be on seeking sustainable construction, it would appear that this mainly concentrates on build ability, energy and carbon reduction in manufacture and waste reduction in installation. However, it would be unfair to say that all product design or their manufactures have no consideration for end of life. Those who produce products that lend themselves readily to reclamation or recycling merely have to keep producing those products in a manner that will maintain the status quo, whilst the remainder need to improve on take back schemes or develop their products to make recovery easier and less challenging. Meeting these challenges appears to be a major drawback. Designers, in a survey conducted at the 2006 100% Design Exhibition in London were asked if 100% sustainability was possible. Of those taking part in the survey, 53% felt it was, whilst 47% did not (Chapman et al, 2007). This was hardly conclusive and provides evidence that designers need instruction and information as well as direction. For designers of construction products, in particular, the European Parliament issued its directive 89/106/EEC the Construction Products Directive, which states that construction products may only be placed on the market if they are fit for their intended use, have an economically reasonable working life, the essential requirements with regard to mechanical strength and stability, safety in the event of fire, hygiene and the environment, safety in use, protection against noise, energy economy and heat retention (EEC, 2010). What it doesn't say is that end of life or whole life costing must be taken into account and that the recovery of any products must also include the safety and health of those recovering such products, the reduction of waste at end of life and the measures factored in for ease of recovery, re-use or recycling.

Demolition contractors have confirmed, within the structured research interview, that there is little or no evidence that design for deconstruction is happening or has ever happened in the past. They also confirm that reclamation for re-use, for many products, is extremely difficult, costly and time consuming. It also involves a large amount of labour to carry it to fruition and the markets for salvage are dwindling. In all, it is not commercially favourable in many instances. DEFRA (2007) urged producers and retailers to reduce waste impacts through designing and marketing products that use less material and avoid the use of harmful substances, last longer and are easy to disassemble and recycle. The demolition sector needs to have a clear understanding of how product design is progressing, and to what degree their use is intended in a building, the inherent opportunities for reclamation that their design and end of life cycle may bring and the negative aspects that these products may incur. In this way the demolition sector can determine its methodology, explore and take advantage of the market opportunities and better assess the risk factors to include specific training or the procurement of bespoke equipment to reduce the risk. Therefore there is justification for agreement with these propositions which should not be lost on UK Government legislators and regulators.

5.4.4 Propositions 11-12

<u>In Brief</u>. *'Does sustainability or sustainable development have an impact on accident occurrence, risk taking or behavioural patterns? Have we reached man's limitation for accident reduction given man's propensity for risk taking in business etc?'*

The drive to improve sustainability, particularly in the developed world, is picking up pace and has a large influence on construction related activities, the introduction to new environmental legislation and practice, as well as amendments to existing. It has also been suggested, by some within the research cohort, that the desire to increase reclamation, re-use and recycling has had a tangible effect on accident rates within the demolition sector.

However, if such a policy has generated a perceptible effect on accident occurrence in the demolition sector it is largely unsubstantiated as there is little evidence to prove that working practices have been influenced, although it is accepted that there has been a substantial rise in the accident rate from the year 2000 (RIDDOR, 2010). Proposition 11 is therefore unsubstantiated at this present time, but such a notion must be borne in mind for the future.

As to whether we have reached the zenith or nadir of accident reduction is largely subjective and based on how one perceives the success or result of the initiatives and deterrents to accident occurrence or causation. Whilst it can be shown that accidents within the construction industry per se appear to be falling, the demolition sectors continue to rise as do those for the waste industry. What does seem to be true is that the more people are engaged to work in a manual capacity, which particularly involves handling, lifting and carrying of materials, the greater the risk of injury occurring. Shaw (2002) discusses job factors and human characterizations which influence behaviour at work in a way that affects health and safety and suggests that 80% of accidents are attributed to human causes. Therefore should we be surprised that people receive injuries or are exposed to risk of injury if we require them to tear down and strip out, unbolt or unfasten and lift down, carry, stack and load materials? In deliberating the accuracy of proposition 12, one is compelled to discount the notion that accidents cannot be reduced further as the weight of evidence for the causes of accident is largely a result of human decision making, actions or the lack of actions which can be changed to make a positive impact.

5.4.5 Propositions 13-18

<u>*In Brief*</u>. *'Are the current crop of workplace regulations adequate and relevant, should future regulation be industry sector specific, has regulation become so prescriptive that it becomes useless or irrelevant to most. Do we need more regulation, is it too heavy handed and bureaucratic. Is there a fear of prohibition and prosecution getting in the way of common sense etc?'*

The research study interview cohort was of the firm opinion that the UK workplace safety regulations were, in general, sufficiently relevant and adequate to meet the needs of all industries, including demolition. As this group was reasonably representative of the industry sector, hence proposition 13 is accepted and that proposition 15 is tenuous.

Where new or amendments to existing regulations could target specific industry sectors etc the likelihood is unsubstantiated unless one takes into account regulation aimed at those sectors with a substantial workforce, i.e. construction, agriculture, mining and nuclear etc; and then, this type of regulation is interspaced with the general and mandatory requirements for all. One specific regulation does jump out and that is CDM. Throughout the research study and during the author's work activities, the subject of CDM in its application to demolition and dismantling activities has been one of disappointment and concern. Many of the research interview cohort were of the opinion that CDM works well for construction but is inadequate for demolition as those who are applying the principles of the regulation have little or no understanding of the industry and its needs. Proposition 14 therefore may remain an imponderable for the foreseeable future.

For those who believe that common sense or pragmatism has no place in the application of safety systems and control measures will no doubt also subscribe to the view that fear of prohibition or even prosecution can cloud the judgment of otherwise sensible individuals. This was the view of many within the interview cohort and, through the author's personal experience, is also echoed by a notable number of demolition contractors outside of the research study parameters. The research interview group gave several examples of 'over the top' safety measures that had little bearing on the risk factors present. Panopoulos and Booth (2007) are also of the opinion that employers may spend more than is strictly necessary on control measures or squander money on preventative equipment not used in practice. However, failing to undertake risk management in an explicit and formal manner as a routine of project management is regarded as commercially unacceptable (Smith et al, 2006). It is also foolhardy and unlawful. In the UK, the 'duty of care' is a common theme running through our regulations and is highlighted in the HSWA Section 40 which states that it is for a person or persons under the duty to ensure' so far as is reasonably practicable' that the steps they took were reasonably practical (Barber, 2002). This mandatory requirement can be misinterpreted but most employers are aware of the law of 'vicarious liability; where they are liable for the wrong doings of the employee acting in the course of his or her employment (Barber, 2002) and it is this defining order that most probably influences the need for 'over the top' control measures or an inability to accept a certain amount of risk. Proposition 16 therefore has merit in some circumstances.

In terms of the sufficiency of the workplace regulations it has been established that the research cohort are in agreement as to the adequacy of what is in place but one was left with a feeling that they were of the opinion that directives emanating from the European Parliament had little appreciation of the UK workplace and its nuances. However, like it or not, the UK has been bound by 'Community Law' which is self executing and does not require action by UK legislation to be immediately incorporated into English law (Ashworth, 2006); Proposition 17 therefore can be judged to be largely irrelevant.

The level of bureaucracy within the UK is an often debated topic and is one which puts demands on the social and economic fabric of the workplace and home. It was also a theme that was echoed by the research cohort in that ignorance and apathy, towards the demolition process, by clients and main contractors was construed as bureaucracy in the insistence of irrelevant or unnecessary documentation. Regulation 10 of the MHSW regulations requires employers to provide information to employees which is comprehensible and relevant. Many within the research cohort were particularly incensed at having to make unnecessary and often irrelevant changes to their method statements, by clients and CDMC's, who had either misinterpreted or clearly did not understand the detail. However, it was not clear that this same principal necessarily applied to the workplace regulations, codes of practice or guidance and for this reason Proposition 18 is considered to be unfounded.

5.5. Chapter summary

In this chapter a number of issues have been raised and conclusions reached of which some of the main points are as highlighted.

There would appear to be a large discrepancy between accident data reported 'voluntarily' (RIDDOR), collected by 'voluntary questionnaire' (LFS), 'mandatory industry sector annual return' (NFDC) and that which has been 'individually requested' (nine regional contractors). Accidents recorded in the demolition sector have increased by 100% over the last ten years when construction rates have declined. The most common injuries recorded for the demolition and waste sectors are cuts and abrasions which would indicate that the main causes are attributable to manual handling activities. It has been determined that there is no tangible evidence to suggest that a change in legislation, regulation or risk taking within the demolition sector would have a significant effect on the reduction of accident occurrence but that such a gain may be more likely should the sector change its attitude to working methodology and equipment use.

It is also recognised that whilst it is incumbent on the demolition industry to do all that they can in seeking a reduction of accident/injury occurrence there are a number of other factors to which they have little or no control over; these being the design of buildings and the products with which they are constructed from, including the exterior and interior fittings, cladding and furnishings. It has been acknowledged that design and designers can have a significant influence on the reduction of hazards and therefore risk. They also have a duty to encourage sustainable thinking and to incorporate that within their designs taking into account all health, safety and environmental issues in equal amount. Those contractors who took part in the research interview indicated that clients, in the main, did not specify absolute requirements on the recovery of materials nor does it appear that design for deconstruction in the future is as prevalent as it should be. This chapter has highlighted many inadequacies in the management of sustainable demolition practices which would need the input of the industry practitioners, the UK Government, influential NGO's, procurers of building and structures, designers and users of secondary materials to address the issues raised.

6 CHAPTER SIX: CONCLUSIONS and RECOMMENDATIONS

6.1 Introduction

This chapter summarises the key findings and makes recommendations for further research and working practices. It concludes the research and responds to the research objectives set in Chapter One. The aim of the study was to understand the contextual issues associated with work in the construction industry, but more important, that relating to sustainable demolition operations. A reminder of the objectives of the research developed in Chapter 1 of the thesis is presented in Table 6.1.

Table 6.1: Research Objectives

	Research Objectives
1	To evaluate the importance that both design and designers have on the ability to provide a safe working environment to reduce significant hazards and therefore risk, which in turn may influence human characteristics or traits
2	To examine the interactivity between sustainable demolition activities and the propensity for an increase in accidents or incidents
3	To question the need for small or radical changes in UK safety regulations and workplace policy in order to simplify and make relevant those demands for work in a demolition environment
4	To identify efficient ways in handling and disposing of secondary materials or products liberated from the demolition process with a specific emphasis on the reduction of accident or incident

6.1.1 Contribution to Knowledge

This research has achieved the overall aims and objectives by examining the values and emphasis, placed on the demolition sector, regarding the aspirations of others towards meeting sustainability targets and what impacts this may have. The research has demonstrated that there is a tangible link between traditional soft strip activities and the propensity for a rise in accidents. It has also identified that such a rise in accident occurrence is not readily acknowledged by the demolition sector nor do the current reporting regimes accurately measure the sectors rate of increase or record causation. Through a series of interviews and questionnaires conducted with senior practicing exponents of the demolition sector important evidence has been gathered that clearly identifies a gulf between the perceived ideals of sustainable demolition practices expressed through government, NGO's and the enforcing authorities and those that demolition contractors have readily acknowledged. This important point serves to emphasize that introducing the ideals of others to nurture aspirations must be a fully inclusive process that has considered all aspects and impacts of the target community. This research project has therefore demonstrated that sustainability, within the demolition sector, cannot be safely attained unless there are changes to current working methods without the risk to further increases in accident and incident occurrence. The results of this work contribute to the extant literature on construction management but additionally give a far greater insight into a satellite discipline that has been underreported for decades. This is important because government policy directs the construction industry to improve on reclamation and recycling efficiency but has not been asked some fundamental questions on the effects of changing or adopting new work practices. If the findings of this research are adopted by industry it will reduce the overall number of accident occurrence and it will inform on future policy.

6.2 Attainment of Objectives

6.2.1 Objective 1

'To evaluate the importance that design and designers have on the ability to provide a safer working environment to reduce significant hazards and therefore risk, which in turn may influence human characteristics or traits.'

The attainment of this Objective was mainly derived from the literature review in Chapter 2 in which there is overwhelming evidence that designers can make an enormous contribution to reducing hazards and providing safe working environments. However, there is to date minimal evidence that design and designers are considering whole life cycle issues associated with demolishing structures and the considerable constraints imposed on resource efficiency when dealing with the arisings. Demolition contractors, it seems, embrace change regarding usage of mechanical plant but maintain many historical methods of soft strip which involves manual handling. This calls in to question the consequential health and safety issues associated with the removal/stripping of building products as part of the demolition process, in particular for difficult, complex and high rise buildings where design for deconstruction may provide many of those solutions. For these reasons it is recommended that the UK Government legislate, i.e. through the planning criteria, against any acceptance of a development that does not consider whole life cycle of the products used in the new build and the inclusion of a design element that assists the predicted deconstruction/demolition methodology at the end of life. Without a clear mandate it is unlikely that any developer will commit to an investment without ensuring that all stakeholders are aware of the consequences and in this way design will surely improve, the environment will benefit, waste will be reduced and accident rates will fall.

6.2.2 Objective 2

'To examine the interactivity between sustainable demolition activities and the propensity for an increase in accidents or incidents.'

The attainment of Objective two was mainly reliant on the data collection to provide the evidence that there is a direct correlation between sustainable demolition activities and a rise in accident rates. Although there are agreed flaws in the RIDDOR and LFS reporting routes, there is compelling evidence derived from RIDDOR and the research cohort that segregation, handling and disposal of demolition arisings by hand increases the risk of injury and is almost certainly the root cause for an increase in the accident rate. One may point to an exponential rise in labour numbers and work undertaken. However, both RIDDOR and LFS point to gradual reduction in the construction industry accident rate over the same period, where the demolition rate has been in the ascendancy. Therefore the recommendations are threefold and are cited in Section 6.4, 6.5 and 6.6.

6.2.3 Objective 3

'To question the need for small or radical changes in UK safety regulations and workplace policy in order to simplify and make relevant the demands for work in a demolition environment.'

Prior to the HASWA 1974 the UK workplace regulations were few and those that were in place were prescriptive in their nature. Following the 'Egan Review' the UK embarked on putting into place workplace regulations that were goal setting and making employers ultimately responsible for theirs and their employees actions. The construction industry is well serviced and regulated by legislation and has a number of bespoke regulations, codes of practice and guidance notes. A number of the research cohort indicated a desire to see specific regulations aimed at the demolition sector although it is unclear how this would be of benefit. One of the main criticisms of the workplace regulations was aimed at CDM which the majority were unhappy with, citing the responsibilities of the client and CDMC, in particular, as being imprecise and open to abuse. However, invoking changes to current regulations to suit an individual discipline is unlikely to be initiated and if it were to be so, may constrain the individual sector more than it would help. Therefore, the demolition sector would be better served if it assisted in the production of specific industry guidance targeted at informing of best practice, injury/accident reduction policies, waste minimization principles, plant and equipment utilisation, training schemes, education initiatives and industry forum opportunities. The recommendations would be for industry focus groups such as NFDC, NDTG and IDE to compile and publish such guidance working in conjunction with the enforcing authorities, the construction industry forums and the waste industry action groups. In addition, to nurture closer relations with other focus groups, in particular HSE and the EA, meeting on a regular basis to discuss concerns, the need for change, new technology and new initiatives may provide a platform for better understanding of the sector and its foibles or virtues.

6.2.4 Objective 4

'To identify efficient or effective ways in handling and disposing of secondary materials or products liberated from the demolition process with a specific emphasis on the reduction of accidents or incidents.'

The attainment of Objective 4 has largely been answered by objective 2 in that the reduction of accidents is possible if there is a step change in how demolition contractors manage the soft strip process and dispose of their waste streams. There is though a difficulty in trying to determine the efficiency of the work process which can be somewhat subjective and may depend greatly on the site conditions and the environment to which one is working in. There is little doubt that mechanization has certainly helped to make the overall demolition process more efficient and although capital expenditure on plant and equipment is necessary, it can be said to have dramatically reduced the cost and time of undertaking demolition work. The data collected from the research questionnaire and the interview cohort indicate a rise in the use of attachments to demolish, segregate and load demolition arisings and that where such usage is enacted it is effectively a one man, one machine process. Accident causation data further indicates that the majority of injuries occur as a result of manual handling therefore the propensity for an accident occurring would be significantly reduced should mechanization be increased. However, efficiency is only possible if the conditions on site permit the use of mechanical plant and attachments.

Therein lays the age old question for demolition contractors, can the work be undertaken without using people? In many instances it would appear that it cannot or that there is no desire to seek change of a process that has been executed over many decades. Throughout the research period, the author has not been made aware that it is common knowledge that the demolition sectors accident rates are appallingly bad. Indeed, the impression given by some within the research interviews was that the sector was particularly good at accident reduction and could be said to be performing better than construction per se. This apparent lack of understanding is quite worrying and indicates that little if any information on the sectors accident rates or trends is in the public domain or is kept to be referenced. The NFDC have shown that data collected from its members are inaccurate and misleading. Therefore if there is no general realization that working in a particular manner increases risk of injury it is difficult to perceive how change can be made to rectify the situation and therefore Objective 4 cannot be fully achieved until the sector comes to the same conclusion.

6.3 Conclusions to the Research Objectives and Propositions

The research concentrated on answering the four Research Objectives as stated in Section 1.2.4 and the propositions, shown in Appendix 2, that were derived from the research questions and the literature review. One of the major problems encountered in providing the answers was the lack of information regarding the activities of the demolition sector, which has greatly contributed to an understanding that the research was necessary and overdue. The research has addressed this need by firstly identifying that accidents are common place in the modern demolition industry sector and that a great deal of those recorded is generally caused as a result of manual operations.

Secondly, the research has identified that many accidents and this includes minor as well as major, could have been avoided if both design and designers had played a bigger part in ensuring that those products derived from the demolition process where easily recovered; and that buildings and structured were designed with a specific eye on ease of dismantling and deconstruction where recovery of materials was important. In attempting to carry forward the desires of government and NGO’s regarding sustainable demolition processes, many of the ideals of others towards recovery and salvage in particular and more commonly recycling, are adding to the problems encountered by contractors thereby influencing a rise in the overall risk.

Thirdly, that demolition contractors are slow to make changes in historical methodology and are perpetuating the processes determined many years ago when mechanical plant and attachments were rare or unobtainable. This fact, coupled with the difficulty in separating out the various waste streams for recycling and to provide a clean secondary aggregate means that risk factors are not being reduced to an acceptable level. In addition, those working within the demolition sector are unaware that such a high level of risk is in evidence and have not received any information of note to this fact.

Fourthly, the demolition sector is in a strong position to influence equipment and plant manufacturers to produce the kind of innovative equipment that is necessary to reduce or eliminate manual handling injuries.

Finally, that it is apparent that little of no change in the UK Workplace Regulations would provide an answer to the conundrum arising from historical work habits, other than legislation that is aimed at ensuring all stakeholders are aware of the limitations and constraints imposed on all industry sectors in reducing risk. One small exception may be a change in the CDM Regulations to give greater power of understanding and responsibility on clients and CDMCs, in particular, regarding the demolition process and the undeniable problems facing many demolition contractors for effective and adequate information about the site and the working environment.

6.4 Recommendations for the demolition industry

Despite the fact that this thesis has produced theoretical propositions it can also demonstrate a practical engineered purpose. Of the four objectives, three have demonstratively produced evidence to show that engineering principles and therefore tangible acts would almost certainly induce change in demolition methodology, plant and equipment usage and manning levels.

- The demolition sector, possibly through NFDC or IDE channels should embark on a structured process of education highlighting the advantages and disadvantages connected with resource efficiency and sustainable ideals. The sector has an opportunity to discuss the rising accident rate which appears to be inextricably linked to historical working processes where an increase in production invariably leads to an increase in accident.
- Demolition contractors should increase usage of waste transfer stations and materials recycling facilities for all but aggregate and scrap metals disposal. Aggregate and scrap metals are generally easy to dispose of and have a residual value making them a favourable commercial prospect, even in relatively small quantities. However, the remainder of the demolition arisings, in the majority of cases, incurs a cost for disposal and although there are invariably products that have a residual value when fully recovered are not generally in sufficient quantities/size to make it commercially viable to separate. Contractors who use WTS or MRF can expect to pay a gate fee that is usually in sympathy with that charged at a landfill site, but will escape the landfill tax charge. By being reliant on these types of facilities, the demolition contractor may find that there is less necessity to be careful in his approach to materials separation which will lessen the need for manual handling. This in turn will constitute to make the disposal process cheaper, along with the saving of the landfill tax and will inevitably increase their recycling rates.
- Demolition contractors should employ a greater use of mechanical plant or equipment to facilitate the process of soft strip, salvage and or pre-weakening. Whilst many NGO's and some UK Government departments bemoan the lack of salvage or re-use of secondary building products, the evidence that the recovery of these products necessitates a manual approach which appears to have an incremental effect on the number of injuries recorded by the demolition sector, is conclusive. The statement given by one of the research cohort that 'putting the man back into the workplace increases the risk of accidents occurring' is echoed by others. Therefore, conversely, taking the man out of the workplace will decrease the risk of accidents occurring. Demolition contractors have an opportunity to influence manufacturers of bespoke demolition equipment to innovate and produce the types of mechanical aids that will either negate the use of hand held tools or supplement their usage to provide a power assisted tool with no residual detriment to the health, safety and welfare of the user.

> Whilst there is no shortage of machine based attachments, their application is hard edged and damaging to many building products when trying to recover or handle. Therefore, if salvage of building products is to increase without affecting the accident rate, innovation through new technology needs to be developed and manufactured at a price that encourages its utilisation.

With the use of a questionnaire, structured interviews and the real time collection of accident data from individual exponents it has been possible to drive a wide hole in the accepted industry reporting regime, employed by RIDDOR and the LFS, to show a large discrepancy in the actual number of accidents that occur. This research has demonstrated that voluntary reporting of accident occurrences distorts the real picture and that data derived from requests to a small number of individual companies for accident statistics will produce figures nearer the actual reality. For example, the research has identified that for one year, at least, the discrepancy between the LFS and RIDDOR was around 14%; and that over the research period the NFDC only reported 2.3% of accidents against RIDDOR, whilst the nine companies giving accident data as part of this research reported around 50% of the number identified via RIDDOR.

6.5 Recommendations for the Health and Safety Executive

It is almost impossible to undertake any research that is intended to interrogate health, safety and welfare without some reference to the HSE and their role as guardians of the workplace Acts and Regulations. In this role one would be inclined to believe that any infringement or non conformance of those legislative instruments would attract the attention of HSE who would presumably enact their powers as regulatory policemen to bring suitable retribution upon the heads of offenders? However, whilst there is little doubt that such activities are carried out in all industry sectors, the evidence that there are sufficient numbers of HSE inspectors to police the whole of the construction industry is insubstantial. A number of those who were interviewed as part of this research were particularly vocal as to the lack of policing undertaken for demolition activities and particularly the duty holders under CDM. Indeed, as early as 2002 HSE raised concern about the high proportion of casualties that occur in refurbishment, demolition and dismantling work and asked whether this potentially high risk work required a higher standard of management and expert advice (HSE, 2002). Despite this statement there is no further evidence to show that HSE were interested in understanding why a small sector of construction has consistently shown an increase, year on year, in accidents occurring in the workplace. Therefore, the recommendations within this research are for HSE to include, specifically, the demolition sector in all future research undertaken for accident causation, prevention and management

6.6 Recommendations for theory

The research confirms that the majority of accidents occurring on a demolition site may be attributed to manual operations and that this process has been perpetuated for many years, either through necessity or habit. The research has also identified that demolition contractors do not readily share experiences or knowledge and that although they may utilise the same or similar tools and methodology each has his or her own way of executing the works. Therefore the education of all stakeholders is paramount to achieving a reduction in such accidents whilst striving to meet sustainability targets for salvage and recycling.

This thesis has also contributed positively to the methodological body of knowledge within construction management research and in particular to the satellite discipline of demolition and waste handling. Furthermore, it has shown that despite a very minimal amount of funding being available that much important data can be gathered, on an industry sector and its operations that remains largely alien to many constructors. How much could be achieved with substantial funding in place is subjective but this research may invoke further questions from academia to take up the mantle and properly evaluate the demolition sector's operations over the next decade.

6.7 Recommendations for further research

The following recommendations are made for future research into the demolition industries accident/incident rates, its operations relative to this point and the interface with the construction and waste industries:

- Extend the research to fully appreciate the actual accidents occurring by a strategic process of data collection

- Extend the research to determine the methodology and practices that influence accident causation
- Extend the research to involve the demolition sectors client base and determine how influence may be brought to encourage change
- Investigate further the impact that designers have on demolition methodology and what options may be taken up by the design community to improve demolition and dismantling
- Investigate further how sustainable demolition practices can be undertaken using new technology and innovation to reduce risk or exposure to risk
- Investigate the probability of the demolition sector aligning with the waste industry to step away from the construction industry

6.8 Limitations

This research has been constrained by a number of limitations.

The first data limitation was a distinct shortage of written information on the operations and processes regarding the demolition sector. Whilst the author has a great deal of personal experience, the collection of data has been difficult to validate and although issues such as bias have been reduced to the lowest expectation, the lack of quality references has made it problematic to fully verify the data.

The second data limitation has been one of access to data either held by individuals or on a corporate level. With regard to individuals, the author was aware that there is reluctance for persons to divulge information about theirs or their organisations activities. Although little or no explanation was given as to why this should prevail it facilitates to add fuel to the notion that communication between organisations is practically non-existent. So far as a corporate level is concerned, the NFDC allowed the author access to the member's mandatory annual returns which reveals a distinct deficiency in the reporting regime. The absence of any beneficial or reliable accident data being so stark, as to warrant the exercise as futile.

Methodological limitation and bias were particularly concerning. The research employed quantitative and qualitative data collection methods. The qualitative data were mainly derived from the one to one interviews and although this was a small scale exercise, involving only twelve respondents, it was thought that those who took part in the interviews were representative of the sector. However, the answers to the open questions were also personal opinions needing the skill of the interviewer to decipher the data where there was a tendency for the respondent to elucidate and expand away from the actual question. The problem of bias was reduced by standardising each question to all respondents. The quantitative data were collected from a number of sources and involved a research questionnaire as well as statistical data from industry practitioners, enforcing authorities and UK Government agencies. The research questionnaire was distributed to 300 persons, but only 75 were returned which was a response rate of 25%. Although the data may be valid underreporting is a problem as it raises questions about accuracy as well as bias.

A final, process limitation and probably one which is common to PhD studies, was the time frame involved in collecting sufficient and adequate data to bring the research to a conclusion. Over the period of the research it was apparent that data changed and therefore the research had to adjust to bring in this new information. In addition, the author juggled his duties as a full time company director and a part-time student, which often resulted in a clash of priorities.

6.9 Reflections

The undertaking of this research has, at times, been an arduous process but has also been one of learning. During the research period the author has gained an understanding in research skills and techniques, in qualitative and quantitative data collection, analytical skills and surprisingly patience. Having served in a number of capacities and positions within the construction industry, but more relative, the demolition sector, the author has been surprised at how little the knowledge is or understanding of factors that influence accident and incident and how there is a general reluctance to embrace change or communicate thoughts and feelings. Having served as the President of the Institute of Demolition Engineers, the author is only too well aware of the need to use such forums to disseminate and proliferate information for the good of individuals and corporations. This research has allowed the author, through his position and rank within the industry sector to gain access to heads of organisations and to speak on the industries behalf at seminars and functions. There has been some reaction to some of the data gathered within this research, albeit a small amount, but with the publishing of the research it is hoped that this will give impetus to further research and data collection.

6.10 Chapter summary

This chapter has summarised the key findings of the research and made recommendations to the relevant stakeholders regarding working practices or further research. Whilst it was important to achieve the research objectives the data collected from all aspects of the research project has also highlighted other areas of concern and some shortfalls in legislation, data collection, the working practices of other industry sectors, Government and NGO initiatives and those of the enforcing agencies. The chapter identifies that this research has contributed to an understanding that the research was necessary and overdue and finished with recommendations to follow up and move the research forward towards fully understanding the nuances and intricacies of an industry sector that has been largely ignored.

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Appendix A

RESEARCH PROPOSITIONS

Proposition (P) 1:	There is an inability or unwillingness of product and or building designers to take a holistic approach to sustainability in the built environment and design for deconstruction.
Proposition (P) 2:	There is an apparent indifference, to the importance of designers, displayed by those who have a major influence on the procurement process.
Proposition (P) 3:	Unrealistic targets and objectives are being set, mostly by government and NGO's, for sustainable initiatives without placement of the infrastructure necessary to drive through change. In particular, there is with a lack of or inconsistency in the markets to take back reusable and recyclable products and materials.
Proposition (P) 4:	Waste from construction and demolition sites must be separated at source and disposed off in the most economic, but environmentally friendly, manner to realise its full potential
Proposition (P) 5:	Waste production from construction and demolition sites must be minimised by better design and use of technology
Proposition (P) 6:	Product design must meet sustainable aspirations to protect the environment, reduce accidents at work and minimise waste sent to landfill
Proposition (P) 7:	Those who would influence product utilisation and or shape the built environment must embrace sustainability and sustainable development to reuse components or materials of a secondary / recovered nature
Proposition (P) 8:	Can further advances in technology provide the design, machinery, methodology or framework to increase safety factors and reduce risk
Proposition (P) 9:	Could design for deconstruction be the answer to a reduction of significant hazards arising from demolition and waste handling
Proposition (P) 10:	Do designers of products, materials and the built environment need to be brought under the influence of more or stricter legislation to reduce significant hazards arising from use or workplace activities

Proposition (P) 11: Does the desire to improve on and drive through sustainability and sustainable development initiatives have an impact on accident occurrence, risk taking or behavioural patterns

Proposition (P) 12: Have we reached the limitation to which man can reduce accidents at work given the nature and number of projects undertaken, the natural tendency for risk taking in business activities, the human psyche and societies desire to expand mans influence on the planet.

Proposition (P) 13: Are the current crop of workplace regulations adequate and relevant for today's working environment given that in general they try to encompass as diverse a number of workplaces as possible

Proposition (P) 14: Should new or future regulation be targeted at specific industry sectors, departments, groups of workers and or individuals to focus responsibilities, duties or best practices

Proposition (P) 15: Has regulation become so prescriptive that it is irrelevant or useless to most organisations or individuals in managing their daily duties to employees, clients, the enforcing authorities or the public in general

Proposition (P) 16: Does the fear of prohibition or prosecution get in the way of organisations or individuals taking a pragmatic or common sense view on safety matters and if so what measures can be taken or adopted to rectify this

Proposition (P) 17: Is there insufficient regulation in the workplace, do we need more or should we seek to standardise with Europe

Proposition (P) 18: Is the UK too bureaucratic, heavy handed, high minded or insensitive when dealing with organisations or individuals regarding implementation or infringement of the workplace regulations, codes of practice or guidance.

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Appendix B RESEARCH QUESTIONNAIRE

An Investigative Study On The Possible Effects Of Sustainability On Accident / Incident Rates Within The Demolition Industry

Researcher: Terry Quarmby

KEY RESEARCH QUESTIONS (for all demolition & trade contractors)

Please find time to answer these questions as fully as possible. Your individual details shall not be made available to others. The information you divulge will remain in the keeping of the researcher only for as long as the collation period and verification process undertaken by the Loughborough University support tutors. Your knowledge and assistance is greatly appreciated.

Company:

Head Office Location:

Nature of Work Carried Out:

Contact Details:

Q1.

Do you carry out 'soft stripping' of materials by hand and or machine?

Always	Sometimes	Never	A mixture of both

Q2.

Do you take into account the value of any material before you soft strip?

Always	Sometimes	Only if asked	Never

Q3.

Would you salvage more if the markets were freely available?

Absolutely	Possibly	Only if pushed	Never

Q4.

Do you think that machine attachments used today make it harder to salvage materials?

Yes	Possibly	No	Don't know

Q5.

How many notifiable accidents have you had over the last 10 years

Over 10	5 or more	Less than 5	None

Q6.

What kind of accidents (all accidents minor or major) are the most frequently recorded?

Falls	Entrapment	Striking *being hit by plant or vehicles*	Cuts & Abrasions	Collision
Burns	Slipping	Striking *being hit by falling objects*	Trips	Other

Q7.

On your sites, have the numbers of accidents (minor or major) risen over the last 10 years?

Noticeably	Slightly	No change	Fallen

If yes to this question, what would you say were the reasons for this?

Q8.

Have you as a company or individual made an effort to get to know all the issues regarding waste management and all the sustainability issues affecting your workplaces?

Fully	Partly	Only when necessary	Never

Q9.

Do any of your clients insist on you reclaiming, recycling or making available for re-use materials from the project?

Always	Sometimes	Only if they are pushed	Never

Q10.

Do you think that demolition contractors have a major role to play in improving sustainability target results?

Absolutely	Sometimes	Not sure	Not ever

Appendix C

RESEARCH INTERVIEW QUESTIONS

1. It has been suggested that there is a need to improve the design and or use of sustainable products and materials in the new build process. What new initiatives, processes or procedures could be implemented or adopted to achieve this?
2. Given that there is an almost universal call for greater use of secondary products or materials either in the new build process or on the open market, how can improvements be made or initiatives driven to accomplish this?
3. What, in your opinion, are the greatest barriers to implementing a sustainable waste strategy in the demolition sector and how can these be best broken down?
4. Could regulatory / legislator changes or a relaxing of the present regime make a significant difference to waste handling and utilisation?
5. If design, at all levels, can have a major influence on how we manage our activities should it be obligatory for designers to accept a greater level of responsibility than at present?
6. If the significant risk of an accident occurring is increased by the introduction of the man in the workplace, is it reasonable to expect that the recovery of building components take second place to efficient and effective work methods where safety factors may be increased and sustainability initiatives be decreased?
7. How helpful, or otherwise, are the UK's workplace regulations in providing a common framework to improve safety, welfare and health on site?
8. Would statutory regulations specifically targeted at each individual industry sector be of greater benefit than an holistic approach as at present?
9. Do you believe that the fear of prohibition or prosecution could have an undue influence on an individual's capacity to take a pragmatic or common sense view on Health, Safety and Welfare requirements in the workplace?

One further question was added to the review process to provide the recipient with the opportunity to elucidate on personal preferences for improvement in the workplace or the management process. This is as stated:

10. What, if any, changes or initiatives would <u>you</u> like to see implemented or developed that could improve health, safety, welfare and environmental practices in the workplace?