The Effect Of Offsite Construction On Occupational Health and Safety

By

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ABSTRACT

The continuous desire to improve health and safety in UK construction has in recent years been challenged to adopt offsite strategies in order to address the poor health and safety record of construction. Despite the benefits of using offsite there has been little research on the actual benefits and disadvantages of the effect of offsite on occupational health and safety. This is important given that the UK government has promoted the use of offsite to improve health and safety performance.

This thesis provides a strategy for the management of offsite risk and a risk management tool has been developed. The study investigated offsite manufacturers' views on offsite activities and risks in comparison with insitu activities and risks. This was achieved through three phases: phase I comprised two expert group interviews, phase II involved ergonomic audits and phase III consisted of three semi-structured interviews with three offsite manufacturers.

The thesis identified that there are significant health and safety benefits of offsite. The benefits relate to specific activities within the offsite categories and context studied. Examples include the elimination of work at height, reduction in noise, reduction in work in confined space, reduction in congested work with trade overlap and greater control over work in the factory.

The research revealed that there are still potential health and safety risks with offsite. Examples include; transportation and delivery of units of large size and weight with associated high consequence craneage and handling risks (unit fall and hand injury), whole body vibration, cuts, MSDs, RSIs, fumes and slips trips and falls. There appears to be little in the literature to support the identification of offsite risk issues.

The study identified strategies to eliminate and reduce offsite residual risks. The case study investigated solutions to further reduce residual risks, which were further explored in phase III the semi-structured interviews. The solutions are grouped into four approaches: process change, workplace environment designing out risks, automation and the use of tools.

An offsite risk management tool was developed which transfers knowledge from the study to provide awareness and management of offsite risk. The thesis provides a contribution to knowledge by providing a better understanding of offsite risks, offsite residual risks and strategies used to reduce residual risks.

Keywords: Offsite, offsite risk management, offsite residual risk, offsite manufacturers

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My sincere thanks to the industrial partners who contributed to the group interviews, provided case study material and support for the ergonomic audits and semi-structured interviews for the project they include: *INNOGY Plc*, Trent Concrete Ltd, Crown House Engineering Ltd, Carillion Construction Ltd, Caledonian Building Systems Ltd, Geoffrey Reid Associates (now 3D Reid), Revolutionary Pod Modules and the Trades Union Congress (TUC).

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LIST OF ABBREVIATIONS

BRE	Building Research Establishment
DEFRA	Department of Environment Food and Rural Affairs
DETR	Department for Environment, Transport and the Regions
EPSRC	Engineering and Physical Sciences Research Council
HASPREST	The effect of standardisation and pre-assembly on health, safety and accident causality in construction.
HSE	Health and Safety Executive
HSWA	The Health and safety at Work Act
ICE	Institution of Civil Engineers
ICT	Information and Communication Technologies
IEA	International Ergonomics Association
IMI	Innovative Manufacturing Initiative
IMMPREST	Interactive Method of Measuring Pre-Assembly and Standardisation Technique
MCNS	Meeting Clients' Needs through Standardisation
MMC	Modern Methods of Construction
OSF	Offsite Fabrication
OSM	Offsite Manufacturing
OSP	Offsite Production
POST	Parliamentary Office of Science and Technology
S&P	Standardisation and Pre-assembly
SME	Small and Medium Size Enterprise
TUC	Trades Union Congress
UMIST	University of Manchester Institute of Science and Technology

1 INTRODUCTION

1.1 Introduction

The construction industry in the United Kingdom (UK), a major contributor to the nation's gross domestic product (GDP), has been challenged to review and improve their health and safety performance (Egan 1998). In particular, a review of their use of the methods of construction has been promoted to address health and safety performance, skills shortages, reduce environmental impact, improve quality and meet the Government's need to increase output (Bourn 2001). Much has been said about the increased use of offsite technologies (offsite) in recent years as a strategy to address all of these issues and improve the overall performance of construction (Egan 2002). However, there is no conclusive evidence that this is the case – much is anecdotal. There has been no real investigation of the activities and risks between offsite and insitu construction methods and strategies such as offsite. Furthermore, although the actual health and safety risks reduce with offsite, the risks change and need to be considered carefully throughout the project process. This study explores how offsite impacts on health safety by a detailed study of the activities and risks between offsite and insitu. This introductory chapter presents the context for the use of offsite and its impact on health and safety within the organisations investigated as part of the offsite construction sector. It also introduces the aims and objectives of the research, outlines the research methodology and describes the structure of the thesis.

1.2 Research Context

The need to improve health and safety in construction is overarching. Bearing this in mind, this section presents an overview of the UK construction industry, its health and safety performance, accident rates in comparison with other industries and, coupled with the drive to use alternative construction techniques, suggests a need to use offsite techniques.

1.2.1 UK Construction Industry

UK construction output is the second largest in the EU and contributes to 10% of the nation's GDP. The industry comprises over 250 000 companies which employ 2.1 million people in a variety of roles (Office for National Statistics 2005). The sector is ranked in the global top ten. The industry is defined as one which embraces the construction materials and products; suppliers and producers; building services manufacturers, providers and installers; contractors, sub-contractors, professionals, advisors and construction clients and those organisations that are relevant to the design, build, operation and refurbishment of buildings (Office for National Statistics 2005).

However, the poor health and safety performance within the UK construction industry, has been a significant criticism over the years. Individual companies have introduced new and innovative techniques designed to improve the systems of operation in an attempt to improve overall safety performance, but the construction industry as a whole has failed to achieve a similar overall improvement (Egan 1998, Egan 2002, Anderson 1992, Brown 1997). In the manufacturing industry there can be much greater control over the workplace and the methods of completing tasks. In contrast, the construction site is a scene of continuous change, affected by site constraints, housekeeping and the fragmented approach to work scheduling which all contribute to generate increased health and safety risks (Cameron et al 2008, Cameron and Duff 2007a, Gibb et al. 2006, Gyi et al. 1999, Gyi et al. 1998).

1.2.2 UK Construction Industry – Accident Rates

The construction industry has been repeatedly targeted for its poor safety performance record (HSE 1988, HSE 2002). Fatal and major injury rates in construction and manufacturing provide a means of assessing the relative danger for people at work in these industries. Table 2.1 (see section 2.2.1) shows that the risk of a fatal injury is three-and-a-half times greater and the risk of a major injury nearly six times greater in construction than in manufacturing.

The literature provides evidence to show that ill health in construction is also poor, there is substantially higher incidence of diffuse pleural thickening, mesothelioma and asbestosis in comparison to the average for all industries (for a detailed review see section 2.2.1). Above average rates are shown for upper limb disorders and vibration white finger (HSE 2009a). Thus there is a need to improve the health and safety performance of construction, this thesis suggests that the benefits of offsite may help to improve construction health and safety. However, there are residual risks with offsite and these are discussed in chapter 7.

1.2.3 Health and safety review and the gaps in knowledge

A review of the fatal injury rates across agriculture, utility, manufacturing, construction and service industries show that agriculture, utility and construction are the worst for fatal injuries. The construction industry is the worst for non-fatal injuries and the third worst for over 3-day injuries. The types of accident in construction have changed little over the years with construction having a higher proportion of falls and moving/falling objects (2.4.1). There is little in the literature relating to the types of accidents in offsite manufacturing.

1.2.4 Offsite review and the gaps in knowledge

The literature reveals that there are a number of terminologies in use to describe “offsite” such as: prefabrication; pre-assembly, industrialised building; system building; offsite manufacturing; offsite fabrication; offsite production and modern methods of construction (MMC). An important distinction between offsite and MMC is that all offsite may be regarded as a sub-set of MMC but not all MMC may be regarded as offsite, e.g. thin jointed blockwork and “Tunnel Form” see (Goodier et al 2005, Lusby-Taylor et al. 2004).

It is claimed that the use of offsite, in a controlled factory environment, can assist in the reduction of accidents on site (POST 2003). UK government reports including (Egan 1998) identified offsite as a strategy for health and safety performance improvement, however, there is an ongoing need to address the lack of knowledge regarding offsite and its affects. Knowledge relating to the identification of the occupational safety and health risks in the offsite factory is required. The gap in knowledge is revealed, in that a paucity of knowledge relates to the actual effect of offsite on occupational health and safety in the offsite factory.

1.3 Purpose Of The Research

This section outlines the aim and objectives of the study with a description of the research scope.

1.3.1 Aim and objectives

The need to identify the effect of offsite on health and safety and to identify risks compared to insitu construction, coupled with the industry's poor safety record, presents an acute problem for the industry. Offsite manufacturers must be aware of the health and safety challenges of offsite in order to improve health and safety performance.

The overall aim of the study was to:

Develop a strategy for delivering offsite solutions in a manner that maximises the benefits to the health and safety of all those involved in the process.

Thus six research objectives were formulated:

Objective 1. Review the health and safety performance of UK construction, identify barriers and drivers to improvement and identify theories of accident causation;

Objective 2. Identify and clarify the concept of offsite and associated terminologies and provide a definition for the thesis;

Objective 3. Identify the activities and risks for selected elements/units for both offsite and insitu solutions and to identify offsite residual risks and how such risks can be reduced;

Objective 4. Establish the effect of offsite on occupational safety and health in the construction industry – both positive and negative;

Objective 5. Develop a structured and transparent offsite health and safety risk management tool for principal contractors inspecting offsite works, supplier/manufacturer of offsite works and managers of on-site works who are installing offsite products;

Objective 6. Verify and disseminate the research findings.

1.3.2 Scope of the study

The research on which the thesis is based was funded by the UK government through the LINK scheme, Meeting Clients Needs through Standardisation (MCNS). The scheme was jointly funded by the Engineering and Physical Sciences Research Council (EPSRC) and the Department of the Environment, Transport and the Regions (DETR). The project was entitled HASPREST –'the effect of standardisation and pre-assembly on health, safety and accident causality'.

Research funding initiatives such as the Innovative Manufacturing Initiative (IMI) and Meeting Clients' Needs through Standardization (MCNS) programmes have emphasized the use of standardization strategies in achieving efficient production.

The research team for this project was a unique, multi-disciplinary collaboration between the Civil & Building Engineering, Human Sciences & Design and Technology Departments at Loughborough University. The team was established and had completed a number of projects in collaboration with major industry players and produced several publications. The team had been involved with HSE in a major drive to reduce accidents by developing a fuller understanding of their causes. This HSE work formed the health and safety link to the HASPREST project. The team applied the lessons learnt from previous HSE work and review strategies developed from the whole industry viewpoint to the more specific area of offsite.

Industrial partners formed a steering group for the project which included: INNOGY, Trent Concrete, Crown House Engineering, Carillion Construction, Caledonian Building Systems, Geoffrey Reid Associates (now 3D Reid), Revolutionary Pod Modules and the Trades Union Congress (TUC).

The research project, led by Alistair Gibb of Loughborough University, developed an offsite risk management tool. This covered both technical and managerial aspects. The author of this thesis was the main researcher on the HASPREST project.

1.4 Overview of research process

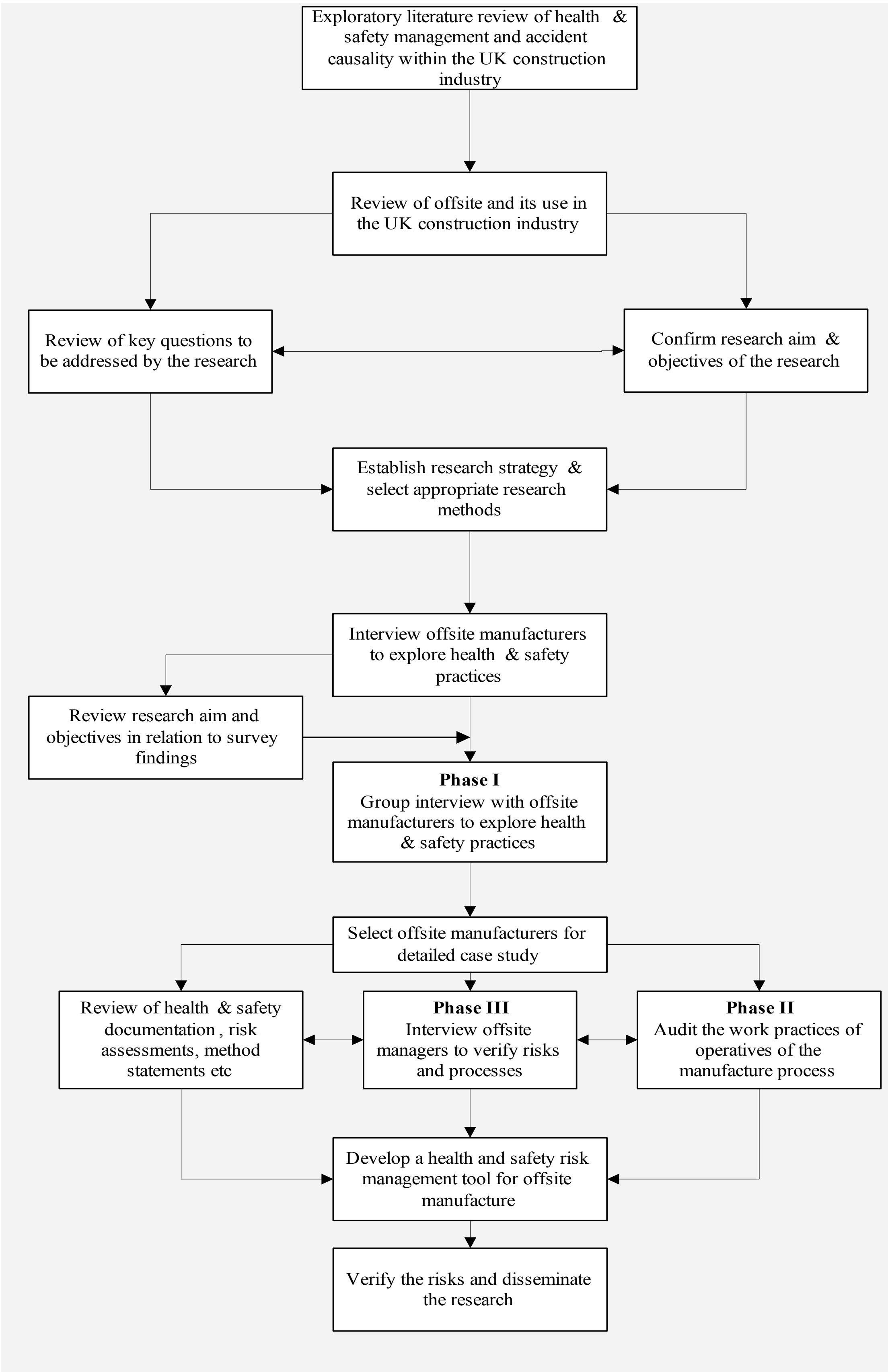
A detailed description of the research approach used for this study is discussed in chapter four. This section provides a brief overview of the research process for this study. A flow diagram of the process is shown in Figure 1.1, which includes the main research steps: literature review, in depth exploration of offsite manufacturers (phase I), the case study (phase II) and the risk change and residual risk management verifications (phase III).

A thorough literature review on health and safety performance, accident causality and offsite manufacture in the UK construction industry indicated a need for performance improvement using offsite construction methods. An appropriate research strategy and methods were selected.

Two expert group interviews with construction professionals explored the current health and safety issues associated with offsite activities and risks (see section 5.3). The aim and objectives of the research were reviewed and aligned in light of the conclusion of the interview analysis.

Three offsite manufacturers were selected for detailed investigation. This included direct observation of live case study projects to explore working practices, full ergonomic health and safety work-place audits for offsite processes (see section 5.4) and semi-structured interviews involving experts to verify key issues (see section 5.5). The main findings from the group interviews and case study analysis work enabled the development of a health and safety risk management tool for offsite. Chapters four and five outline the data collection and analysis from the group interviews and case study projects that informed the development of the risk management tool.

Figure 1.1 Flow diagram of the research process



1.5 Summary of the contribution to knowledge

This section presents a summary of the contribution to knowledge made by the thesis (8.2) The study has provided a contribution to the identification and understanding of the activities and risks in offsite. Previously, little research has been carried out in risk identification of offsite. The expert group interview study and the ergonomic risk audit aimed to improve the knowledge of offsite risk.

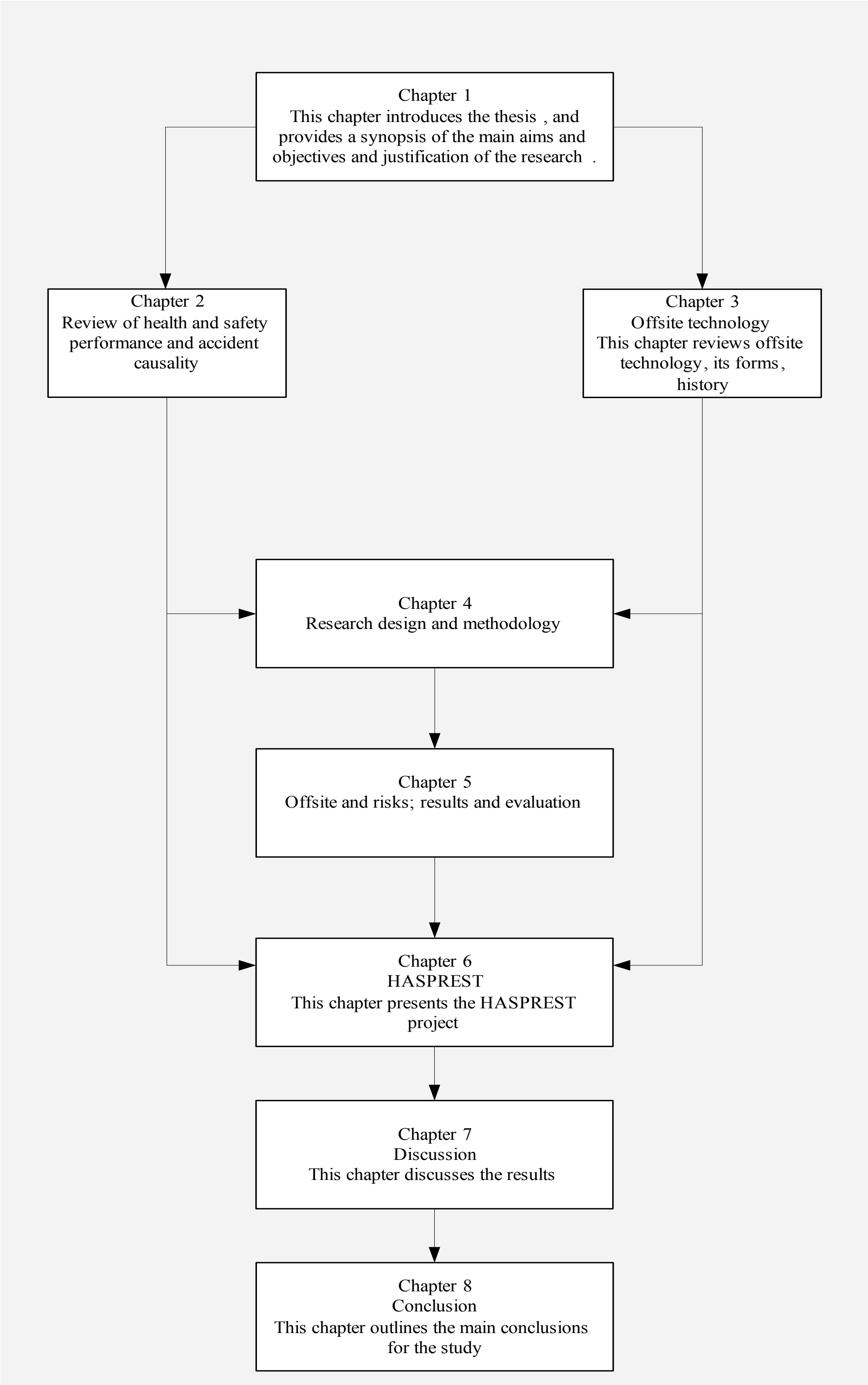
The research has contributed to the understanding of the strategies and practices that offsite manufacturers adopt to minimise offsite residual risk. The semi-structured interviews in phase III identified residual risk in three case study manufacturers. This improved knowledge and gained an important insight into the strategies and process changes that offsite manufacturers adopt to reduce offsite residual risk.

The research has produced an offsite risk management tool which assists in the development of a strategy for delivering offsite solutions in a manner that maximises the benefits to the health and safety of all those involved in the process. This addresses the gap in knowledge available at present regarding offsite risk management. The tool provides access to a database which covers selected elements within building, civil engineering and engineering construction for the identification of risks associated with activities for the insitu solution and the equivalent offsite solution. This provides risk awareness which contributes to the development of risk assessments and strategies for minimising risk in offsite production processes.

The study has provided a contribution to the effect offsite has on occupational health and safety. While there are clearly significant benefits of using offsite e.g., reduction in work at height, a number of challenges were uncovered in the research, in particular an understanding of offsite residual risks and the strategies used by offsite manufacturers to reduce residual risk, were significant knowledge gains.

Overall, the research has contributed to knowledge in relation to offsite and health and safety in relation to activities and risks, ergonomic risk, offsite residual risk and the strategies used to reduce residual risk.

Figure 1.2 Structure of the thesis



1.6 Organisation of the Thesis

The thesis comprises eight interrelated chapters. A brief overview of the content of each chapter is discussed below. Figure 1.2 provides a graphic illustration of the structure of the work.

Chapter 1 - Introduction. This chapter introduces the thesis, and provides a synopsis of the main aims and objectives and justification of the research. In addition, an outline of the research design and methodology is discussed. An overview of the HASPREST project, on which the thesis is based is described.

Chapter 2 - Review of health and safety performance and accident causality. From the published literature, a review of health and safety performance is presented. Construction accident types and a review of health and safety accident causation in UK construction is presented.

Chapter 3 - Offsite technology. From the published literature, a review of offsite is presented including the terminology, its role in health and safety, government promotion in regard to health and safety improvement in UK construction.

Chapter 4 - Research design and methodology. The principles and procedures behind the approaches available for the research are discussed; namely qualitative methods.

Chapter 5 - Offsite and risks; results and evaluation. The collection of data using group interviews, case study and observation and semi-structured interview techniques are discussed. The offsite and insitu activities and risks are identified and evaluated. The results informed the risk management tool.

Chapter 6 - HASPREST. The CD tool – 'The Effect of Standardisation And Pre-Assembly On Health, safety And Accident causality In Construction' is presented. The tool intends to assist offsite manufacturers and offsite suppliers in the health and safety considerations involved in offsite manufacture and installation. They are presented as part of a process map that identifies significant stages in the evolvement of the construction process and where health and safety requires consideration and management.

Chapter 7 - Discussion. The discussion of the results is organised into sections with appropriate themes in connection with the research aims and objectives.

Chapter 8 - Conclusions. The main findings of the research are presented. Conclusions drawn from the findings and the recommendations for further study are discussed.

1.7 Summary

This chapter has introduced the research context. The UK construction industry has been challenged to improve health and safety performance using innovative methods of construction, new regulations, industry initiatives and Government drive to increase output and improve safety generally. The aims and objectives of the thesis have been presented. The study involved three phases; phase I the expert group interviews, phase II the ergonomic audits and phase III the semi-structured interviews. An overview of the thesis' contribution to knowledge has been completed and the structure and organisation of the chapters presented. This provides guidance for the reader and provides a map of the study, leading to the final conclusions of the work.

2 HEALTH AND SAFETY, ACCIDENT CAUSALITY AND ERGONOMIC REVIEW

2.1 Introduction

This chapter investigates the health and safety issues in UK construction. The first chapter introduced the research and outlined the aims, objectives and the justification of the research. This chapter begins with a review of the health and safety performance of the UK construction industry in the literature, placing health and safety in context with the associated issues. The drivers and barriers to improving health and safety in the industry are explored. This is followed by a review of the characteristics of accidents in construction. Key theories relating to accident causality are examined. Ergonomic audits formed part of the investigation (Chapter 5) and the use of ergonomic programmes in the literature are discussed.

2.2 Drivers to improve health and safety

This section presents the main drivers which indicate the need for improvement in health and safety in UK construction. This helps to suggest a need for a change in the approach to the problem of managing health and safety in construction, by using offsite techniques.

2.2.1 Fatal and major accidents and ill health in construction

In the United Kingdom, the construction industry has been repeatedly targeted for its poor safety performance record (HSE 1988, HSE 2002). The Egan report ‘Rethinking Construction’ (Egan 1998: 28) stated that ‘*the health and safety record of construction is the second worst of any industry’* and that *‘accidents can account for 4 to 6 per cent of total project costs’*. The fatal accident rate, continues to dominate the all-industry figures.

The Health and Safety Executive (HSE) state that, ‘*in the last 25 years, over 2,800 people have died from injuries they received as a result of construction work. Many more have been injured or made ill*’ (HSE 2008). Figure 2.1, 2.2 and 2.3 show the annual fatality record, the non-fatal injury record and the over-3-day injury rate respectively for construction compared to other industries for the years 1997/98 to 2007/08 (HSE 2009b).

Figure 2.1 Fatal injury rate for employees by industrial sector (HSE 2009b)

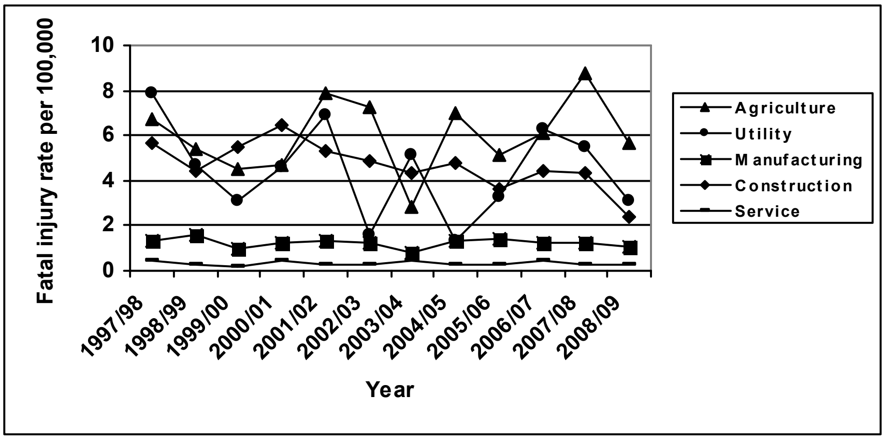


Figure 2.2 **Non-fatal injury rate for employees by industrial sector (HSE 2009b)**

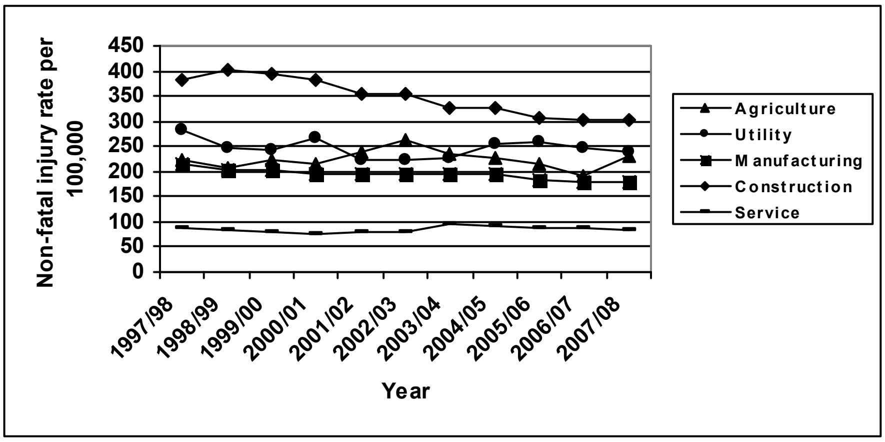
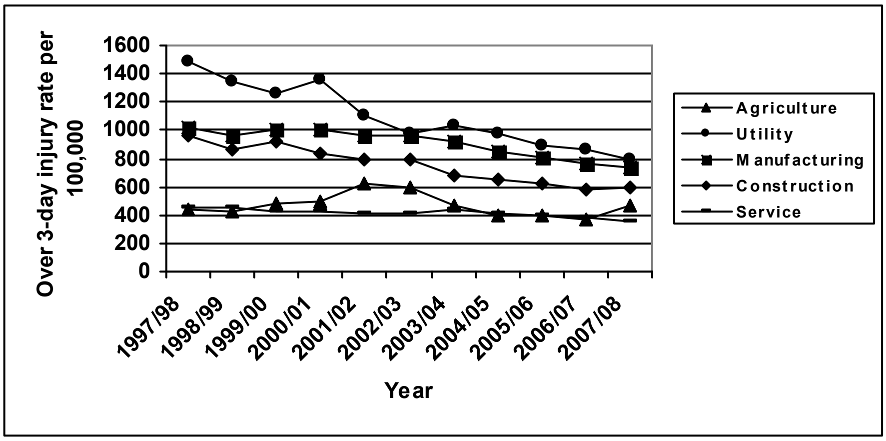


Figure 2.3 **Over 3-day injury rate for employees by industrial sector (HSE 2009b)**



The above graphs show the performance, it can be seen that agriculture, utility and construction have the worst fatal injury rates. The construction industry has the worst non-fatal injury rate and the third worse for over 3-day injury rates. The actual situation in the construction industry is discussed by the HSE; *'construction has the largest number of fatal injuries of the main industry groups. In 2008/09 there were 53 fatal injuries giving a rate of 2.5 per 100,000 workers. This is the third highest rate of fatal injuries, behind agriculture and extractive industries. Since 1999/2000 the rate of reported major injuries to employees in construction has fallen steadily. Despite this falling trend, the rate of major injury in construction is the highest of any main industry group (254.1 per 100,000 employees in 2008/09)'* (HSE 2009c). The latest data from the HSE for rates of fatal injuries by sector for 2008/09 is presented in (Figure 2.1). The HSE discuss the statistics '*Prior to the availability of the rate for 2008/09 the figures for the preceding five years were starting to suggest that the downward trend was levelling off. Therefore, this year's data has changed the picture in an important way. Moreover, the rate for 2008/09 represents a statistically significant decrease compared to the average rate for the previous five years. The most likely explanation for the striking drop in the figures this year is that the play of chance has fallen in a highly favourable way'*. The HSE also comment on the possible effect of the recession *'This has come after two years when based on the underlying trend it would appear that the figures were very much in the upper range of what might be expected. It is also worth mentioning that the recession could be having an effect'* (HSE 2009d).

The Health and Safety Commission (HSC) and Health and Safety Executive (HSE) merged on 1st April 2008 to form a single national regulatory body. This body, known as the HSE, published statistics relating to health and safety at work in supplements to the Employment Gazette up until 1994/95, from 1994/95 statistics are published in annual reports. The HSE statistics from 1994/95 in the Health and Safety Executive Annual Report contain a number of tables giving provisional figures for the previous financial year and are usually published in December. The Annual Report is the first occasion on which the latest years provisional statistics are published. The health and safety executive base their incidence rates on quarterly employment estimates from the Department of Employment, averaged over the year, and are normally quoted per 100,000 workers.

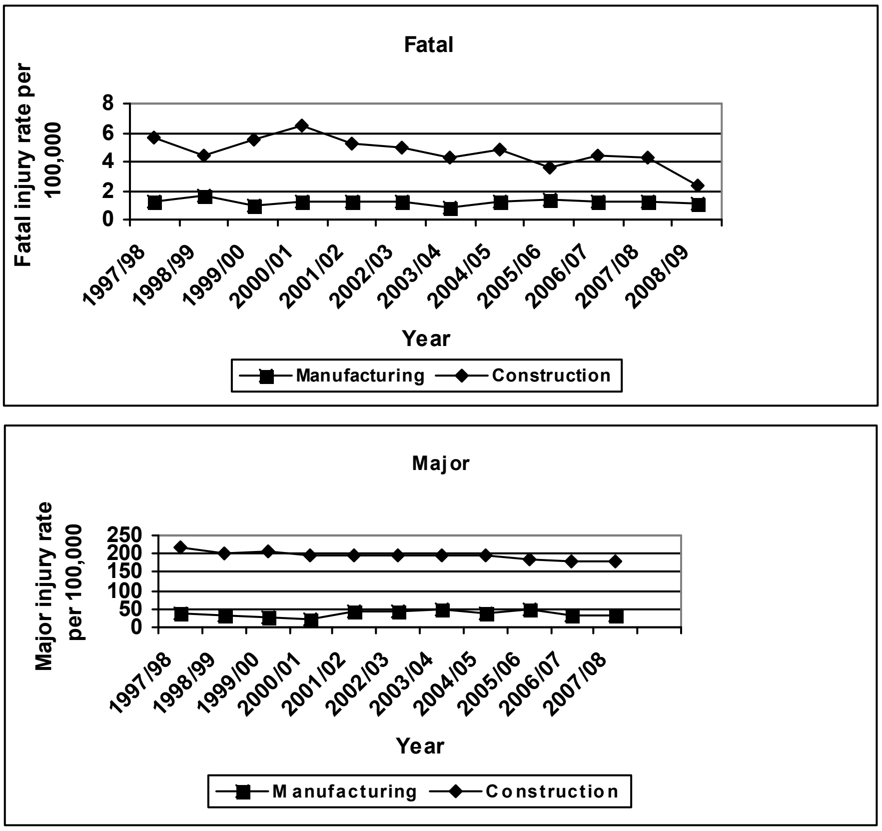
A comparison of incidence rates (per 100,000 employed) for fatal and major injuries in the construction and manufacturing industries provide a means of assessing the relative danger for people at work in these industries. As shown in Table 2.1 the risk of a fatal injury is three-and-a-half times greater and the risk of a major injury nearly six times greater in construction than in manufacturing (Figure 2.4).

Table 2.1 Fatal and major injury rates per 100,000 1997/98-2008/09 (HSE 2009b)

Year [1]	Construction		Manufacturing	
	Fatal	Major	Fatal	Major
1997/98	5.7	216.1	1.3	35.7
1998/99	4.4	201.5	1.6	35.2
1999/00	5.5	204.1	1.0	25.9
2000/01	6.5	194.2	1.2	22.9
2001/02	5.3	194.9	1.3	44.4
2002/03	4.9	194.3	1.2	45.5
2003/04	4.3	194.1	0.8	46.8
2004/05	4.8	195.6	1.3	40.3
2005/06	3.6	182.5	1.4	47.5
2006/07	4.4	179.2	1.2	31.3
2007/08	4.3	180.8	1.2	30.2
2008/09	2.4	-[2]	1.1	-[2]

Note.1. 1996/97 onwards reported under the Reporting of Injuries, Diseases and Dangerous Occurrences Regulations (RIDDOR) 1995. 2. Data not yet available.

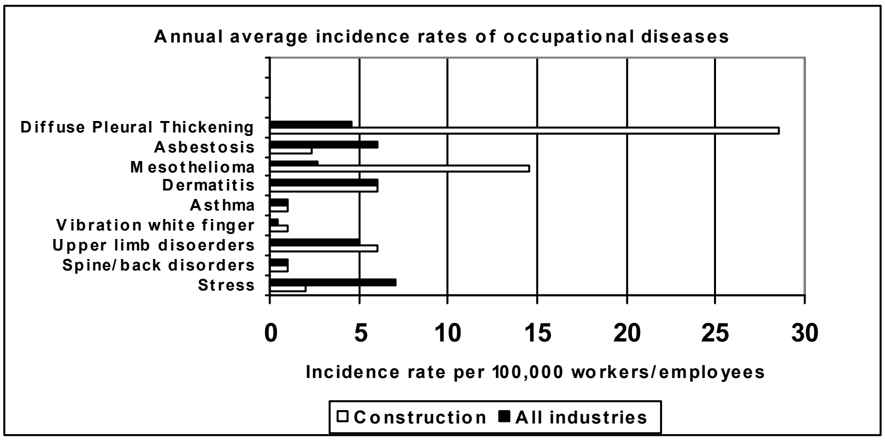
Figure 2.4 Fatal and major injury rates per 100,000 1997/98-2008/09 (HSE 2009b)[1]



1 There is evidence to suggest that there is substantial but uneven under reporting of accidents. The HSE estimate that only 40% of non-fatal accidents are reported in the construction industry (HSE 2009b).

The nature of ill health in construction has been more difficult to measure in part due to the transient nature of the workforce. However, the Health and Safety Executive have published incidence rates for work related ill health as seen by The Health and Occupation Reporting Network (THOR) hospital specialists over the period 2005-2007 (HSE 2009a). Figure 2.5 shows data from the THOR surveillance schemes for the period 2005 – 2007 where there is a substantially higher incidence of diffuse pleural thickening, mesothelioma and asbestosis in comparison to the average for all industries. Above average rates are shown for upper limb disorders and vibration white finger (HSE 2009a).

Figure 2.5 Annual incidence rates of diseases, THOR; 2005-2007 (HSE 2009a)



These statistics are of such concern to the HSE that a ‘Construction Division’ was created on April 2003, within the fields operations directorate (created on April 1990) where specific attention was directed towards the construction industry.

2.2.2 Legal requirements

The legislation covering health and safety in the workplace in the UK is the Health and Safety at Work Act 1974 (HSWA). Under section 3 of the HSWA it is a legal obligation for employees to undertake work in a manner which will not cause risks to other persons. The employer’s duty of care to employees is described by (Ridley and Channing 2003) as covering the following areas:

- a safe place of work;
- safe system of work;
- plant and machinery that is safe to use;
- competent supervision and/or suitable training; and
- care in the selection of fellow employees.

2.2.3 Economic drivers

Injuries have a detrimental effect on the running of any business. Research conducted in the United States by Hinze and Applegate (1991), indicate that the indirect costs (excluding materials, equipment and claims costs) of accidents; loss of productivity, transportation to the nearest medical facility and the time to complete the relevant documentation can be 1.62 times the direct costs (insurance premiums, doctors fees and medical fees). The cost issues tend to be less transparent in the UK.

2.2.4 Contractor's reputation

The contractor's reputation can suffer when the project experiences high accident rates (Smith and Arnold 1996). The study argues that a contractor's safety performance may be used in comparison with other contractors for selection purposes. The desire for a contractor to have a good image in terms of health and safety and maintain their reputation by maintaining safety performance is an important driver. Wilson and Koehn (2000: 77-79), suggests that larger construction projects and larger contractors are better organised in terms of safety, *'larger construction projects generally are better organized from a safety standpoint. These type of projects are often high profile. The companies involved in such visible construction projects have reputations to uphold as well as safety records to maintain; they are generally better prepared to manage the safety aspects of a project*'. They claim that it is important for both large and small contractors to maintain a good safety reputation.

2.3 Barriers to health and safety improvement

This section presents the main barriers which play a role in impeding the improvement in health and safety in the construction industry.

2.3.1 The nature of the construction industry

Unlike manufacturing, construction work seldom involves a stable set of activities, work environment and personnel (Grubb and Swanson 1999). In the construction industry there are several unique problems which provide a challenge to health and safety and distinguish it from other industry groups (Brown 1996). These are:

- the need to set up the site, produce and erect components, construct and make a profit. Then close down the site and move on to the next unique project all in a time period of 1 to 4 years;

- the supervision and control of the labour force, which is itinerant by nature and whose numbers will fluctuate during the project;
- often the construction management team cannot communicate with the client or design team before the tender is submitted for the contract;
- often there is little time for detailed safety planning after the contract has been awarded;
- the construction industry's products are decided by the client and therefore the construction management team cannot create or shape their own market;
- the construction industry is fiercely competitive and operates under conditions of uncertainty. This is because clients are often vague about their objectives and hence construction designs are frequently subject to change at short notice.

The above unique features can create problems in planning for safety. The continuous and cumulative nature of construction projects leads to dramatic changes in activities undertaken and in the working environment. In addition the majority of operatives on many sites are not in the direct employ of the main contractor. Many operatives may work for subcontractors or be self employed. The casual and intermittent nature of the work has always been connected with an unknown amount of "moonlighting", that is the presence of illegally employed workers. This further aggravates the problem of those attempting to control safety because people may be trespassing and working on site who have no knowledge of safety procedures and who are not registered with the site manager. In addition (Grubb and Swanson 1999 : 793-794) state that '*the construction industry relies heavily upon part-time work and temporary workers as well as varied work schedules, and there is often a seasonal aspect to the work*'.

Unfortunately, it is not only construction workers themselves who suffer injury and death. A brief examination of the available data from the HSE (HSE 2009e), reveal that '*the requirement to report injuries to members of the public was introduced under the Notification of Accidents and Dangerous Occurrences Regulations (NADOR) 1980. In 1986/87 there were 14 575 non-fatal injuries to members of the public, injuries then steadily decreased to their lowest level under RIDDOR 85 to 9981 in 1990/91. From 1991/92 there was an upward trend to 13 234 non-fatal injuries in 1995/96, the last year that reports were made under RIDDOR 85 and the second highest number of reports since 1986/87.*

In 1996/97 reporting requirements were further revised under the Reporting of Injuries, Diseases and Dangerous Occurrences Regulations 1995 (RIDDOR 95), again increasing the *number of reports when 35 694 members of the public were injured. Numbers generally decreased until 2003/04; since then the number of reports has risen steadily, with 18 163 injuries reported in the provisional year 2007/08*'.

2.3.2 The need for improved health and safety training

Anderson (1992) argues that, while some safety skills and knowledge can be used on site using a common sense approach, there is no substitute for targeted education and training, especially the specification and testing of basic competence. These problems need to be addressed by asking how safety training should be conducted, what should be the appropriate timing of that training, what methods need to be implemented to check and test the validity of training and that regular updates to the content are required (Anderson 1992). Knowledge of the accident and ill-health record of the industry is vital. Education and training of construction professionals is vital as they have a key role in the health and safety of site personnel. Langford and Webster (1986) studied the effect of the 'Site safe '83' campaign (HSE 1983). They believed the campaign was successful with the major companies but it had a poor response from the majority of smaller building companies and subcontractors. They found evidence to support this from among safety officers whom they interviewed. It was reported that the campaign did not get down to the right level, namely, the people having the accidents. Langford and Webster (1986) also believed that the implementation of the campaign occurred too late in 1982 to permit effective participation by the HSE and many companies. They also feel that a longer planning time was needed with more positive aims such as concentration on specialised safety training with regard to the problems which arise in practice in the application of safety rules and procedures.

The literature presents a number of strategies to attempt to improve construction health and safety. A full review will not be covered here, however recent research by Cameron and Duff (2007b) discuss the use of safety initiatives which utilise goal setting and feedback to improve the focus on health and safety. The research findings discuss records of monthly goal setting and review meetings for induction training, toolbox talks, safety committees, subcontractor safety, safety records and documents, safety manager actions and safety considerations. The study reports that *'collectively, findings from the case study support the proposition that goal setting can improve management safety performance in the construction industry'*.

2.3.3 Attitudes toward health and safety

Anderson (1998) argues that when a contractor experiences a long period of reduction in the number of accidents, then there may be a sense of operatives having "lost the fear" of an accident. Lord Robens stated in the UK committee on health and safety at work report (Robens 1972) that '*the most important single reason for accidents at work is apathy'*.

2.3.4 Insufficient finance allocated to health and safety

The literature presents evidence to suggest that there exists a perception among some contractors that there is little return on investing in health and safety. A full review is out with the scope of this thesis, however it has been claimed that many health and safety plans are inadequate and do not place a significant emphasis on safety (Hislop 1999).

2.3.5 Time pressure and overtime

Research indicates that overall performance has an effect on safety performance. The work by Rodriguez and Jasleskis (1996), suggests that projects that are behind programme have more accidents. The study examined the relationship between project performance and accidents. An increase in the number of accidents on construction sites which are over budget and behind schedule were discussed, and furthermore, safety performance levels were shown to be significantly different during the middle and end for projects that were behind schedule.

Goldenhar et al. (2003), researched the effect of working overtime on 64 construction workers in the US and identified four main categories relating to health and safety issues: sleep; injury; fatigue and stress. A number of the respondents made a direct link between working overtime and personal injury. The need to meet bonus targets and to keep the project on target can result in rushed tasks leading to errors in judgement causing injury (Hopkins 1995).

2.4 Characteristics of accidents

The preceding section discussed the drivers and barriers for health and safety in construction. This section explores the characteristics of accidents in the construction industry, which helps to distinguish between the main kinds of accidents and distribution by size of firm.

2.4.1 Types of accidents

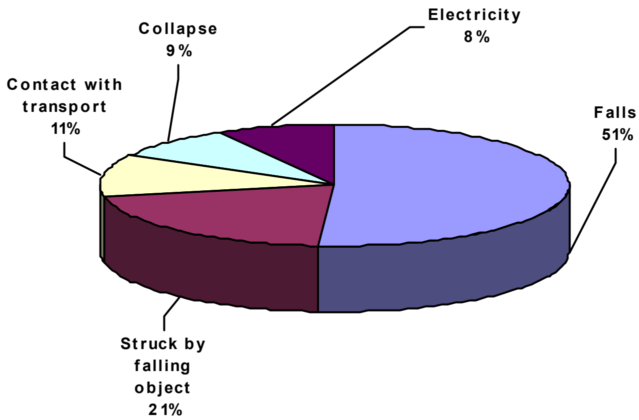
Data from HSE state that *'the most common kinds of reported injuries to workers in all industries occur as a result of handling, or slips and trips. These also represent the most common kinds of reported injury within construction. In 2008/09, handling accounted for 29% of reported injuries to workers, and slips and trips 22%. Compared to workers across other industries, construction has higher proportions of reported injuries caused by falls* *from a height (17% of construction injuries compared to 8% across other industries) and moving/falling objects (16% construction, 11% other industries). Contact with moving machinery accidents account for 4% of worker injuries in construction, compared to 3% across other industries. In comparison with other industries a much higher proportion of all reported injuries within construction are serious, i.e. the ratio of fatal and major injuries to over-3-day injuries is higher in construction than most other industries'* (HSE 2009f).

This depressing observation about the recurring patterns of accidents in the construction industry has been made time and time again. Table 2.2 shows an analysis of fatal accidents in construction published by the HSE in 2009 entitled Construction Intelligence Report (HSE 2009a). Of the 873 deaths in the years 1996/97-2007/08, the kind of fatal injuries were as illustrated in the pie chart Figure 2.6.

Table 2.2 Kind of fatal injuries in construction 1996/7-2007/08 (HSE 2009a)

Cause of fatal injury	Total Number	%
Falls	442	51
Struck by moving including flying/falling object	184	21
Contact with transport/mobile plant	100	11
Trapped by something, collapse overturning	76	9
Electricity	71	8
Total	873	

Figure 2.6 Kind of fatal injuries in construction 1996/97-2007/08 (HSE 2009a)



A central observation of the "Site Safe 83" (HSE 1983) campaign echoed the serious nature of the characteristics and pattern of accidents and was summarised from the following extract from the Site Safe '83 package '*the general pattern of accidents remains very little different from earlier years, it is possible to write in advance the epitaphs of men who will be killed each year, in falls through roofs, when painting under roofs, by contact with* *overheads lines and in trenches. Declining accident figures so often only reflect declining construction activity'.*

It is clear that the most common types of construction accidents are falls of people from heights, people being struck by falling objects and by persons being struck by vehicles.

2.4.2 Accident distribution by size of firm

Available evidence also suggests that the size of the firm, the size of the site and the size of the work group are major factors in determining the distribution of accidents within any type of employment activity or in the construction industry as a whole. The vulnerability of the small firm has been a constant theme in official accident reports on site safety in construction. In 1956, for example the factories report observed that: '*the small contractor seems to think that safety organisation is a thing outside his orbit, if he is aware of its existence*' (Williams 1960). Cameron et al (2008) compare the number of fatal accidents in small construction firms between Scotland and England *'2/3 of fatal accidents in GB occur on sites where the main/only contractor is small, in construction industry terms'.*

The 1977-78 HSE Construction Health and Safety report commented that, '*in general the problem no longer lies with the major firms; they have the motivation and the resources. The problem now is getting the message across to a multitude of small firms*' (HSE 1979).

2.5 Health and safety legislation

There is a substantial amount of legislation relating to construction health and safety, a full review is out with the direct scope of this thesis. However, in order to implement offsite, action prior to the construction process is necessary. The Construction Design and Management (CDM) regulations are concerned with eliminating and removing risk in the design phase, one design option is to use offsite to eliminate risk. The next section discusses CDM 1994 and 2007.

2.5.1 CDM Management Regulations (1994)

A consultative document was issued by the Health and Safety Commission in September 1989 which sought proposals for a new set of regulations and a supporting code of practice. These became the Construction (Design and Management) Regulations 1994 (CDM), which were enacted in 1995. These were developed prior to and pending the release of the European Directive: the Temporary or Mobile Construction Sites Directive (1992/57/EEC). '*The CDM regulations were introduced in an attempt to improve the management of health and safety in the UK. They provided a system for the individuals and companies involved in* *a project to follow in order to structure the way in which they approach health and safety management'* (Preece and Cavina 1999: 436).

CDM (1994) aim was to avoid, minimise and combat health and safety risks suffered by workers or others engaged in all types of construction work or those affected by their work. In addition, emphasis was placed on the client and contractor to provide reasonable measures in their approach to health and safety. Clients must also ensure that contractors are provided with all the information about the state or condition of the land or premises which might affect the health and safety of those affected by the works. The regulations applied to all construction work including: alteration and conversions; fitting out; commissioning; repair, upkeep, redecoration and general maintenance (including certain cleaning operations); demolition or dismantling structures and preparation works including site clearance exploration but not site surveys (Joyce 2001).

(Joyce 2001) provides a summary of the main requirements of the regulations (Table 2.3):

Table 2.3 Legal appointment of responsibilities CDM 1994, (Joyce 2001)

Clients (or Clients agent)	Designer	Planning Supervisor	Principal Contractor
Appoint a planning supervisor	Make client aware of their duties	Ensure the Health and Safety Executive is notified of the works	Co-ordinate and manage health and safety issues during the work
Provide information to the Planning Supervisor on health and safety matters	Give due regard to health and safety matters in all design work, including when the full regulations do not apply (for instance, work for a domestic client)	Ensure co-operation between designers	Develop the health and safety plan before construction starts and keep it up to date during the construction phase
Appoint a principal contractor	Provide adequate information about the health and safety risks of the design to all relevant parties.	Ensure that designers comply with their duties	Co-operate with the Planning Supervisor and designers
Check and ensure the competence on health and safety matters of those appointed by him	Co-operate with Planning Supervisor and other designers	Ensure a pre-tender stage Health and Safety Plan is prepared	Prepare risk assessments/method statements when required
Ensure that a suitable construction stage Health and Safety Plan has been prepared by the Principal Contractor before the start of the work		Advise the client when requested to do so, in particular on competence and adequacy of resources of contractors and designers on health and safety matters	Collect and collate detail of services, plan and equipment that are part of the structure from specialist suppliers and installers, and pass it on for incorporation into the health and safety file.
		As for Principal Contractor	
Ensure that a Health and Safety File is kept available for use		Ensure that a Health and Safety File is prepared	

Anderson (2003: 176), criticises the CDM regulations, stating that '*an explosion of the paperwork generated and handled by the industry in response to parts of this recent legislation*' and the '*creation of thousands of "new" competent persons in the form of planning supervisors whose only statutory duties relate to construction health and safety matters*'. Beal (2007: 82), also states that '*despite having cost several billions of pounds to implement, the regulations have produced very little improvement in safety*'. Preece and Cavina (1999: 442), reports on research, which included, surveys and interviews with clients, designers, planning supervisors, contractors and independent specialists on the roles and competence of the new duty holders in particular, the planning supervisor. The findings echo the problem of excessive paperwork and bureaucracy, '*68% felt that the health and* *safety plan should be more project specific. Many people say that the health and safety plans are filled out with information regarding the companies safety policy and has no relation to the project'*. In addition, the survey suggested that 'the *duties of the planning supervisor should be given to the Principal Designer and the role of Planning Supervisor as a separate function should disappear'. The amount of paperwork, such as the number of health and safety files produced, should be reduced as much of it is instigated by the Planning Supervisor in an attempt to justify their role'.* As a consequence, the CDM regulations were revised as discussed in the next section.

3.1.1.1 CDM Regulations (2007)

The Construction (Design and Management) Regulations 1994 were replaced on 6 April 2007 with the Construction (Design and Management) Regulations 2007. The main change was that the planning supervisor was replaced with a "CDM coordinator" and that, The Construction (Health, Safety and Welfare) Regulations 1996 which dealt mainly with health, safety and welfare requirements on site during the construction phase, have been revoked and incorporated as part 4 of CDM 2007, with little change. The declared aim of the new regulations is to reduce administration and bureaucracy, and to improve safety.

Rabin (2007: 1), discusses the key differences between the old and the "new" regulations. '*The CDM coordinator will undertake a more hands-on and involved approach to health and safety issues than the planning supervisor, whose role was more "supervisory" in nature. For example, under the 2007 regulations, the CDM coordinator has express obligations to prepare the health and safety file. Under the 1994 regulations, the planning supervisor's obligation was to ensure the health and safety file was prepared. There are also obligations on the CDM coordinator to facilitate good communications between the client, designers and contractors, and to ensure that all relevant pre-construction information is provided in a timely fashion to those who need it. Finally, the CDM coordinator will assist clients with the task of assessing whether the designers, contractors and principal contractors proposed for appointment are competent*'.

There are also more responsibilities for clients, '*To prevent clients from transferring their statutory liabilities to an agent, it is no longer possible to appoint a client's agent. However, where multiple clients exist for a project, they can elect one of them in writing to be the "client" for the purposes of CDM 2007. The client's role is central to the 2007 regulations and the client's responsibilities are increased. The client's general duty is to ensure that suitable project management arrangements are in place which will allow the construction works to be carried out safely. A pre-construction information pack must be provided by the* *client to every designer of a "structure" and every contractor appointed by the client. The construction phase cannot start unless suitable welfare facilities, such as washing facilities, drinking water, changing rooms/lockers and rest facilities are in place. The pre-construction information pack is new, replacing the old pre-tender health and safety plan. All designers and contractors bidding for work in connection with the project must be provided with pre-construction information, including details of the pre-construction period allocated for planning and preparation work. This means the client must assemble such information at a very early stage of the project and add to the information pack as the project progresses'* (Rabin 2007: 1).

Rabin (2007: 1), describes the duties of duty holders: '*There are four general duties that must be complied with by each of the five types of duty holder; client, designers, contractors, CDM coordinator and principal contractor—as opposed to specific duties attributable to each type. These general duties are to:*

- *address "health and safety" competence;*
- *cooperate with others to allow all duty holders to meet the requirements of CDM 2007;*
- *coordinate activities to ensure the health and safety of those carrying out and those affected by the construction work;*
- *apply the principles of prevention contained in The Management of Health and Safety at Work Regulations'.*

Barnard (2007: 142), states that while certain advances have been made in improving clarity, maximising flexibility and reducing bureaucracy, '*there remains an amount of uncertainty and cynicism about CDM. Both individuals and organisations were encouraged to persevere in applying the above principles as a way of overcoming the bureaucratic, tick-box and derisive mentality which had emerged in some parts of the industry'*. The literature reveals that there is still an ongoing need for improvement in the legislation.

The discussion in relation to CDM have presented a context which promote the use of offsite to removing risks. The problems in relation to CDM 1994 in relation to the need to open designers eyes to early safety considerations could be addressed by the CDM coordinator. The CDM coordinator could be an offsite champion, to promote the benefits of early design action using offsite. An example can be the removal of work at height which has been identified as a serious risk particular to construction. Also, the study by Gibb et al. (2004) argue that greater benefits in achieving a reduction in construction risks are a result of early action in the design phase. A significant contribution to increasing the benefits of realizing earlier design action would be the change in CDM 2007, where a CDM coordinator is appointed earlier than the planning supervisor was in CDM 1994. The advantage of this change is that there exists the opportunity to choose offsite early in design and the subsequent benefits of risk reduction, notably reducing the risks of working at height.

2.6 Context of accident causation

This section explores literature on the causes of accidents in construction. The definitions in the literature of the term accident are discussed, which provides a basis of reviewing the main accident causation models.

2.6.1 Definitions – safety and accident

Many definitions of safety have been offered in the literature. Ngowi (1996: 417), defines safety '*as the prevention of accidents or mitigation of personal injury or property damage which may result from accidents*'. Cox and Cox (1996) define safety as '*a state of freedom from unacceptable risk of personal harm*'. The Oxford English dictionary defines safety as '*denoting something defined to prevent injury or damage*' (OED 2009a). A workable definition would be that which suggests that a construction site is safe when persons can go about their normal daily work without undue risk. This accepts that there are risk situations in all everyday activities and does not pretend that a workplace can be entirely accident proof.

In the construction industry and in industry in general, those involved in hazard analysis and accident research have generated many definitions for the term accident for example:

Arbous and Kerrich (1951: 342), define an accident as '*in a chain of events each of which is planned or controlled, there occurs an unplanned event which, being the result of some non-adjusted act on the part of the individual (variously caused),may or may not result in injury. This is an accident'*.

'*An accident is an unexpected, unplanned event in a sequence of events, that occurs through a combination of causes; it results in physical harm (injury or disease) to an individual, damage to property, a near-miss, a loss, or any combination of these effects'* (Ridley and Channing 2003: 188).

'*An unplanned and uncontrolled event which has led to or could have caused injury to persons, damage to plant or other loss'* (Stranks 1990: 44).

Probably the simplest definition of an accident is an uncontrollable occurrence which results in injury or damage. The events leading up to an accident are, of course, controllable in most cases and this is what safety is all about. The controlling of work situations by providing safe conditions, effective safety training and insisting on the use of safe working methods and procedures is the aim of accident prevention.

Accident causes are not always as obvious as they first appear to be. Persistent investigation often reveals some obscure yet significant feature which entirely changes the original picture of the incident (Heinrich et al. 1980: 34-36). It is therefore important that the general nature of the relationship which exists between an accident and the preceding chain of events is understood. Heinrich et al. (1980: 22-23) describes the features of an accident-occurrence series:

- *'Ancestry and social environment: undesirable traits of character may be passed along through inheritance. Environment may develop undesirable traits of character or may interfere with education.*
- *Fault of person: ignorance of safe practice, constitute proximate reasons for committing unsafe acts or for the existence of mechanical or physical hazards.*
- *Unsafe act: unsafe performance of persons, such as removal of safeguards and insufficient light, result in accidents.*
- *Accident: events such as falls of persons, striking of persons by flying objects are typical accidents that cause injury.*
- *Injury: fractures, lacerations are injuries that result directly from accidents'.*

An important subtle difference between the cause of an accident and an actual accident is that the former is capable of being interrupted at some stage in its development, so that the sequence of events may be broken or modified in some way which will eliminate the danger. The next section reviews a selected range of theories of accident causation.

2.6.2 Theories of Accident causation

The literature reports a large number of accident causation models on human error theory. This section provides a contextual background as to why accidents happen.

Stranks (1994), postulates the *pure chance theory*, in which everyone has an equal chance of having and accident. This theory states that no identifiable pattern exists in the events that lead up to an accident. Prevention is not possible. Stranks (1994), also proposes the *biased* *liability theory*, which states that '*once an individual has an accident, the probability that the same person will have a further accident in the future has either decreased or increased when compared to the rest of the population at risk. If the probability has increased, the phenomenon is referred to as the contagion hypothesis. If the probability has decreased, it is commonly called the burned fingers hypothesis'*.

Stranks (1994) and Hinze (1997) discuss the *accident proneness theory*, which states that certain characteristics in some individuals make them more susceptible to accidents than others. These "accident-prone" individuals have some personal characteristics that cause them to have more accidents than non accident-prone individuals. It is argued that accident-prone individuals, through their decision making process, place themselves at a greater risk than non accident-prone individuals.

The *theory of unconscious motivation* (Stranks 1994), states that this is derived from psychoanalytic theory and that accidents are a result of sub-conscious processes such as aggression, anxiety, conflict, ambition and guilt. The theory suggests that individuals and the interaction of their perception of the environment and their underlying personality factors contribute to accidents.

Hinze (1997) discusses the *adjustment stress theory.* This theory states that workers who suffer stress are more likely to have an accident. A stress related working environment provides a poor climate for workers. The type of stress can be either job-related or non-job-related. Job-related stress may be as a result of the conditions that exist in the workplace. A second and complimentary theory, the *goals of freedom alertness theory* focuses on the goal driven aspects of human behaviour. In order to see results, individuals set goals for themselves. Hinze (1997) argues that it is important for flexibility in the work environment in order that individuals can pursue these goals, and that they are able to meet tasks by concentrating their work efforts. The theory is that there will be better safety performance where there is a psychologically rewarding work environment.

A fault and event tree approach was presented by Bomel Ltd (2006). This approach discusses a fault and event tree analysis technique. '*The two techniques can be used in isolation or in combination, and describe scenarios as; fault trees describe incidents (e.g. falls from a roof) in terms of the combinations of underlying failures that can cause them (such as ignoring method statements combined with 'failure' leading to a trip). Event trees describe the possible outcomes of a hazardous event, in terms of the failure or success of reduction and mitigation measures such as fall arrest equipment. In terms of the two components of risk: fault trees give an indication of the likelihood of an incident occurring.*

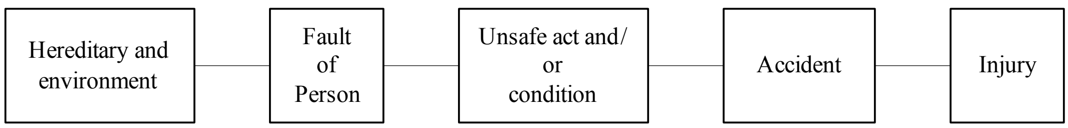
Event trees give an indication of the consequences of an incident. Fault tree and event tree analysis is time-consuming, and it may not be practicable to use these methods for more than a small number of scenarios. However, the methods have the advantage that they provide a visual interpretation of the causes and consequences and can include control measures in a transparent way. Whilst the typical application of these methods in the major hazard industries involves quantifying the likelihood and consequences, sketching the causes and consequences can provide a means of visualising how a construction activity may end in an incident'. These techniques describe incidents and the possible outcomes, there is still a need for feedback and learning and this is discussed in section 2.8.

2.6.3 Domino theory

The *domino theory* Heinrich et al. (1980), proposes five main causes of accidents (Figure 2.7) these are:

1. hereditary and social environmental factors, leading to;
2. a fault of the person consisting of the proximity reasons for;
3. either an unsafe act or unsafe condition, which result in;
4. the accident which may lead to;
5. the injury or loss.

Figure 2.7 Domino theory of accident causation



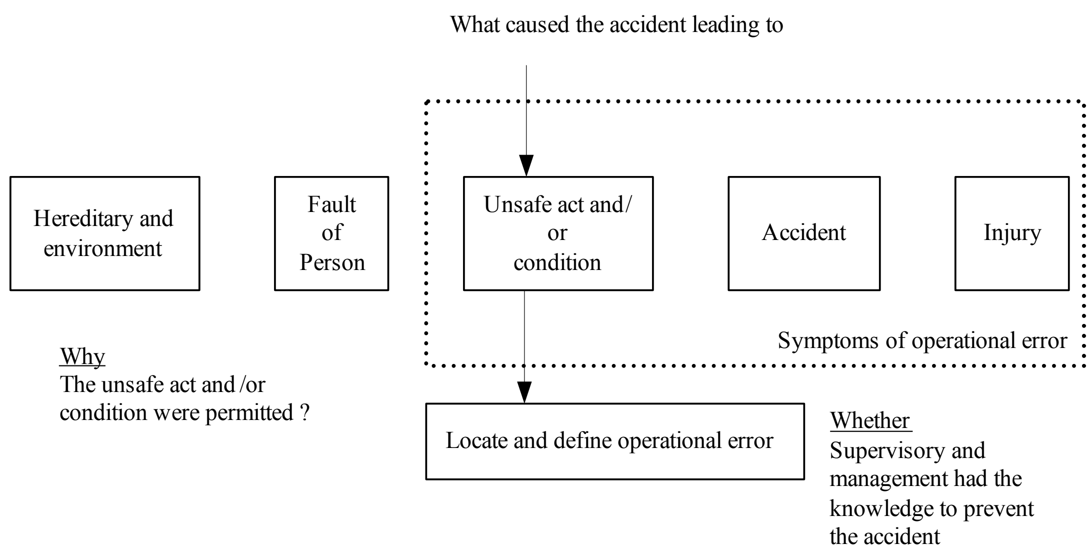
This concept can be thought of as a series of five dominoes: if the first domino is triggered, it will immediately cause the second to fall which in turn will cause the next to fall and so on until the final domino is reached (Cox and Cox 1996). Thus an injury can be prevented by removing one of the first four dominoes. Heinrich et al. (1980) states that removing the critical domino (unsafe act/situation) will prevent accidents happening.

2.6.4 Weaver model of multiple accident causation

Building on the domino theory, Weaver (2006) proposed the *multiple causation theory* (Figure 2.8). The *multiple causation theory* suggests that all contributing factors need to be traced to determine accident causes, not just the proximal causes of accidents. Unsafe acts should be considered as symptoms wrong in the management system as opposed to the causes of accidents.

Each accident provides an opportunity to observe the symptoms and procedures. Different accidents may reveal similarities which may point to flaws in the same management system. The theory states that the factors combine, to cause accidents. The theory deals with the causes of accidents not just the symptoms.

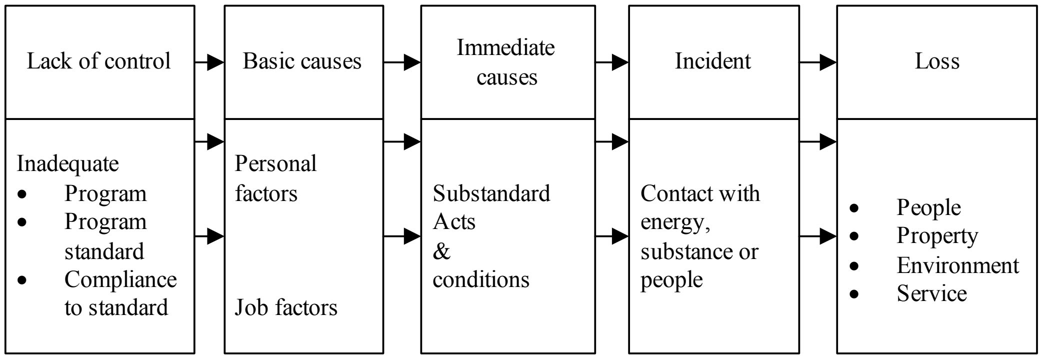
Figure 2.8 Weaver model of accident causation (Weaver 2006)



2.6.5 Loss causation model

Based on the domino theory, Bird and Germain (1990) proposed the *loss causation model* (Figure 2.9). The lack of control (inadequate program/compliance to standard) precedes the basic causes which are the real causes behind the symptoms; why the substandard acts and conditions occurred. These are the root causes and can assist in the identification of substandard practices or conditions. The basic causes have been categorised as personal factors and job factors, these cause or permit the substandard acts and conditions, behind which are the faults in the management systems.

Figure 2.9 Loss causation model (Bird 1985)



The circumstances that immediately precede the incident are the immediate causes often they are termed the unsafe acts and unsafe conditions. These immediate causes are symptoms, in order to avoid recurrence of symptoms, the basic causes must be addressed.

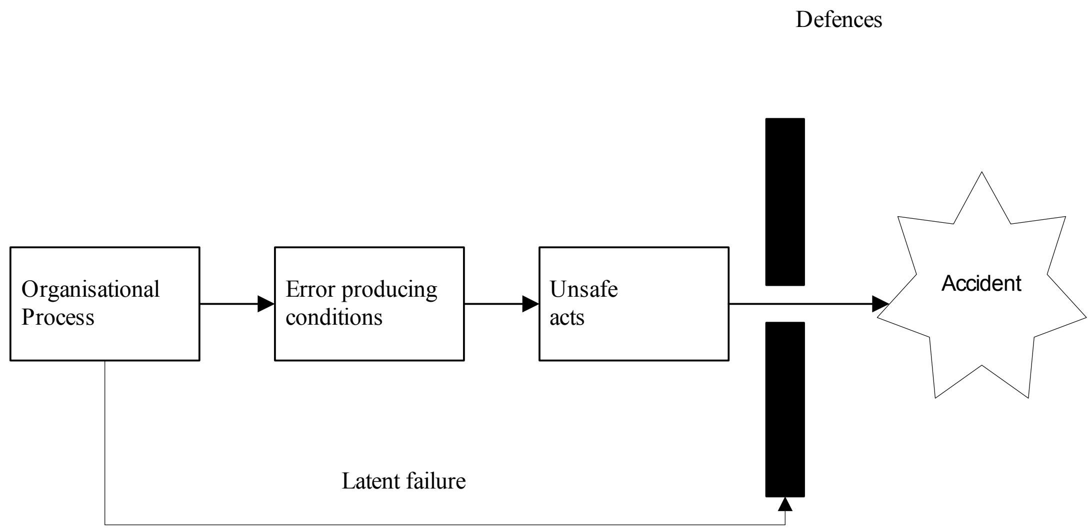
Directly preceding the loss is the incident – this is the contact that causes injury or damage. The loss is the result of the accident, the type and extent of the loss can range from insignificant to a major catastrophe. The arrows illustrate multi-linear interactions of cause and effect. A point to note is that this model does not include the safety measures that may be introduced during the design phase. The decisions to include offsite should precede the lack of control (inadequate program/compliance to standard). The model is concerned with site and personal factors. In addition, this model discusses the accident itself but it has not included the systems perspectives to include a feedback loop to enable learning. This is discussed in section 2.8.

2.6.6 Framework of accident causation - Reason

Reason (1997), identified two types of accidents those that affect individuals and those that affect organisations. Accidents relating to organisations have multiple causes and involve many people. Individual accidents are where a specified person or group is the agent and victim of an accident. Individual accidents have remained unchanged over the years whereas organisational accidents have evolved through technological innovation.

Reason (1997), presented a basic framework (Figure 2.10) which illustrates the relationship between hazards, defences and losses. The framework proposes that when an individual performs an unsafe act, which breaches defences or occurs in the absence of defences, an accident occurs. Reason is modelling what happens with accidents and does not comment on the need for a cyclical approach to allow feedback and learning.

Figure 2.10 Framework of accident causation (Reason 1997)



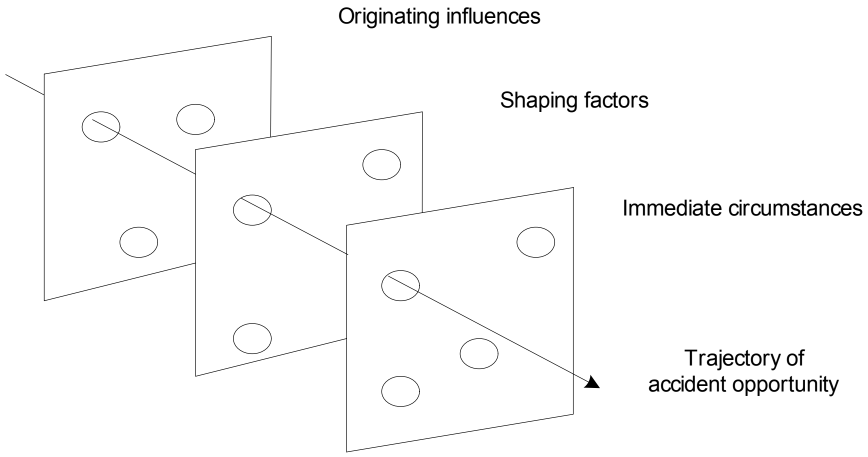
The defences are breached by three factors, human, technical and organisational. It is argued that human factors play the dominant role and two ways in which humans contribute to the breakdown of accidents are identified:

- active failure: errors and violations which have an immediate effect; and
- latent failures: decisions/actions, the consequences of which may lie dormant for long periods and become evident when they are triggered by active failures to breach the safety defences.

The unsafe acts (active or latent) are failures to maintain the defences or actions that cause or exacerbate the abnormal event.

Gibb et al (2006) applied the model by Reason to the ConCA model (2.6.10). The defences or plates become the immediate circumstances, shaping factors and originating influences (Figure 2.11).

Figure 2.11 ConCA model (after Reason)



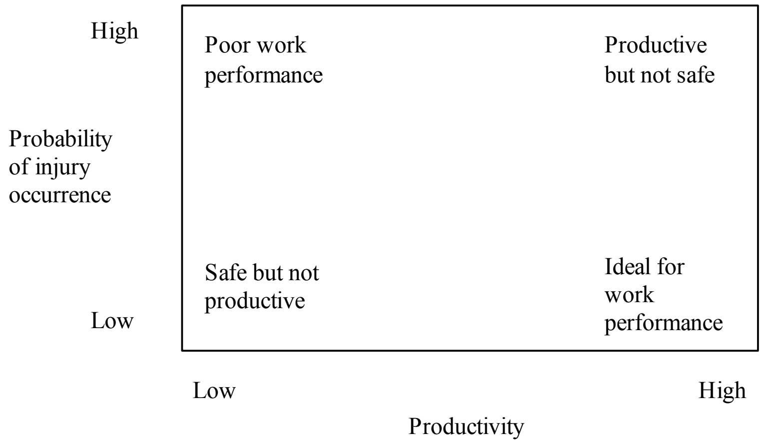
It is argued that the ConCA/Reason model can be used to simplify the message and challenge for the construction industry. Gibb et al (2006) state that: '*the site team, who are largely responsible for the immediate circumstances, need to concentrate on reducing their own holes (i.e. site environment, workplace, worker and tools and equipment issues). The project management team and detailed designers (the main influencers of the shaping factors) should ensure that they work at the preconstruction planning and design aspects to reduce risk and hence close holes in their plate. Finally, the client team, concept designers and others who have influence over the industry as a whole can work to reduce risk both at a project and at an industry level'*. The decision to use offsite could be included in the permanent works design thus adding an additional defence to close more holes in this plate (originating influences).

The ConCA model considers factors within the accident episode, the model could be extended to include the ongoing cycle by including a return loop from a systems perspective to allow feedback and learning. The impact of offsite on the ConCA model is discussed in section 2.7.

2.6.7 Distraction theory - Hinze

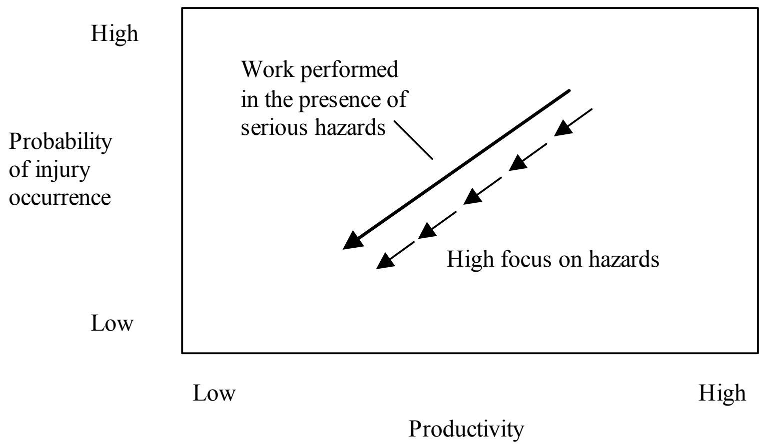
Hinze (1996) suggests three components of the *distraction theory* (Figure 2.12): The first is the probability of injury occurrence and is plotted along the y axis, the second, is a measure of probability of achieving a work task, measured along the x-axis, and referred to as a measure of productivity. The diagram indicates that performance can either be ideal (safe and productive), poor (unsafe and unproductive), productive but not safe, or safe but not productive.

Figure 2.12 Distraction theory (Hinze 1996)



The third component are the mental distractions experienced by workers. Hinze (1996), argues that unsafe physical conditions are dynamic variables where the worker may or may not be influenced by the distraction and the extent to which the worker is influenced may be determined by the extent to which the worker is focused on the distraction. When the worker is aware of the unsafe act, good safety performance will be achieved. If the worker has little regard for the unsafe condition, then that worker is likely to be productive but at an increased risk of accident.

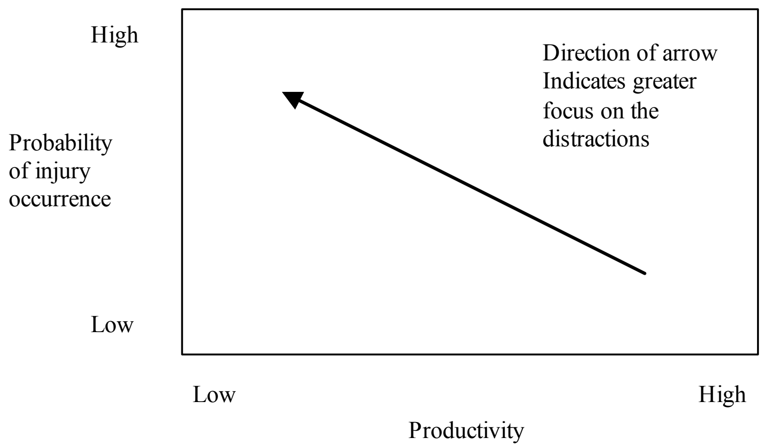
Figure 2.13 Influence of hazards on productivity and safety (Hinze 1996)



The theory where unsafe physical conditions contribute to distractions (Figure 2.13), indicates that in the presence of serious hazards, productivity and safety are not mutually achievable. When serious hazards exist, interventions are employed to reduce the opportunity of an accident, this can have the effect of reducing productivity as the worker devotes more attention to the hazards.

The above relates to situations where distractions occur due to serious hazards. Hinze (1996) also proposes that there are other distractions, such as issues or concerns the worker may bring to the workplace or are as a result of the conditions at work (Figure 2.14).

Figure 2.14 Influence of diversions on productivity and safety (Hinze 1996)

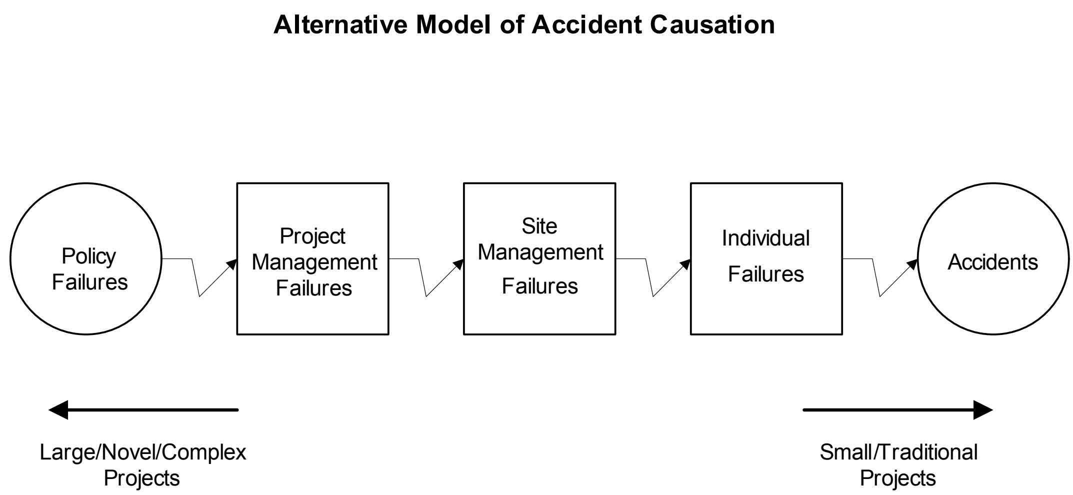


The greater the mental distraction, the more attention will be drawn from the work task and hence productivity will reduce. The attention paid to the distraction will divert attention from the work environment and hence increase the chance of injury. Safety and productivity are jointly compromised by mental diversions, provided the distraction is not related to the physical hazards in the workplace. This theory can assist in relating accident causation to productivity.

2.6.8 Basic model of accident causation – Whittington et al 1992

Whittington et al (1992: iv) describes data from which a model of accident causation was developed. *'A detailed analysis of 30 serious accidents which identified failures at a policy, site and individual level. Interviews with safety managers and company, project and site managers from 24 different construction companies. A postal survey of a further 21 construction companies. Interviews with representatives of a number of major clients'.* The model (Figure 2.15) illustrates how unsafe behaviour can be propagated over the project life-cycle. The starting point of the model is where safety management has been assumed by a main contractor. Whittington et al (1992) assert that poor management decision-making and inadequate management control are major contributors to many construction accidents. The accident causation process is simplified into a sequence of failure initiation, these are termed as individual failures, site management failures, project management failures and policy failures.

Figure 2.15 Basic model of accident causation (Whittington et al 1992)



Whittington et al (1992: 28) describe the four main levels at which failure can occur. *'Failures at level 1 will increase the probability of failures at level 2 and so on.*

1. *at a company policy level – for example, inadequate training policy or poor methods of procurement;*

2. *at a project management level – for example, lack of planning, poor scheduling of work or choice of inappropriate construction methods;*

3. *at a site management level – for example, poor communications, lack of supervision or failure to adequately segregate work;*

4. *at an individual level – for example, use of wrong equipment or failure to comply with an agreed method of work'*.

A number of additional aspects are discussed regarding this approach '*it discriminates between those failures that occur immediately before the accident (so called "active failures" usually committed by those at the sharp end) and those failures that may lie dormant until an active failure subsequently reveals them (so called "latent failures" which are by definition present in the organisation long before the accident happens). Generally speaking, projects which are large, complex or novel are likely to be particularly vulnerable to latent failures occurring at levels 1 and 2 whereas accidents on smaller traditional sites are more likely to result from failures at the site management or individual level*'. In addition, it is indicated that unsafe acts do not always lead to injury, the environment in which the work is performed is often tolerant in repeated risk taking. The model can be useful in the development of connections between management control and the intermediate preconditions for safe performance. It can be used to provide background for investigation into accidents and to suggest routes by which unsafe behaviour can be propagated. It can also be used to develop specific performance indicators which can be used for organisational, project and site audits. This is discussed in section 2.8 where the model is extended to include a feedback loop.

2.6.9 Causal model of accident causation – Suraji et al 2001

The development of a causal model for construction accident causation was proposed by Suraji et al (2001). The conceptual model (Figure 2.16) was intended to provide a practical model of accident causation for construction which included management and organisational aspects of accident causation. *'The model addresses the distal and proximal factors that may generate situations or conditions that increase the risk of accidents'*. In addition *'the objectives of the model are to improve understanding of the accident causation process, assist in the structured investigation of accidents and offer guidance on effective accident prevention measures. The model attempts to represent ways in which all participants in construction projects, from client to site operative could lead to accidents'*. The basic assumption of the model is that all participants operate within a variety of constraints as a result of the project environment or behaviour of project participants. The response to these constraints can cause inappropriate situations or conditions which increase the risk of an accident.

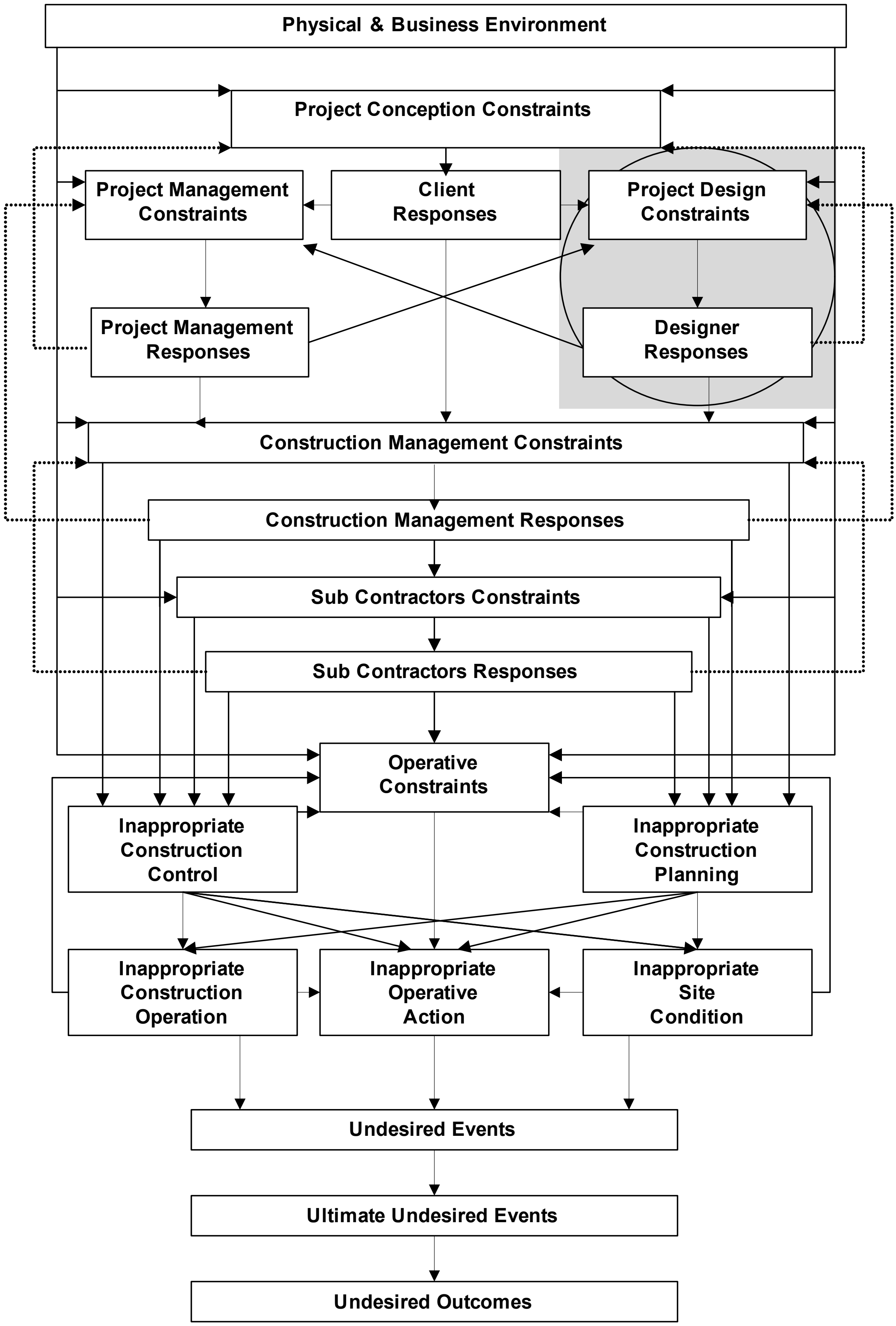
The model discusses two classes of causal factors, proximal and distal. '*Proximal factors are those that can be said to lead directly to accident causation, for example a method of construction which uses a machine in a dangerous manner or disturbs asbestos based materials. Distal factors are those that can, in the event of inappropriate responses by project participants, lead to the introduction of these proximal factors in the construction process, and thus to the increased risk of an accident. These would for example, include cost or time constraints, possibly prompting inadequate or inappropriate resourcing of the construction process (e.g. failure to provide personnel to conduct an asbestos survey)'*.

The model illustrates the interaction between all participants involved in a construction project and their potential to initiate pathogens that are likely to increase the risk of an accident. *'Pathogens may originate from project conception, be transmitted through the project development and design phases, and subsequently result in inappropriate system states during construction operations'*. All participants in the construction project have the potential to give rise to pathogens through the following strategic project decisions; project design, selection of technology, project or construction management and supervisory or production activity.

Suraji et al (2001) states that *'any factor arising during, or impinging on, the development of a project brief is classified as a project conception constraint, Factors influencing architects or engineers during the design phase of the project are classified as project design constraints and factors confronting the client's other project team members, project managers, cost consultants etc., during project implementation are classified as project management constraints'*. In addition, the '*construction management constraints, construction management responses, sub-contractor constraints, sub-contractor responses as well as operative constraints also all have the potential to influence accident occurrence in the construction process'*. The lower half of the model deals with the pattern of accident causation. Suraji et al (2001) describe each element, *'the accident process, i.e. the sequence of Undesired Event (UE), Ultimate Undesired Event (UUE) and Undesired Outcome (UO)'*. The investigation of the causal process then moves to the immediate event area, to deal with proximal factors. *'The Model identifies five types of proximal factor, Inappropriate Construction Planning (ICP), Inappropriate Construction Control (ICC), Inappropriate Site Conditions (ISC), Inappropriate Construction Operation (ICO), and Inappropriate Operative Action (IOA)*. The third area of the model are the distal factors, *'the constraints* *and responses upstream of the immediate event area that create the situations in which the proximal factors are generated'*. The model indicates the influence of the client, the design team, and the project management team, as well as recognizing the specific influence of subcontractors in the construction management process. A point worth noting is that the model is concerned with all construction, and not particularly offsite construction.

The client responses and the project conception constraints, influenced by the physical and business environment will in turn influence the project design constraints which in turn influence the designer responses. In connection with offsite, the decision to use offsite is taken as shown in the shaded grey area in Figure 2.16, i.e., the project design constraints and designer responses. These in turn have an impact on the construction management constraints.

Figure 2.16 Constraint-Response Model of Accident Causation (Suraji et al 2001)



2.6.10 Generic health and safety causation model – Haslam et al 2003

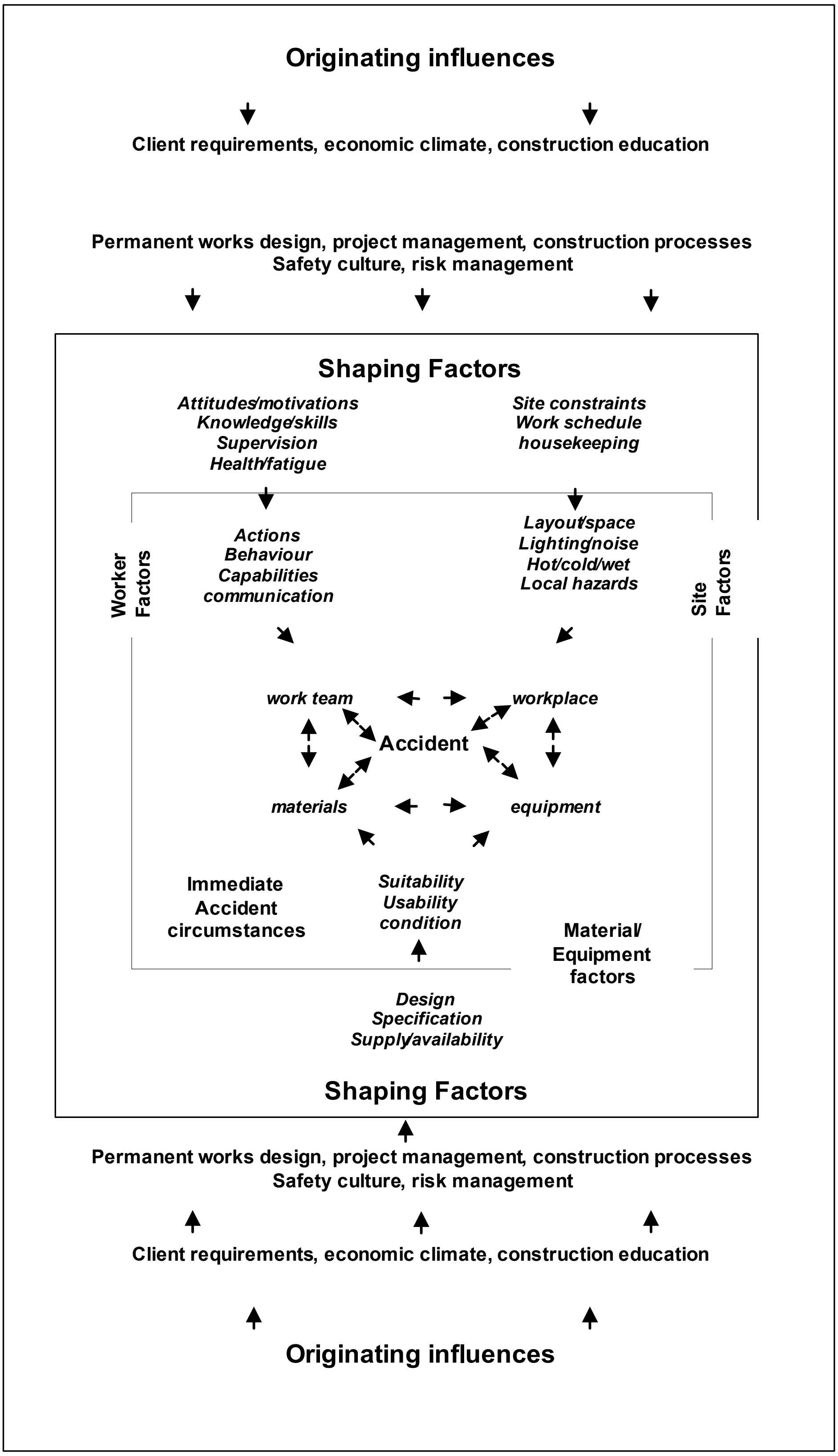
The research project Construction Accident Causality (ConCA) (Haslam et al. 2003), funded by the UK Health and Safety Executive (HSE) used a combination of focus groups and a study of 100 accidents employing an ergonomics systems approach to identify where and why safety is compromised. The aims of the project were to collect data on the factors involved in a large sample of construction accidents, and to describe the process of accident causation, including the contribution of management, project, site and individual factors and to summarise the influences identified which operate to cause construction accidents. The ConCA model indicates the hierarchy of influences in construction accidents (Figure 2.17). The model describes how accidents arise due to a failure in the interaction between the work team, their workplace, and the materials and equipment (including tools and PPE) that they use. Gibb et al. (2006: 46) explain the model,

'These immediate accident circumstances, which relate to the site of the accident or incident, are affected by shaping factors, whereby the actions, behaviour, capabilities and communication of the work team are affected by their attitudes, motivations, knowledge, skills supervision, health and fatigue. The workplace is affected by site constraints, work scheduling and housekeeping. The suitability, usability, condition and, therefore, safety of materials and equipment depend on their design, specification and supply/availability'.

'The shaping factors are subject to originating influences, including the permanent works design, project management, construction processes, safety culture, risk management, client requirements, economic climate and education provision'.

The ConCA detailed study of 100 construction accidents concluded that, in order to obtain a sustained improvement in safety, the construction industry would require effort by all stakeholders throughout the influence hierarchy.

Figure 2.17 ConCA model (Haslam et al 2003)



2.7 Offsite and accident causation

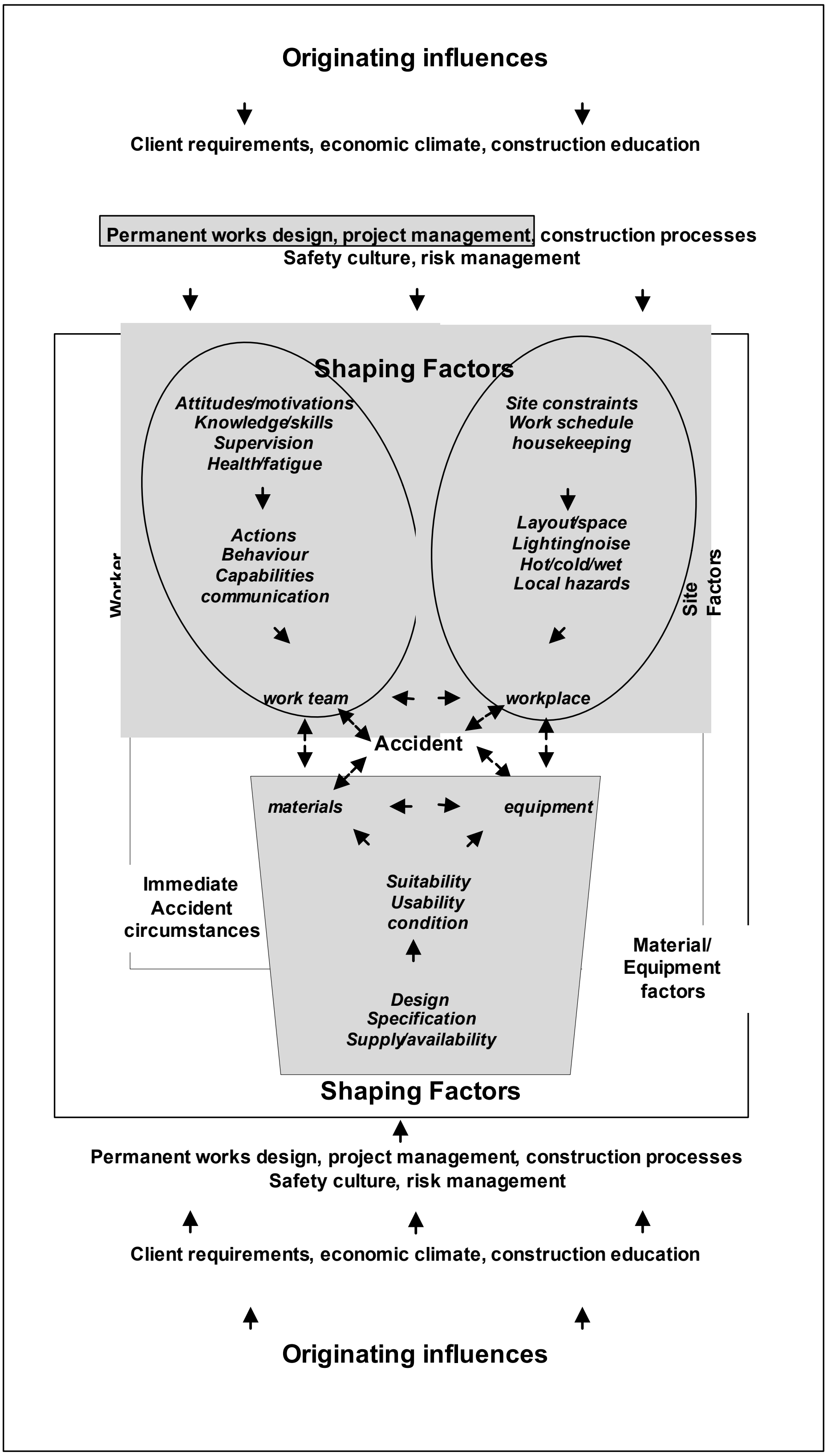
This section considers where offsite fits within these accident causation models. The models discussed are concerned with construction and are not specific to offsite. The decision to use offsite is influenced by design, many of the models presented for example Bird and Germain (1990), Reason (1997) do not include consideration of design and pre-construction. Design does not feature in any of these models as they are concerned mainly with the problems on site, lack of control and personal factors. The models could be extended to include a pre – construction design phase with the opportunity to use offsite.

In addition, they are episodic in nature and need a feedback loop. ConCA models the accident within the episode, it attempts to discover what has happened and offers little to examine what will be done and what was learned from the accident. The models consider the accident and should include an audit process to provide learning from the accident and information prior to the accident from the management process as discussed in section 2.8.

In commenting on the ConCA model with regards to offsite. The decision to use offsite are concerned with the permanent works design and project management. The originating influences, client requirements, economic climate and construction education are what influences the decision to use offsite. The construction processes, safety culture and risk management are significantly affected by offsite as indicated in the shaded grey areas in Figure 2.18.

The changes to the shaping factors are commented as follows. The worker factors will have significantly less workers on site for the offsite solution and therefore less opportunity for accidents. The offsite solution will reduce the amount of work on site. In connection with materials and equipment, materials become the offsite products and components and the equipment become the methods of delivery and craneage (Figure 2.18). This is an important aspect in that the on-site risks are replaced with fewer but higher potential consequence risks as discussed in section 3.6.2.

Figure 2.18 ConCA model (Haslam et al 2003)



2.8 Safety Feedback and learning

The Whittington basic model has been adapted to illustrate a safety audit system (Figure 2.19). This system allows safety feedback loops to aid learning and inform the organisation. The audit system is designed to incorporate feedback from within and outside the organisation. This allows the safety aspects within the organisation to be updated as learning is acquired and allows the integration of new legislation and technical information from outside bodies such as HSE. Whittington et al (1992) describe each level of the audit:

Organisational and policy level

'An audit at this level could be used by clients, contractors or the HSE to assess the potential competence of companies to perform safely. At present companies typically have elaborate policy documents and internal rules and procedures but inadequate management systems for ensuring implementation'.

Project management level

'An audit at this level could be used to identify whether safety commitments had been effectively addressed during planning and early implementation phases of a project. In addition to core safety elements the nature of this audit could differ from project to project depending on the specific demands of the work. It would also serve as a record of the reasons why certain decisions which could have consequences for safety had been made. Results of these audits could be used to compile a project planning database'.

Site management level

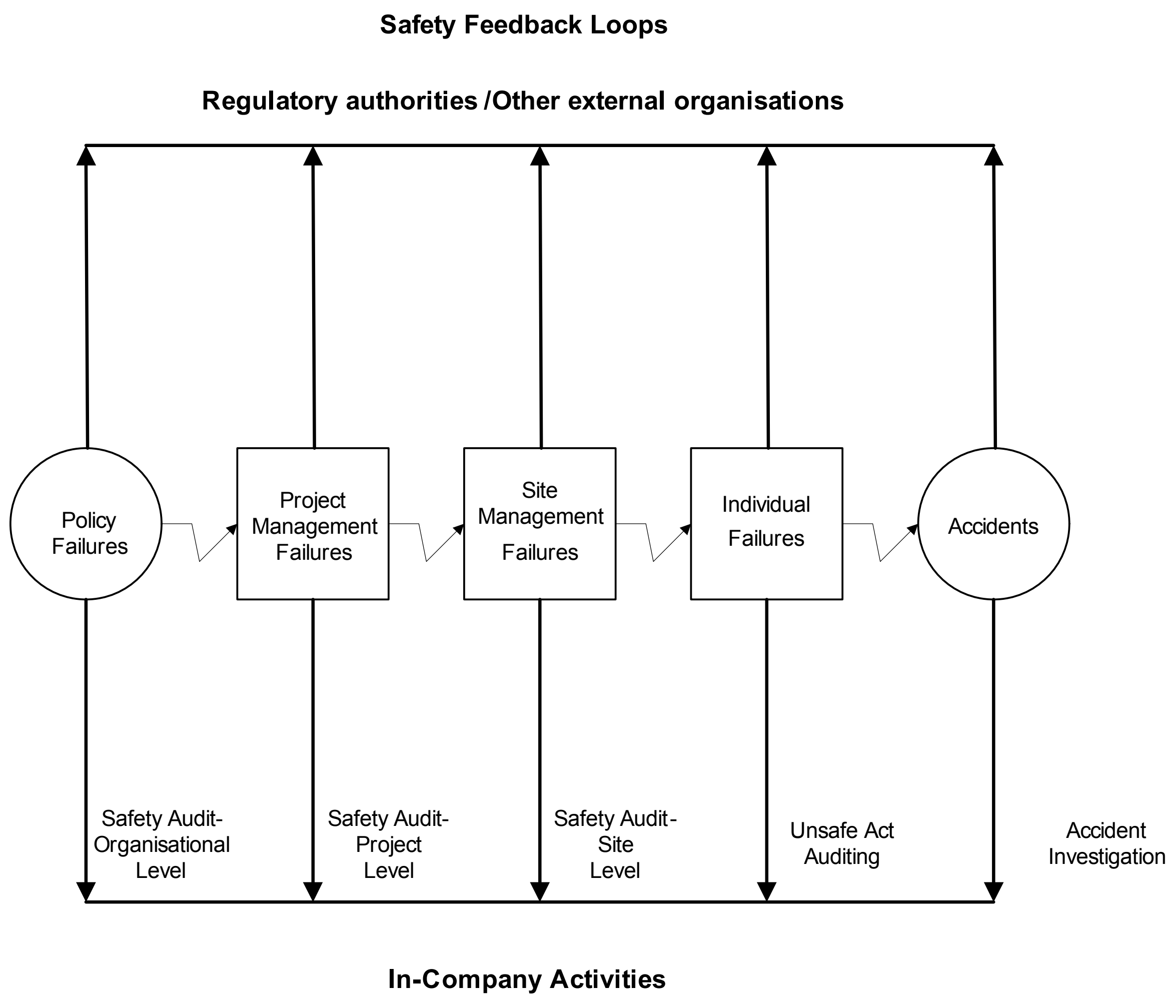
'This audit would examine whether planning decisions had been converted into practice and the extent to which individual safety requirements were being met or were actually appropriate to the conditions on site. Reasons for any deviations would be recorded. Such information would also be used to compile a database to provide feedback at a policy and planning level. A comprehensive system for auditing safety will require an integrated programme of inspections and reviews'.

Unsafe act auditing

'At the level of individual behaviour, unsafe act auditing, although rarely used and resource intensive, can provide feedback on common safety violations. One of its advantages is that it clearly demonstrates on-site commitment to safety although, to be successful, responsibility

for rectifying the causes of the behaviour must be correctly assigned and the results of the process fed back to the workforce'.

Figure 2.19 Safety audit system (Whittington et al 1992)



Petersen (1989: 226), discusses the internally constructed audit that emphasises the interaction with employees using interviews as opposed to simply checking paperwork. The key features of this type of approach are to *'conduct interviews with employees at all levels, inspect the workplace and evaluate incident investigation, reporting and analysis and feedback'*. The importance of the communication process in ensuring an environment for information exchange within the organisation and from outside bodies is highlighted.

2.9 Ergonomic programmes

The research involved the use of ergonomic audit analyses in identifying risks in each of the three case study organisations examined (see section 5.4). This section provides a definition of ergonomics, it explores the use of ergonomic programmes in the literature in connection with improving the health and safety in industrial workplaces. Ergonomics was developed during the Second World War, when technology and the human sciences were systematically applied in a co-ordinated manner. '*An inter-disciplinary approach involving physiologists, psychologists, anthropologists, medical doctors, work scientists and engineers worked together to address the problems of the operation of complex military equipment'* (Dul 2001 :1). The International Ergonomics Association (IEA) defines ergonomics as:

'Ergonomics or (human factors) is the scientific discipline concerned with understanding of the interactions among humans and other elements of a system, and the profession that applies theory, principles, data and methods to design, in order to optimize human well-being and overall system performance' (Dul 2001 :1).

A useful definition is provided by Petersen (1989 :199):

'Ergonomics by its very definition is safety related. While it is not an exact science, it is a rational approach to the problems of designing and constructing things so that the user will be less likely to make errors resulting in accidents. It attempts to make machines more convenient and comfortable, less confusing, less exasperating, and less fatiguing'.

Close attention to the principles of ergonomics, ergonomic design, interface design and anthropometry can have significant benefits in reducing stress in the workforce, thereby promoting greater efficiency and reduced manufacturing losses (Stranks 1990).

There is considerable compelling justification for the use of ergonomic practices in industrial workplaces in the ergonomics literature. A full review of this work is out with the scope of this thesis. Simpson (1990), suggests that the implementation of ergonomics programmes in manufacturing organisations can potentially improve both productivity and safety. The use of ergonomics programmes is well represented in large automotive manufacturing organisations, with specific health improvements. Moore (1994), reports that ergonomics was used in a participatory approach to improve one task in an assembly plant, which resulted in a 29% decrease in the incidence of total musculoskeletal disorders, a 78% decrease in upper extremity disorder incidence and an 82% decrease in lost days.

The *participative* approach is defined as: '*participation is seen as providing the opportunity for real, early and full involvement of the people involved (operators, supervisors, etc.) in the making of decisions about their jobs, systems, workplace and organization'* (Wilson 1991: 69).

The participative approach has several advantages Wilson (1991: 72) states:

- *'solution ownership and therefore commitment;*
- *increased ergonomics awareness for all concerned;*
- *better solution design (from the knowledge of the people closest to the work);*
- *better utilisation of the company's employees; and*
- *reduced undesired side effects at implementation'*.

Wilson (1991: 73) also lists a number of disadvantages:

- *'reduced support if participation is 'half-hearted' (if undertaken solely as a public relations exercise);*
- *poor decision making (especially if the group decision ends up being the 'lowest common denominator');*
- *increased time, and cost, to plan and develop solutions*
- *a poor result if the motivation and knowledge of participants is insufficient for the process;*
- *the risk that other groups may want to be involved in a similar process when it is unfeasible or undesirable for them to do so'*.

However, there is an acknowledged support for the participative approach, Fox (1985) states that '*commitment entails conscious choice'*, support for participative approach to workstations changes. Sell (1980) suggests that an imposed workstation change breaks the psychological contract with the worker about how his job is performed.

The use of participation results in the sharing of knowledge to the participating workforce. Corlett (1991: 418), states that, in order to achieve benefits, '*we must give ergonomics away, transfer our knowledge and methods to others who are close to the places where changes have to be made, so that they do much of the ergonomics for themselves'*.

In order to implement changes in job design, Sell (1980) suggests that a steering group is used to maintain an organisation-wide perspective. In addition he advises the use of working parties and the formation of workforce groups to enable regular communication and the sharing of knowledge. Rose (1995) discusses the use of an employee advisory group in his five step plan for ergonomic implementation.

The use of ergonomic audits, are advised to evaluate the ergonomic situation, prioritise attention and provide a consistent approach. Lovesay (1993) discusses a two stage audit approach which reviews the existing data in an organisation (medical records and absence rates) which point to potential problems and a workplace survey. He suggests three objectives for this survey:

- identify violations of ergonomic principles;
- be useable in field conditions;
- give unambiguous, directive output to alert the user to redesign opportunities.

Weneck, quoted in Vasilash (1994), discusses the importance of ergonomists to provide tools and methods which can be used by a wide variety of people and applied to a wide variety of processes. Naderi and Baggerman (1992) suggest a methodology where a workplace survey forms part of a review of all relevant existing documentation and completion of an ergonomics workplace checklist. The process includes a high, medium or low priority with both high and medium ratings resulting in a full ergonomic task analysis and redesign. Kittusamy et al. (1992) describe a workplace audit which considers a range of factors which may put workers at risk. The use of ergonomic audits is well established in the literature, the actual tools used, and their development is discussed in chapter 4.

2.10 Summary

This chapter has reviewed the health and safety performance of UK construction and discussed the context of health and safety including, the drivers and barriers to performance improvement. The chapter has reviewed the key theories relating to accident causation and the characteristics of accidents. The type of accidents have changed little over the years with falls accounting for almost half of all fatalities. This has achieved the first objective (1.3.2). A discussion of the ergonomic programmes used in industrial workplace have provided a background to the presentation of the development of the ergonomic tools (see section 4.5). The next chapter looks at offsite: its terms, the drivers and barriers to the use of offsite and a review of the extent and affect of offsite on occupational health and safety in the literature, thus providing a basis for achieving the second research objective (1.3.2).

3 DEFINITIONS AND THE EFFECT OF OFFSITE ON HEALTH AND SAFETY

3.1 Introduction

The previous chapter explored health and safety in UK construction, the key models of accident causality and reviewed ergonomic programmes. This chapter provides a definition of offsite, a review of the numerous terminologies relating to offsite in the literature is explored including the advent of the term modern methods of construction (MMC). The history of offsite in the UK is discussed and the categorisation and taxonomy of offsite is presented. The chapter then reviews the nature and extent of the effect of offsite on health and safety in the construction industry in the literature, in particular the need to investigate the effect of offsite on occupational health and safety. The gap in knowledge is revealed, in that a paucity of knowledge relates to the actual effect of offsite on occupational health and safety in the offsite factory. The chapter also discusses the use of automation and tele-operated equipment for the installation of offsite elements. Furthermore, the extent of integrated construction systems is examined, i.e. bringing the factory to the construction site and manufacturing for construction is reviewed This provides a contextual background and a basis for understanding for the thesis.

3.2 Definitions: Offsite and Related Terms

Offsite construction or offsite technology embraces a range of modern construction techniques. A number of terminologies are in use such as: prefabrication; pre-assembly, industrialised building; system building; offsite manufacturing; offsite fabrication; offsite production and modern methods of construction. These terminologies of the concept of offsite have developed over the years. A review of the literature provides a useful background which clarifies the concept of offsite for the thesis. Ministry of Works (1944), defines prefabrication as *'the production under factory conditions of components that may be used in building, and of the pre-assembly of such components into complete units of a building*'. White (1965), provides a more practical definition: '*a continuing trend, with many fluctuations, to manufacture always more of a building under a factory roof, be it only a temporary factory at or near the site*'. Tatum et al. (1986), quoted in Gibb (1999 :1), provides a clear definition of prefabrication as: '*a manufacturing process, generally taking place at a specialised facility, in which various materials are joined to form a component part of the final installation'*. A further succinct definition of pre-assembly is *'a process by which various materials, prefabricated components and/or equipment are joined together at* *a remote location for subsequent installation as a sub-unit. It is generally focused on a system*'.

Groak et al. (1997) define standardisation as '*the extensive use of components, methods or processes in which there is regularity, repetition and a background of successful practice*'. The term industrialised building is much less used in the UK but is more common internationally (Goodier and Gibb 2005a).

System building, sometimes called building system is any pre-engineered method of building that has a predefined scope and configuration limits. Building systems can be volumetric (see section 3.3), panel, stick build or hybrid (Goodier and Gibb 2005a).

Offsite manufacturing, offsite fabrication, offsite construction and offsite production - these terms relate to that part of the construction process that is carried out away from the building site, usually in a factory. It may often refer to specially created temporary production facilities close to the construction site (Goodier and Gibb 2005a). More fully, the concept '*requires a project strategy that will change the orientation of the project process from construction to manufacture and installation*'. Thus the process includes the design and manufacture of units or modules and a change in construction strategy (Gibb 1999 :2). The next section presents construction as a manufacturing process.

3.2.1 Construction as a manufacturing process

Manufacturing for construction has been considered in the past. Gann (1996 :438), states that *'ever since Henry Ford developed the standard production line for car manufacture, leading European and North American architects, builders and manufacturers have been seduced by the idea of producing houses in factories. Many attempts have been made to transfer knowledge from mass-production of automobiles and other consumer products to low-cost housing production. The long history of attempts at technology transfer make for rich comparative material on which to base our analysis of learning between industries*'. There are important differences between traditional manufactured products and manufactured buildings or construction products. *'In comparison with many products, housing is large and usually immobile; there is a higher degree of complexity in the number and range of component parts; its production on site introduces varying degrees of uniqueness; and housing must be more durable and is often more expensive than manufactured goods*' (Gann 1996 :438). The size and immobile nature of housing and construction products often result in the products being assembled at the place where they will be used, an important distinction between other manufactured products. The nature of housing and construction dictates to a certain extent activities, such that the use of labour, machinery and the supply and transportation of parts must be viewed differently than traditional manufacturing. The large number of complex components coupled with the range of interconnections between each component and sub-assembly, has been seen to inhibit innovation and the use of mechanized production processes (Gann 1996 :438). McCutcheon (1975) quoted in Gann (1996 :438) states that, '*the risk of failure – as experienced in some of the systems used in 1960s high-rise housing in Britain helps to perpetuate conservatism in design and construction*'. The need for long term durable products such as houses create difficulties in testing materials, components and production methods. The cost involved in research and development may create barriers to innovation (Gann 1996 :438). However, the use of manufacturing techniques for construction particularly housing has been used in the past as discussed in section 3.3. The next section defines modern methods of construction, and clarifies its relationship with offsite

3.2.2 Modern Methods of Construction (MMC)

The UK Government through initiatives such as the Sustainable Plan ODPM (2003), and the Barker Review (Barker 33 Cross Industry Group, 2006), triggered the term Modern Methods of Construction (MMC). MMC typically involves the manufacture of house parts offsite in a specially designed factory, though it can also include innovative site-based methods. According to Barker et al, (2006) two main products of MMC are panels and modules, which include ready made walls, floors and roofs. These are transported to the site and assembled quickly, often within a day. Some panels have wiring and plumbing already inside them, making construction even faster. Modules are ready made "rooms", which can be pieced together to make a whole house or flat but are used most frequently for bathrooms or kitchens (also known as pods), where all the fittings are added in the factory (POST 2003).

Barker 33 Cross Industry Group (2006: 5), defines MMC as '*Modern methods of construction are about better products and processes. They aim to improve business efficiency, quality, customer satisfaction, environmental performance, sustainability and the predictability of delivery timescales. MMC is, therefore, more broadly based than a particular focus on product. It engages people and in particular process to seek improvement in the delivery and performance of construction*'.

An important distinction between offsite and MMC is that all offsite may be regarded as a sub-set of MMC but not all MMC may be regarded as offsite, e.g. thin jointed blockwork and "Tunnel Form" see (Lusby-Taylor et al. 2004, Goodier and Gibb 2005a). The next section reviews the historical development of offsite in the UK.

3.3 The History and Development of Offsite

Gibb (1999 :9-14), provides a useful commentary on the development of offsite, where, '*off-site fabrication has developed in response to a number of external factors such as:*

- *sporadic urgent demand for buildings or facilities e.g. British colonialisation and the subsequent need for rapid European-style housing;*
- *changes in business practice causing rapid commercial development in London in the late 1980s;*
- *rapid response to natural disasters such as earthquakes;*
- *the industrial revolution in the developed world changing both the manufacturing capabilities and public perception of the desirability of industrialised products;*
- *changing fashion where a prefabricated appearance is alternately either desirable or to be avoided;*
- *advances in technology in other sectors combined with a desire for technology transfer;*
- *increase in labour costs driving the desire to optimise labour utilisation and productivity;*
- *decrease of available skilled labour at the worksite driving the need for a stable skilled workforce at the manufacturing facility;*
- *changing client expectation e.g. a desire for more predictability in project outcomes;*
- *development of digitally controlled manufacturing facilities and high-powered computer-aided design systems giving more flexibility to manufacturers;*
- *increased concern for health and safety of workers driving the desire to reduce more hazardous on-site work*'.

A complete history of offsite is beyond the scope of this thesis and will not be covered here. This section summarises key developments in offsite using healthcare and housing as examples from early Roman times up until 2008, this provides a useful historical background for the thesis.

3.3.1 Early Offsite/Prefabrication

Evidence of prefabrication can be traced back to the iron age, with the use of timber crucks for barns (Hill 2005). In the UK, the Roman Army used prefabrication at a 600 bed hospital at Inchtuthil, Dunkeld, Perth and Kinross, Scotland between AD 83 and 86 (Gibb 1999 :10). Moving on to the nineteenth century, in 1827 and 1829 a small group of British settlers which had gone to settle on the banks of the Swan River in West Australia produced a pamphlet directed towards prospective migrants advising them to bring packed houses, these houses were of various sizes and could be erected in a few hours (Herbert 1978). During the Crimean War, timber huts and houses were used to relieve acute shortages of hospital provision (Gibb 1999 :10). During the American Civil War flatpack hospitals were used, the largest of which was the Confederate Army's Chimborazo Hospital for 7,000 patients (Bender 1993).

3.3.2 1880s -1945

Hospitals made from prefabricated elements for speed of erection and dismantling were employed to provide a response to a rise of smallpox and scarlet fever in London in 1880 (Taylor 1991). The hospitals '*were prepared by the Metropolitan Asylums Board, from the comprehensive standardised product range of the manufacturers and suppliers of prefabricated iron structures*' (Gibb 1999 :12). The first half of the twentieth century saw industrialised building in the form of a standardised expandable and prefabricated sanatorium design to counter the spread of tuberculosis (Gibb 1999). In addition, after the First World War, there was an acute need for houses, as a result of labour and material shortages at this time, the UK Government used new construction methods. 50,000 system-built houses were constructed between 1919 and 1939. The systems were of timber frame, concrete/frame/slab and insitu wall slab (Marshall et al. 1998). At the start of the Second World War, the use of prefabricated accommodation in the form of Nissen[2] huts were employed as temporary hospital wards (Gibb 1999).

3.3.3 1945-1990

Similarly at the end of World War Two, there was an acute shortage of labour and materials, to replace damaged accommodation and to meet the demand for new houses. During the

[2] The **Nissen hut** was invented and built as housing for troops in WW1, The Great War. Due to its semicircular, corrugated iron shape the Nissen Hut deflected shrapnel and bomb blast making it a perfect bomb shelter (McCosh 1997).

period 1945-1955 approximately 500,000 houses were system-built in the UK (Marshall et al. 1998). Many different systems were used including steel frames, pre-cast concrete and cast insitu concrete walls (Marshall et al. 1998). These industrialised house building techniques were not generally employed for large public buildings such as hospital construction. Offsite use in hospitals, was generally restricted to pre-cast concrete components for example, insitu concrete structural frames clad with external precast concrete panels (Gibb 1999). Throughout the 50s 60s and 70s major inner city redevelopment took place in the UK. This was typified by high rise construction for housing accommodation, using industrialised building techniques. (Marshall et al. 1998) states that 500,000 low/medium rise and 140,000 high rise accommodation units were built. The collapse at Ronan Point[3], created considerable public concern regarding non-traditional building (Housing Forum 2002) and in the 70s industrialised building fell out of favour (Marshall et al. 1998).

3.3.3.1 Manufactured housing in Europe and North America

The method of transferring knowledge between industries in order to improve construction performance is not new. Gann (1996 :439) defines manufacturing as, '*manufacturing, the system of production involving the concentration of materials, fixed capital and labour in more than one or more plants, had long been perceived to demonstrate efficiency over scattered craft production in traditional housebuilding. Manufacturing provided three main advantages over craft:*

- *economies of scale, when the cost per unit drops more quickly than production costs rise as the volume of materials being processed increases;*
- *technical possibilities to develop and deploy capital equipment, and*
- *the opportunity for tighter managerial control'*.

Crowley (1998 :389) discusses a useful definition which distinguishes most peoples idea of manufacturing as mass-production; i.e. high volume production on an assembly line of relatively simple, standardized, self-contained products. A more appropriate definition is provided by Chryssolouris (1992): '…*the process of transforming materials and information into goods for the satisfaction of human needs'*.

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[3] **Ronan Point** was a 23-storey tower block in Newham, East London, which suffered a fatal partial collapse due to a natural gas explosion on 16 May 1968 (Griffiths 1968).

Mass production was first exploited by Henry Ford, using scientific management and the mass-production line which allowed volume production of standardized products made from interchangeable parts (Gann 1996 :438). A summary of the main points of the mass-production line is discussed by Womack et al. (1990 :26-47):

- complete and consistent interchange ability of parts and the simplicity of attaching them to one another;
- the same gauging system used throughout the manufacturing process, driven by savings on assembly costs;
- subdivision of labour, employing unskilled or semi-skilled workers on high cost, dedicated machinery;
- design and management by narrowly skilled professionals;
- buffers, such as extra supplies of materials and labour, to ensure smooth production;
- production kept standard designs in production as long as possible as changing machinery to produce new products was expensive.

This approach to manufacturing was considered for the construction of housing in the early part of the 20th century. Gann (1996 :439) discusses the desire of the leading architects of the time to use manufacturing techniques to mechanize construction. '*In the first half of the 20th century influential architects such as Le Corbusier, Walter Gropius, Bemis, and Buckminster Fuller believed fervently in the idea of mechanization and industrialisation of construction. Their stated aim was to raise efficiency by rationalizing the process through the application of scientific methods. Buckminster Fuller argued that the production of buildings should be carried out in similar ways to that of cars and other volumetric-produced goods. In criticising the inadequacies of craft production he argued that each house was treated as a pilot model for a design that never had any runs*'. In addition, Le Corbusier produced the "Dom-ino House" in 1914, ' with its simple, standardized, slender frame, slab floors, flexible floor layout independent of structure, lightweight movable internal walls, and external non-load bearing cladding' (Gann 1996 :439). These ideas were the forerunners to the methods of construction which influenced design into the 1960s and the evolution of "systems building" (see section 3.2).

The development of industrialised housing was assisted by manufacturers who promoted new products and components. In addition, contractors used prefabricated and standardized parts for reasons of economy, labour reduction and to reduce construction time, '*contractors* *realized that prefabrication of standardized parts could cheapen components, reduce on-site labour requirements and speed up the construction process, and at the same time potentially provide the buyer with a higher-quality product because factory tolerances were tighter than those achievable on site*' (Gann 1996: 439).

3.3.4 1990-2009

The advent for more cost effective construction where more of the funding for major projects is raised from the private sector through vehicles such as the Private Finance Initiative has led to renewed interest in the use of offsite techniques. Offsite techniques are used in many large hospitals for structural frames, cladding, plant rooms and operating theatres (Gibb 1999). The publication of the 'Rethinking Construction' report (Egan 1998), which called for efficiency and quality improvements in construction and to make the industry more responsive to customer needs has encouraged an increase in using manufacturing techniques. A recent report by (Goodier and Gibb 2005b) quoted the market value of offsite to be worth £2.2billion in 2004, which at the time of publication was 2.1% of the total value of the UK construction sector, including new build, refurbishment and repair, and civil engineering. This section has provided a useful historical background to the development of offsite in the UK. The next section explores research into the predicted growth of offsite.

3.3.5 The Future growth of Offsite

A number of assessments of the likely growth in the offsite market range from steady growth (Mintel, 2004) to 9.7% growth per annum until 2010 (Goodier and Gibb 2005b) to a radical market aspiration of a ten-fold increase in the uptake of offsite (BuildOffsite, 2006) by 2020. There is ongoing debate as to which sector the aspirational targets for growth apply to (i.e. volumetric and modular or mature non-volumetric). Anecdotal evidence collected by Loughborough University and Buildoffsite suggests the following growth patterns (Figure 3.1).

Figure 3.1 Indicative possible growth projections for offsite (Gibb 2006)

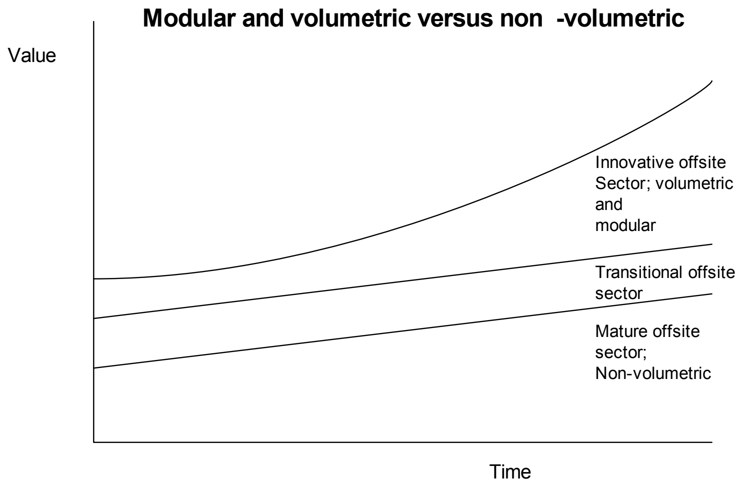

Figure 3.1 provides indicative predictions of the value growth of modular and volumetric versus non-volumetric offsite over time. The graph projects that the modular and volumetric sector, which it may be argued experiences product innovation, has the greatest potential for growth, there is a transitional sector which acknowledges the difficulty in the demarcation between what is considered innovative and what is considered mature. For example, innovative panellised systems, within the non-volumetric sector. In the non-volumetric sector, the graph indicates that the growth will be relatively slow, this sector is a mature technology e.g., pre-cast concrete units, with an established market (BuildOffsite 2006).

The next section reviews the taxonomy of offsite. A review of the drivers and barriers of offsite is presented, which provides a contextual background for a review of the previous research into the effect of offsite on occupational health and safety as discussed in section 3.6.

3.4 The Taxonomy of Offsite

This section provides a description of the taxonomies of offsite technologies as discussed in the literature. (White 1965, Kelly 1951) present a taxonomy of prefabrication ranging from pre-cutting, panel fabrication, box sections and complete manufactured units. (Gibb 1999 :7-8) provides a useful taxonomy (see table 3.1) where four levels of offsite range from fundamental base materials, non-volumetric pre-assembly, volumetric pre-assembly through to complete modular buildings.

Table 3.1 Taxonomies of offsite and definitions (Gibb 1999)

Level	Description	Definition
Level 0	Base material	Basic materials with no pre-assembly
Level 1	Component sub-assembly	Relatively small scale items that are invariably assembled offsite – not really part of the true offsite spectrum. e.g. light fittings, windows, door furniture.
Level 2	Non-volumetric pre-assembly	A large category covering items where the designer has chosen to assemble in a factory prior to installation. Units do not enclose usable space. Applications may be skeletal, planar or complex. e.g. cladding panels; above ceiling service modules.
Level 3	Volumetric pre-assembly	Units that enclose usable space and are then installed within or onto a building or structure. Typically fully finished internally. e.g. toilet/bathroom pods; plantrooms.
Level 4	Modular 'whole building'	A colloquial term commonly used to describe units that enclose usable space and actually form part of the completed building or structure. Typically fully factory finished internally (and possibly also externally). e.g. edge of town or restaurant facilities, multi – residence housing.

In addition, Gibb and Pendlebury (2006) proposed a delineated system to indicate the extent of offsite completion within each category. A points system is presented as follows:

★ One star – no significant internal or external finishes applied in the factory

★★ Two stars – either internal or external finishes applied in the factory

★★★ Three stars – both internal and external finishes applied in the factory

There are also "hybrid systems", these are a combination of volumetric pre-assembly and non-volumetric pre-assembly. Housing Forum (2002), state that '*offsite manufacture is typified by two – volumetric and panellised construction – which involve the factory production of three-dimensional units and two-dimensional components respectively,* *transported to site for assembly into dwellings. These two basic forms of construction are sometimes combined into hybrid systems (often referred to as "semi-volumetric")*'.

Venables et al. (2004), describe a variety of offsite manufactured (OSM) products that they considered in their research which include volumetric systems, open panel systems, closed panel systems, hybrid systems, sub-assemblies and components. Birckbeck and Scoones (2005), provide a comprehensive taxonomy of offsite including both primary construction form and offsite methodology used, in addition to the type of material used. The categorisation is in agreement with the above taxonomies.

In this thesis the term offsite relates to the whole process including strategy, design, manufacture of offsite assemblies/units remote from the place of final installation and the installation of these assemblies/units. The offsite technologies include components, non-volumetric units, volumetric units and modular buildings as described by (Gibb 1999 :7-8).

3.5 The Drivers for and Barriers to Offsite

This section reviews the drivers for and barriers to the use of offsite technologies. The literature review provides a series of key issues which are important in understanding those factors which drive, and those which inhibit the take up of offsite. This provides additional contextual understanding of the nature of offsite for the thesis.

3.5.1 Drivers

3.5.1.1 Offsite and the reduction of health and safety risks

Groak et al. (1997), discuss the contribution that offsite can make in creating a safer an healthier work environment. This is important given the accident rate for construction compared to manufacturing as discussed in section 2.2.1. The use of offsite, in a controlled factory environment can assist in the reduction of accidents on site (POST 2003). In addition, the advent of more health and safety legislation will have cost implications in the future (SCRI 2004). However, the effect of offsite on occupational health and safety remains unclear (see section 3.6).

3.5.1.2 Skills shortages

Construction in the UK experienced a reduction in craft skills coupled with an ageing number of people in most of the construction trades which were not being replaced by new recruits (Edge et al. 2002). The second report of the Housing Forum MMC group - UK capacity in offsite manufacturing Venables et al. (2004), investigated the UK's offsite industry in relation to the supply of offsite components for housing. The report focused on two main areas: producer and capacity issues, and labour supply and skills. It is suggested that an increase in offsite may form part of a solution to the problem of the shortage of skilled labour. There was a great deal of commentary from both practitioners and researchers on the factors and circumstances that were contributing to shape the construction labour market skills crisis during the early part of the decade. Mackenzie et al. (2000) identified factors such as; demographic decline in the number of entrants to the labour market; changes to its inherent features and the decline in operative skills; the emergence of new technologies; the increase in self-employment, the use of labour-only sub-contractors; and fragmentation of the industry. The construction industry experienced difficulties in fulfilling its skills requirements, which was due principally to; competition from other industries, reduced training throughput; and the gap in the workforce from low levels of recruitment as a result of the acute recession of the early 1990s (CITB 2002). Dainty et al. (2005) comments on significant shaping factors contributing to skills shortages among SMEs. These include a labour market characterized by informality and flexibility, with contractors paying little attention to the availability of skills during construction planning (Uwakweh and Maloney 1991).

The skills problems may be offset to some extent by technological change, and particularly developments in offsite construction. Offsite construction has been identified as one of the most important innovations to improve the performance across all the sectors of the construction industry. This is supported by a number of the UK Government's reports (e.g. Egan 1998, Egan 2002, Latham 1994). More recently, the Barker Review, (Barker 2003) identified an impending shortfall in housing in the UK with a requirement to implement Modern Methods of Construction (POST 2003). The next section considers the future proofing of buildings as a driver for the use of offsite.

3.5.1.3 Future proofing of buildings

The increase in the demand for more energy efficient buildings, the incorporation of information and communication technologies (ICTs) and the drive for structural integrity as determined by the amendments to the building regulations require modern buildings to be future proof (POST 2003). Offsite has been identified as helping to meet these regulations, in particular with regard to the need for increased energy efficiency (Energy Saving Trust 2005). The preceding sections have emphasised a selected number of the factors that have been identified as driving the take up of offsite, the next section reviews those factors that are inhibiting offsite use in the UK construction industry.

3.5.2 Barriers

There are a number of barriers to the widespread adoption and implementation of offsite. This section presents an overview of the main issues that emerged from the literature review.

3.5.2.1 Perception of prefabrication

The literature reveals some negative attitudes towards prefabrication (POST 2003). There still persists the image of the "prefab" which retains connotations of poor build quality, inferior materials and workmanship (Edge et al. 2002). In addition, in the financial services sector, mortgage lenders, building insurers and building warranty providers require convincing that offsite construction has the same financial risk as traditional build (Housing Forum 2002, Barker 2003). Research undertaken by Venables et al. (2004), found that suppliers believe market demand and production capacity as the two main contributory factors that are inhibiting the use of offsite. Perceptions among developers regarding offsite was highlighted by Lusby-Taylor et al. (2004), where the developers believed that customers may not want houses which incorporate offsite technologies.

3.5.2.2 Measurement of cost and value of offsite – need for education

The use of cost analysis techniques that consider individual elements may result in problems and do not take into account the complex nature of construction methods (Groák 1992). Gibb (2001: 312) states that, *'This is particularly the case for S&P, where many of the benefits are realized elsewhere in the construction process (e.g. reduced site labour and associated costs). Taking an elemental view by considering the building element in isolation, it is not surprising that pre-assembled units may appear more expensive. For example, the overheads and set-up costs of the factory must be covered, whereas for site works the equivalent costs are often "lost" in the principal contractor's preliminaries'*.

The use of offsite methods can utilise economies of scale and the associated reduction in costs. Groák (1992: 135), indicates that, *'the realities of manufacturing production for established systems were that the manufacturer had to wait on orders via the general contractors. Supposed economies of scale were rarely realized, although better prices through bulk buying were achieved.'* In addition, Gibb (2001: 312) states that, '*furthermore, in line with a free market economy, many manufacturers and suppliers seek the maximum price that the market will sustain'*. Thus the actual tender prices may not reflect the actual costs, and therefore make a comparison with traditional construction processes difficult.

The measurement of offsite can be assisted by using some of the available tools that have been developed. IMMPREST (see www.immprest.com), provides a value based assessment for standardisation and pre-assembly (Pasquire et al. 2007).

3.5.2.3 The Existing Culture in Construction

The high capital costs required for the investment of offsite manufacturing facilities, such as factories, plant and alternative construction methods coupled with the industry's risk-averse attitude has inhibited the take-up of offsite techniques (Barker 2003). In addition the Barker 33 Cross Industry Group (2006) suggested that because building regulations change frequently and that different sections within the regulations compete with one another this can inhibit the case for the investment required in new construction techniques such as offsite.

3.5.2.4 Offsite constraints: Site, Process and Procurement

Research undertaken by Gibb and Pendlebury (2005) discussed the constraints in using offsite. The toolkit developed, contains a list of those potential project constraints in relation to site, process and procurement. A further Loughborough University research study by Blismas et al. (2005) revealed, through a questionnaire survey of industry stakeholders, that the main constraints at the project level to the use of offsite production (OSP) were process, value, supply chain and knowledge. An important finding from this study was that offsite research '*has largely concentrated on project-level issues. Insufficient attention has been devoted to adequately exploring the wider economic, social and environmental issues surrounding OSP*[4]' (Blismas et al. 2005: 161). The study concluded that the toolkit developed provided some assistance in bridging the knowledge gap, but there are more deeper issues constraining the use of offsite in construction. The body of knowledge needs expanding, including the identification of the effect of offsite on occupational health and safety, '*the benefits of OSP cannot be realized until a more holistic view of the factors affecting its use is taken'* (Blismas et al. 2005 : 161). The preceding sections have reviewed selected drivers and barriers to offsite. The next section reviews in more detail offsite and safety and health.

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[4] OSP = offsite production, more generally termed offsite.

3.6 The Effect of Offsite on Occupational Health and Safety

This section reviews the effect of offsite on occupational health and safety in the literature. The context of the main safety and health performance improvements using offsite is discussed. This is followed by a review of previous research in connection with offsite and safety and health in the literature. The gap in knowledge is identified indicating that there is a paucity of knowledge relating to the actual effect of the nature and extent of offsite on occupational safety and health thus indicating the need for this work. A review of techniques which replace operatives on site by machines are presented, including automation, integrated construction and manufacturing for construction.

3.6.1 The context of safety and health and offsite

The literature suggests that Gibb (1999) and Court et al (2009), seem to be the main research source in relation to offsite and health and safety. Gibb (1999 : 44), discussed the safety and health aspects of offsite. '*construction sites, even well managed ones, are hazardous. Off-site fabrication reduces the amount of work that is done on-site and therefore reduces exposure to hazards. In many cases off-site fabrication will reduce, or completely remove, the need for on-site work at height, which is an operation that is particularly hazardous. Furthermore, off-site fabrication tends towards a more thought-through approach to construction management, in that deliveries and installation need to be planned in advance in order for them to work at all'*. The reduction in on-site hours, site labour and the elimination of certain hazards, such as working at height are examples of enhanced safety performance using offsite techniques.

It has been claimed that '*there is a tendency in traditional construction for certain operations to be left to "look after themselves". The increased planning involved in off-site fabrication provides opportunity for appropriate risk assessments to be completed. Increased management input usually associated with the installation of off-site fabricated units also mean that agreed method statements are more likely to be adhered to. These factors should lead to a reduction in the risk to health and safety from installation activities'* (Gibb 1999 :44). The use of offsite techniques imposes a management discipline which assists in improving health and safety.

UK legislation in connection with health and safety and the demolition of buildings, is an important area where offsite plays a unique role '*the UK's health and safety legislation (Construction [Design and Management] Regulations) with regard to the possible future demolition of the building. This would be facilitated by being able to dismantle the services in their original modular form'* (Gibb 1999 :101).

In the factory, the health benefits for the operatives can be controlled. Gibb (1999 : 44) states that, '*The factory environment enables responsible manufacturers to make appropriate provision for the health and safety of their workforce. The onus on site construction employers is just as great, but their task is more demanding because under site conditions it is far harder to eliminate the hazards or control risks'*. The factory environment lends itself to the assembly, operation and manipulation of work at a convenient height and orientation with easy access and readily available craneage. The increased control of certain hazardous on-site tasks such as "hot" working, e.g. welding reduces fire risk during construction when completed in the factory. In addition, '*established fabrication facilities generally have a core of permanent experienced workers very familiar with production and quality procedures. Also, work at off-site facilities is usually carried out in partially or fully covered structures, which means that inclement weather conditions do not have as great an influence on productivity as they do on-site'* (Gibb 1999 :146). Thus, the transient nature of traditional construction operatives and the influence of the weather can be eliminated.

An offsite strategy often enables the project team to organise the whole project to minimise risk and maximise efficiency. In order to achieve the health and safety benefits from offsite (Gibb 1999 :226) proposes that '*it is essential that a project-wide strategy be developed at an early stage. Off-site fabrication must be considered from an overall project perspective rather than on an element by element basis'*. The main health and safety benefits from the use of an offsite strategy are Gibb (1999 :226-227):

- reduced on-site duration, by moving work offsite;
- reduced disruption to other site works or adjacent operations; by shorter and better organised on-site installation works; this is particularly important for work within existing buildings or facilities;
- increased overall labour productivity; by exploiting the benefits of a factory environment;
- efficiency savings elsewhere in the project process, which brings forward construction and manufacturing input into the design process;
- improved environmental impact, better control in factory environment, less on site waste, less noise.

In addition Gibb (1999 :172), discusses the advantages of just-in time deliveries and reduced site storage, '*applications of principles such as just-in-time where units are manufactured* *and held remote from the construction site itself and delivered only when needed, means that fewer components are stored on site. Consequently, sites are kept tidier and safer, waste and theft of materials from site are reduced and the construction schedule can progress as smoothly and efficiently as possible'*. An offsite strategy assists in reducing safety hazards through better control in a factory environment and improved organisation of on-site operations. The next section looks at previous research into the effect of offsite on occupational safety and health.

3.6.2 Recent research relating offsite to safety and health

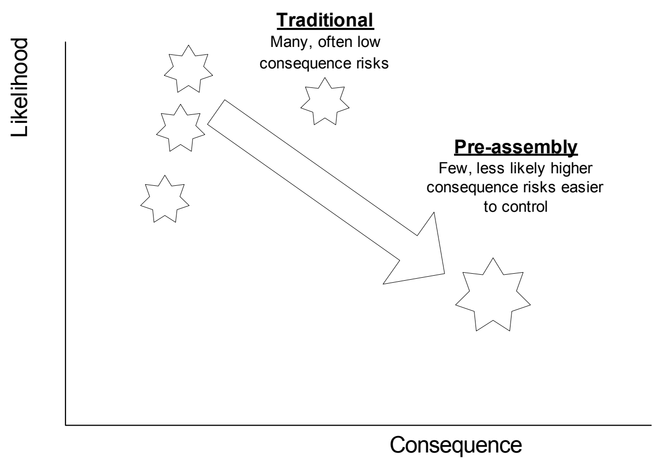
Previous research has discussed the benefits of offsite, and has indicated that health and safety aspects have been stated by respondents as an important driver for using offsite. Court et al (2009) state that *'a combination of countermeasures have been developed and incorporated into a wider construction system, in the same way that manufacturing has used this strategy with great success'*. In addition, *'use of an innovative method for assembling, transporting, and installing mechanical and electrical modules, whereby modularisation can be achieved with or without offsite manufacturing capability'*. The study claims that *'The research forecasts a reduction of onsite labour of 35% compared to using traditional methods of construction, with less onsite operatives at risk of injury carrying out simpler assembly tasks within ergonomic mobile work cells'*.

Gibb (2001 :313), states that '*interviewees considered that safety and productivity performance should improve as offsite and on-site personnel become more familiar with the materials and components. The fact that they are tried and tested was believed to control risk and increase reliability, both during the construction phase and throughout the life of the building or facility: the building should perform reliably, be more easily maintained and require fewer spare parts'*. An important benefit of offsite manufacturing is that the environment is more predictable and can be controlled. Gibb (2001 :313), states *'because pre-assembly brought the construction site into the factory where the environment was more controllable, safety, productivity and quality could all be improved*'. However, the problem of effective measurement of the health and safety benefit remains problematic. In addition the health and safety benefit will only be realised if the traditional construction techniques are not just transferred to the factory, but are altered to reflect production manufacturing techniques and culture (Gibb 2001 :313). Thus there is a gap in knowledge in relation to the effect of offsite on occupational safety and health in the factory.

Gibb (2001 :313) also considers installation, '*even though pre-assembly changed the site processes and could actually increase the hazards in some cases (for example increased* *craneage), the installation processes, by their very nature, had to be thoroughly planned'*. Thus, although in some cases the use of offsite may lead to an increased risk e.g. the lifting of large heavy offsite manufactured units into their final position on site, the fact that more planning and appreciation of the scale of the risk lead to more focused consideration from site management.

Gibb et al. (2004 :3) discusses what happens to risk through the increased use of pre-assembly, see Figure 3.2, and argues that '*the main thing that happens to on-site risks by using pre-assembly is that the many, common-place, high-likelihood, low consequence risks are largely replaced by fewer, higher potential consequence risks, which are much less likely to occur as they tend to be easier to identify and control'*.

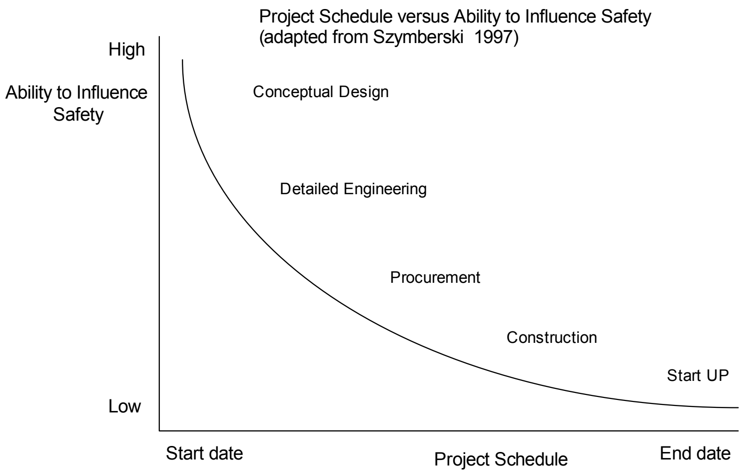
Figure 3.2 What happens to risk by increased pre-assembly (Gibb et al. 2004 :3)



The higher consequence risks, while easier to control, through focused planning for safety and health, nevertheless present a risk, which has been identified as one of the negative effects of offsite.

Gibb et al. (2004) argue that '*accidents and ill-health triggers can be reduced by designer action*', in addition Gibb et al. (2004) state that *'the argument is that the earlier in the design phase that action is taken to eliminate or reduce construction risk, the greater the benefit and the higher the chance of the benefit being realized'.* Szymberski (1997) quoted in Weinstein (2005) proposes a diagram (Figure 3.3) which indicates that there is a greater influence on safety earlier in a project. '*The results are consistent with the notion that recommendations for design changes are most likely to be implemented when presented early in a project, and complements the belief that there is a greater ability to influence* *safety on a project earlier in the project'.* The diagram indicates project schedule versus ability to influence safety.

Figure 3.3 Schedule versus safety influence (Szymberski 1997)



The graph indicates that the earlier decisions are made in a project the greater the impact on health and safety and risk elimination. Smith (2003) echoes the point that '*hazards are introduced at the earliest stages in a project's life through the process of procurement and design. Hazards can often be eliminated and risks reduced through the design process, especially during the first steps'.* Gibb et al. (2004) also argue that '*almost all the concentration so far has been on safety, to the exclusion of occupational health, except for issues surrounding hazardous substances*'. However, the importance of occupational health has been highlighted (Gibb et al. 1999, Smallwood et al. 2000, Gibb 2002). The extent of the occupational health challenge for construction is illustrated by Bray (2003) quoted in Smallwood et al. (2000) '*a staggering 137 000 people in UK construction suffered from an illness they believed was caused or made worse by their jobs'.*

There is a scarcity of coverage of offsite and health and safety in the literature. Research undertaken by Pan et al. (2007) identified a number of drivers for using offsite among UK housebuilders, where health an safety is considered. *'the most important drivers were considered to be in addressing traditional construction skills shortages (61%), ensuring time and cost certainty (54%), achieving high quality (50%) and then minimising onsite duration (43%). Reducing health and safety risks, sustainability issues, government promotion, complying with building regulations, restricted site specifics were also highlighted, but less frequently (less than 15%)*'. The health and safety drivers appeared to be of less importance. However, this study was limited to housebuilders perspectives, knowledge input from the general construction context and the offsite manufacturing group is needed in connection with health and safety.

Thus there are gaps in knowledge relating to the effect of offsite on occupational safety and health. Knowledge relating to the identification of the occupational safety and health risks in the offsite factory is required. The next section reaffirms the need for more research in this area.

3.6.3 The need for research on the effect of offsite on safety and health

Government calls for the increased use of offsite to improve health and safety performance (Egan 1998, Egan 2002), Gibb (2003 :156), states that *'the government and industry champions hope that it will be one of the main methods of re-engineering the construction process and achieving their intended improvements in time, cost, quality, and health and safety'*. However, it is argued that this will not be achieved unless research is conducted into '*the problem of client inertia is addressed along with the perceived or real concerns that clients hold to'* (Gibb 2003). Thus despite the recent UK government reports including Egan (1998), which discussed the need for performance improvements in the UK construction industry by using offsite techniques to improve construction processes, there is an ongoing need to address the lack of knowledge regarding offsite and its affects.

Pasquire and Gibb (2002) conducted a pilot study, which found that the decisions to use offsite are based on anecdotal evidence as opposed to data analysis as no appropriate measurement procedures are available. Blismas et al. (2006) extended this research and found that '*decisions required to choose one method of construction over another involving OSP are too often based on cost rather than value. OSP is hindered by the industry's perception that value is best ascertained using traditional rate-based measuring systems. Softer issues such as health and safety, sustainability, and efforts on management and processes are either implicit or disregarded within their evaluations'*. There is a need for a more rigorous method for offsite benefit analysis. In addition Blismas et al. (2006) argue that '*a wider account of value-based measures including quality, health, safety, sustainability, and logistics is suggested as the means of broadening the comparative exercise from the one-dimensional cost basis to a multi-dimensional value-based system'*. Furthermore, '*monetary measures are inadequate for items that cannot be directly attributable to an element, such as health and safety, or sustainability and wider human factors'*. Further research is required to investigate the affect of offsite on occupational safety and health in the offsite factory.

The next section discusses the use of automation and tele-operation techniques for the installation of offsite products. Integrated construction, the technique of bringing the factory to the site, to manufacture offsite units insitu is explored. Innovative techniques such as automation and integrated construction are discussed.

3.6.4 Automation and integrated construction

Offsite removes operatives from the construction site and places them in a factory, automation replaces site operatives with machines. This section presents selected highlights of automation in construction to provide a contextual background. The Oxford English dictionary, provides a general definition of automation: '*Automatic control of the manufacture of a product through a number of successive stages; the application of automatic control to any branch of industry or science; by extension, the use of electronic or mechanical devices to replace human labour'* (OED 2009b). The concept of automation in construction and civil engineering has advanced over the past twenty years in Japan, mainly in areas such as concrete finishing, material handling, earthworks and integrated construction automation systems. This has resulted in improvements in site safety, efficiency and productivity.

There has been limited automation on UK construction projects, the main form of automation is in the form of tele-operated construction plant. Research relating to automated construction processes was undertaken in 1978 by a team of academics, robot manufacturers and general contractors, and was sponsored by the Japan Industrial Robot Association (Taylor 2003). This lead to further construction robot research, (Hasagawa 2000) and, during the following 20 years, the Japanese construction and civil engineering sectors witnessed the development of more than 550 systems for unmanned operation and automation of construction works (Obayashi 1999). Cobb (1998) defines, '*the term "robot" is synonymous with almost every machine that incorporates an automated component*'. Taylor (2003 :34) categorises construction robots as: '*the following four fundamental definitions of construction robots prevail:*

1. *tele-operated human-machine systems;*
2. *pre-programmed systems;*
3. *autonomous with onboard sensors;*
4. *integrated construction automation systems*.

Current practical applications generally fall within the first two categories. The third category universally describes ongoing construction mechatronics research and the fourth category describes the amalgamation of existing capabilities and their application within a re-engineered construction site, having a similar appearance to a traditional automated manufacturing facility. The Japanese Construction Mechanisation Association recently concluded that the failure of construction automation site use rests upon the inability to recover the research, development and manufacturing costs and the overall inability to reduce on-site labour requirements. Nevertheless, construction automation and robotics is still seen in Japan as the key to a safer, more successful and profitable construction industry'.

In addition, the use of tele-operated automation systems has been cited as key to offsetting skills and labour shortages, 's*killed labour shortages and an ageing workforce have generated a real need for increased productivity through the use of single-task, human-machine construction systems'* (Fujii et al. 1995). These systems appear to be an economic and efficient means of using automation in construction (Taylor 2003 :36). Three systems are presented for discussion, they consists of material manipulators, concrete finishers and remote operated construction plant. The manual handling of materials, placing of concrete and hazardous substances and the use of plant in mechanical handling and installation of offsite units are discussed in chapter 7. The next section provides a contextual background and brief description of each and their health and safety benefits.

3.6.4.1 Material manipulators

These systems are generally used to remove the need for manual handling, by providing a method of manipulating, orientating, transporting and positioning large heavy and awkward materials. '*Material manipulators have been developed as practical solutions to placing oversized heavy components within the construction environment. These systems are generally guided manually but automated guided vehicles have been successfully adapted for use on construction projects, providing autonomous transportation of building components to their appropriate erection location'* (Taylor 2003 :36). The health benefits of eliminating manual handling and repetitive operations, make them particularly indispensible.

3.6.4.2 Concrete finishers

These include concrete distribution and placing machines which reduce the labour requirement and concrete trowelling and finishing tools, '*tele-operated articulated concrete distribution arms improve the quality and safety of concrete placing while greatly reducing the number of operatives required. Tele-operated and autonomous trowelling machines* *provide a more predictable finishing rate in combination with increased productivity'* (Taylor 2003 :35). Thus the automation of heavy concreting work, which is associated with health issues such as dermatitis can be reduced with these systems.

3.6.4.3 Remote operated construction plant

These systems use remote control technology to remove the need for an operative when operating plant in hazardous areas, *'radio-control adaptation enables the operator to control a machine while observing images at a place remote from the immediate work environment. In general, these systems combine global positioning systems, stereoscopic images, virtual reality and various work monitors in a control room located away from the machine working area. The main advantages of the radio-controlled construction plant are increased operator safety, improved labour management and greater work efficiency'* (Taylor 2003 :36-37). These systems isolate the operator from risks and provide a convenient method of controlling a range of tasks. Cousineau and Miura (1998) discuss robot technology and claim that *'Among safety issues in construction, most frequently mentioned is danger from working at high elevations, such as structural steel erection work and exterior painting. Many robots have been successfully developed in this area, eliminating most of the danger. Almost all robots are equipped with safety devices that stop their operation as soon as they touch an obstacle or detect drop off'*. The next section discusses the use of fully integrated automation systems.

3.6.4.4 Integrated construction systems

This section presents integrated systems, full construction automation is seen as the future of automation. Wakisaka et al (2000 :229-250) describes the basic elements, *'An all weather automated construction system has been developed. The system incorporates four major elements:*

- *a synchronously climbing all-weather temporary roof;*
- *a parallel material delivery system;*
- *prefabrication and unification of construction materials; and,*
- *a material management system'*.

In this system a computerised building and information management system controls, monitors and coordinates the construction in a factory environment, effectively bringing offsite manufacturing to site (Figure 3.4).

Figure 3.4 The Obayashi Big-Canopy system (Wakisaka et al 2000 :230)

Control of the structural components, construction drawings and work scheduling is handled in real-time by the system. In addition, the system provides control and monitoring of material, labour, safety and quality standards. Offsite manufactured units are delivered "just-in-time". The units are identified, transported from ground level and orientated into their final position within the structure in an automated and controlled manner. Wakisaka et al (2000 :232) describes the main features of the system, *'Improvement of productivity the parallel material delivery system increases the efficiency of delivery and erection. Quality is stabilised by prefabrication and unification, and the all-weather temporary roof. Short construction period: the period is reduced by stable processing by all-weather construction, and early commencement of the interior finishing work. Design freedom: the system can be applied to various building configurations. Improvement of the construction environment: The effects of severe heat, wind and rain are moderated, and workers are able to work safely and comfortably under the temporary roof. Safety of perimeter: The area of activity is compact, resulting in a high level of safety in the neighbourhood. Reduction of debris: Prefabrication and unification reduce the volume of debris'*.

These advanced systems require construction environments that are much more structured and controlled. '*Fully automated construction systems are still too technologically sophisticated and prohibitively expensive for operation within an unstructured construction environment. Tele-operated construction machinery offers limited productivity benefits but can increase operator safety and work quality'* (Taylor 2003 :41). These advanced systems dramatically reduce site labour, and automate many hazardous tasks.

3.7 Summary

This chapter has achieved the second objective (1.3.2) by having clarified the nature of offsite and identified the gaps in the extent of the effect of offsite on occupational safety and health in the literature. There is a paucity of knowledge relating to the affect of offsite on occupational safety and health in the factory. The chapter has defined offsite, investigated the difference between offsite and MMC, reviewed offsite terminology and presented the historical development in the UK thus providing an understanding of the technology for the thesis. The chapter has categorised offsite and reviewed the main drivers and barriers to its use. The safety and health benefits of offsite include, greater control over the environment, reduction in site labour and elimination of many hazardous tasks such as work at height. The health issues include greater control over operatives tasks and work environment. The use of automation and tele-operation systems and integrated manufacture provide alternative means of reducing labour and reducing risks during installation of offsite units. Construction as a manufacturing process provides a number of advantages, economies of scale, the ability to deploy capital equipment and tighter safety management. Innovative manufacturing techniques provide enhanced safety and health benefits, through organisation, automation and respect for people concepts. The reviews provided here build up a sound basis for understanding the use of offsite in the factory, which is discussed in Chapter 5.

4 RESEARCH DESIGN AND METHODOLOGY

4.1 Introduction

The first chapter introduced the research and outlined the aims, objectives and the justification of the research. Chapters 2 and 3 provided a literature context for the study. The research aims to identify and assess offsite risk, and to provide a strategy for offsite risk management. In order to achieve this aim, six objectives were developed which gave rise to the data collection and analysis techniques as discussed in chapter 5. This chapter outlines the research design and methodology. The chapter begins by providing an overview of how the research was arranged methodologically. Basic philosophical approaches are described, with associated consideration for the study. The methodological framework is presented, with discussion on how the research was approached and designed. The research design is presented in the order of the three main phases of the study, namely, the group interviews with experts, the case studies and ergonomic audits and the semi structured interviews with the offsite manufacturer personnel (Chapter 5). The group interviews achieves objectives 2 and 3. It also provides a platform of risk understanding on which the case study and ergonomic audits were undertaken. The semi-structured interviews provided a means of verifying the risks, and gaining an understanding of residual risks. The chapter concludes by discussing the data collection methods.

4.2 Fundamental concepts

This section provides an overview of the main philosophical concepts considered during the study. The philosophy behind the design of research has been extensively reviewed in the literature (Bryman 2004: 3-6, Creswell 2003: 4). The following sections consider the concepts of; epistemology, ontology, methodology and axiology, these provide a contextual background for the research approach discussed in section 4.3

4.2.1 Epistemology

Walliman (2005: 432), describes epistemology as; '*the theory of knowledge, especially about its validation and the methods used. Often used in connection with one's epistemological standpoint – how one sees and makes sense of the world'*. Bryman (2004: 11) in the context of social science research suggests that '*an epistemological issue concerns the question of what is (or should be) regarded as acceptable knowledge in a discipline. A particular central issue in this context is the question of whether the social world can and should be studied according to the same principles, procedures, and ethos as the natural sciences. The position that affirms the importance of imitating the natural sciences is invariably associated* *with an epistemological position known as positivism'.* A precise definition of positivism is difficult to obtain as Bryman (2004: 11) states, '*the doctrine of positivism is extremely difficult to pin down and therefore to outline in a precise manner, because it is used in a number of ways by authors, For some writers it is a descriptive category – one that describes a philosophical position that can be discerned by research – though there are still disagreements about what it comprises; for others, it is a pejorative term used to describe crude and often superficial data collection'.* Bryman (2004: 11) goes on to state that '*positivism is an epistemological position that advocates the application of the methods of the natural sciences to the study of social reality and beyond'.* The term interpretivism is stated as '*interpretivism is a term that usually denotes an alternative to positivist orthodoxy that has held sway for decades. It is predicated upon the view that a strategy is required that respects the differences between people and the objects of the natural sciences and therefore requires the social scientist to grasp the subjective meaning of social action*' (Bryman 2004: 13).

4.2.2 Ontology

In terms of social science research, Bryman (2004: 13) states '*questions of social ontology are concerned with the nature of social entities. The central point of orientation here is the question of whether social entities can and should be considered objective entities that have a reality external to social actors, or whether they can and should be considered social constructions built up from perceptions and actions of social actors. These positions are frequently referred to respectively as objectivism and constructivism'.*

4.2.3 Methodology

Fellows and Liu (2003: 31) state that '*research methodology refers to the principles and procedures of logical thought processes which are applied to a scientific investigation'.* The research method is distinct from the methodology it, *'concerns the techniques which are available and those which are actually employed in a research project'* (Fellows and Liu 2003 :31). The study used a qualititative methodology as discussed in section 4.3.3.

4.2.4 Axiology

Axiology is defined by (OED 2009c) as ' *the theory and study of quality or values'.*

In simple terms, Creswell (2003: 6) states that '*researchers make claims about what is knowledge (ontology), how we know it (epistemology), what values go into it (axiology) and the process for studying it (methodology)'.*

4.3 Research Design considerations

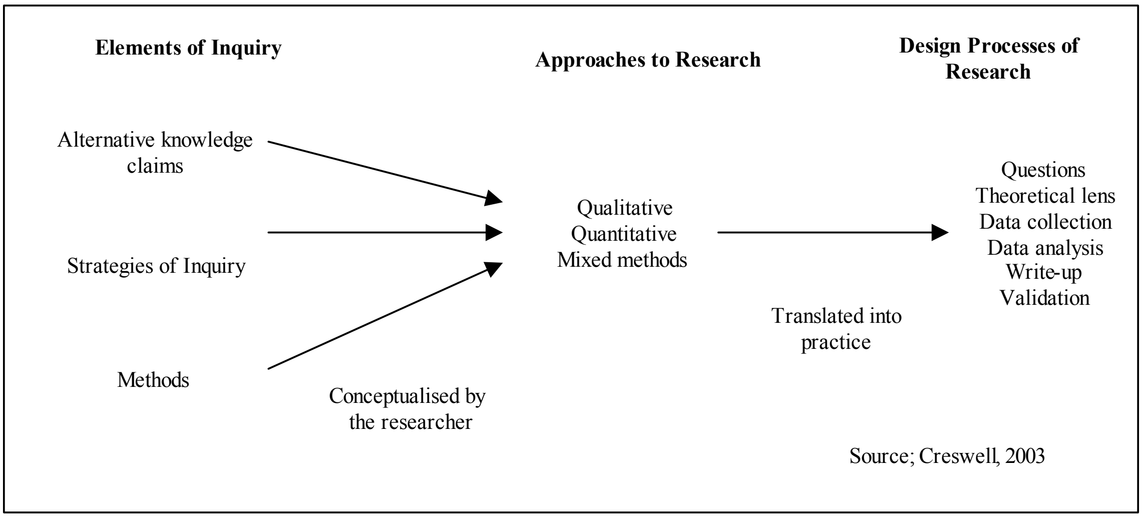
This section provides a contextual background to the research design approach. The research used a qualitative approach, three phases of investigation were utilised. Phase I identified those building elements for detailed study and selected the activities and risks that were analysed in phase II. Phase I and II informed the risk management tool. Phase III provided a follow-up to phases I and II conducted in July 2009 to verify the results and provide identification of residual risks.

The aim of the literature review is discussed. The research involved three main parts, these are outlined in sections 4.4, 4.5 and 4.6. The next section describes the research design process.

4.3.1 Research design process

Bryman (2004: 543) describes research design *'to refer to a framework for the collection and analysis of data. A choice of research design reflects decisions about the priority being given to a range of dimensions of the research process'*. In this study, the three phases; group interviews, ergonomic audits and semi-structured interviews provide a framework in which data are collected and analysed. The research design can be distinguished from the research method. Research methods are the techniques and procedures used for data collection. Fellows and Liu (2003: 31) state that *'method concerns the techniques which are available and those which are actually employed in a research project'*. In designing a research proposal, Crotty (1998: 4-5) suggests considering four questions: '*what epistemology – theory of knowledge embedded in the theoretical perspective – informs the research (e.g. , objectivism, subjectivism, etc.)?, what theoretical perspective – philosophical stance – lies behind the methodology in question (e.g., positivism and postpositivism, interpretivism, critical theory, etc.)?, what methodology – strategy or plan of action that links methods to outcomes – governs our choice and use of methods (e.g., experimental research, survey research, ethnography, etc.)? and what methods – techniques and procedures – do we propose to use (e.g., questionnaire, interview, focus group, etc.)?'*. This model is conceptualised by Creswell (2003: 5), who illustrates how the elements of inquiry; alternative knowledge claims, strategies of inquiry and methods come together to form different research design approaches (Figure 4.1). The diagram presents the process of the development of research design. This model was used to provide guidance in this thesis. The term research design is interpreted in this thesis to include the framework of the philosophical approach adopted to the selection of methods for data analysis and presentation.

Figure 4.1 Elements of inquiry, approaches and the design processes of research



The questions central to research design, which were considered by the author were as described by Creswell (2003: 5).

- '*What knowledge claims are being made by the researcher (including a theoretical perspective)?*
- *What strategies of inquiry will inform the procedures?*
- *What methods of data collection and analysis will be used?'*

Using these three questions as a guide, a qualitative research approach was identified. The steps are explained in the following sections.

4.3.2 Alternative knowledge claims

Creswell (2003: 6) describes knowledge claims where *'researchers start a project with certain assumptions about how they will learn and what they will learn during their inquiry'*. In reviewing the major parts of each knowledge claim positions the following were considered. The postpositivist knowledge claim is detailed by Creswell (2003: 6) as '*this position is sometimes called the "scientific method" or doing "science" research. It is also called quantitative research, positivist/postpositivist research, empirical science, and postpositivism. The last term "postpositivist", refers to the thinking after positivism, challenging the traditional notion of the absolute truth of knowledge and recognising that we cannot be "positive" about our knowledge when studying the behaviour and actions of humans'*.

An alternative knowledge claim is that of social constructivism. Creswell (2003: 8) discusses the knowledge claim, social constructivism (often combined with interpretivism). This position, '*individuals seek understanding of the world in which they live and work. They develop subjective meanings of their experiences-meanings directed toward certain objects or things'*. Creswell (2003: 8) goes further to state that, '*the goal of the research, then, is to rely as much as possible on the participants' views of the situation being studied'*. In addition '*researchers recognize that their own background shapes their interpretation, and they "position themselves" in the research to acknowledge how their interpretation flows from their own personal, cultural, and historical experiences. The researcher's intent, then, is to make sense of (interpret) the meanings others have about the world'*.

In addition, Crotty (1998) states that *'humans engage with their world and make sense of it based on their historical and social perspective – we are all born into a world of meaning bestowed upon us by our culture. Thus, qualitative researchers seek to understand the context or setting of the participants through visiting this context and gathering information personally. They also make interpretations of what they find, and interpretation shaped by the researchers own experiences and backgrounds'*. Drawing on the philosophical debate presented above, this research attempts to contribute to knowledge of the effect of offsite on risk from the position of constructivism.

4.3.3 Strategies of inquiry; qualitative, quantitative and mixed methods

In considering the research approach, qualitative, quantitative and mixed methods were considered. This section discusses the strategies of each approach which assisted in the selection of a qualitative research methodology for the study.

Creswell (2003: 18) provides useful definitions which assist in clarifying the three approaches:

'*A quantitative approach is one in which the investigator primarily uses postpositivist claims for developing knowledge (i.e., cause and effect thinking, reduction to specific variables and hypotheses and questions, use of measurement and observation, and the test of theories), employs strategies of inquiry such as experiments and surveys, and collects data on predetermined instruments that yield statistical data'*.

Alternatively, '*a qualitative approach is one in which the inquirer often makes knowledge claims based primarily on constructivist perspectives (i.e., the multiple meanings of individual experiences, meanings socially and historically constructed, with an intent of developing a theory or pattern) or advocacy/participatory perspective (i.e., political, issue-*

orientated, collaborative, or change oriented) or both. It also uses strategies of inquiry such as narratives, phenomonologies, ethnographies, grounded theory studies, or case studies. The researcher collects open-ended, emerging data with the primary intent of developing themes from the data'.

And finally, '*mixed methods approach is one in which the researcher tends to base knowledge claims on pragmatic grounds (e.g., consequence-oriented, problem-centred, and pluralistic). It employs strategies of inquiry that involve collecting data either simultaneously or sequentially to best understand research problems. The data collection also involves gathering both numeric information (e.g., on instruments) as well as text information (e.g., on interviews) so that the final database represents both quantitative and qualitative information'*.

McQueen and Knussen (2002) provide recommendations in relation to methodology selection. They suggest that a number of conditions determine a quantitative approach, these include:

- the presence of established theory in the area concerned;
- a use of statistical analysis in previous studies; and,
- a potentially high sample of subjects available.

The above were considered by the author, the sample for the study was relatively small, and therefore no statistical claim regarding offsite and risks would be presented. In addition McQueen and Knussen (2002), discuss the following conditions concerning qualitative research:

- a lack of experience in the field of study;
- previous research being predominantly qualitative; and,
- the lack of individuals to study.

These were aligned with the limitations of individuals participating in the study, with the lack of experience in the field of study and with the qualitative nature of previous research. Creswell (2003: 22), suggests that '*if a concept or phenomenon needs to be understood because little research has been done on it, then it merits a qualitative approach. Qualitative research is exploratory and is useful when the researcher does not know the important variables to examine. This type of approach may be needed because the topic is new, the topic has never been addressed with a certain sample or group of people, or existing theories do not apply with the particular sample or group under study'*. The effect of offsite and risk was an area where little research exists, and therefore, this further suggested a qualitative approach.

4.3.4 Research methods

The research was conducted in three main phases: the group interviews (phase I). The case study; ergonomic audits and observation (phase II) and the semi-structured interviews (phase III). Each of the methods was qualitative in nature, the use of triangulation was utilised as defined by Fellows and Liu (2003: 113), *'triangulation is the use of two or more research methods to investigate the same thing, such as experiment and interviews in a case study project'*. In the study see Figure 4.3, two group interviews (phase I) provided data on activities and risks for insitu and offsite solutions. This data was taken to three case studies (phase II) comprising ergonomic audits and observations of offsite manufacturers. The results of these two phases informed the HASPREST risk management tool. The third study (phase III) involved returning to the case study manufacturers and conducting three semi-structured interviews and observations to validate the findings from phase I and II and to identify residual risks. The author was aware of the bias in using a purely qualitative approach, however, the use of a qualitative mixed method approach of group interviews, case study and semi-structured interviews, was intentional and was utilised in order to minimise biases that may be inherent in any single method. Fellows and Liu (2003: 95-96) state that '*observers have to select what is recorded – that may introduce bias. The problem is accentuated in participative observation as the researcher is executing the two functions of participating in the activity and observing (plus recording and, possibly, analysing) it concurrently. Pre-designed, structured forms for recording data help overcome some problems (notably bias) but may, of course, lead to important, but not predetermined observations being omitted'*. Phase II used a structured ergonomic checklist for recording data to assist in minimising bias. Furthermore, Creswell (2003: 210) highlights a strong reason why researchers employ mixed methods '*to expand an understanding from one method to another, to converge or confirm findings from different data sources'*. The research design of the three phases of investigation including research context, research participants, research type, research methods and procedures for data collection are detailed in the following sections 4.4, 4.5 and 4.6.

The literature review assisted in the formulation of the objectives and aims. The review commenced at the start of the study, as an on-going process it continued to the last stage of writing-up. The main purpose of a literature review has been described by Naoum (1998) as; *'it seeks systematic reading of previously published and unpublished information relating to the area of investigation, that it helps improve the study by looking into previous research* *design or questionnaires which will give some insights into how the researcher can design his/her own study more effectively'*. In addition, Creswell (2003: 29-32) states that the literature review accomplishes several purposes, these include '*it shares with the reader the results of other studies that are closely related to the study being reported. It relates a study to the larger ongoing dialogue in the literature about a topic, filling in gaps and extending prior studies'*. During the first six months of the study, the main concepts of offsite in the UK construction industry were examined. In addition, a review of the health and safety in the UK construction industry was examined, in parallel with previous attempts at improvement. The deskwork involved in the literature review consisted of a thorough examination through the analysis of information from sources such as; professional journals and magazines, internet searches across multiple database, documents from companies (including detailed document analysis of steering group member company data), websites, information from government agencies, e.g., Health and Safety Executive (HSE), National Audit Office (NAO) and public domain information sources. After the first project steering group meeting, a series of exploratory interviews were established with six of the steering group members. The interviews covered a range of areas including health and safety, offsite production and health and safety management with senior professionals.

4.3.5 A Practical research approach

Creswell (2003: 23) provides guidance on practical approaches to research, arguing that *'all social research is a coming together of the ideal and the feasible. Because of this, there will be many circumstances in which the nature of the topic or of the subjects of an investigation and the constraints on a researcher loom large in decisions about how best to proceed'*. The research approach incorporated three main practical considerations as discussed below. These were required in order to take account of developments in the literature and to assist in making a contribution to knowledge.

Fellows and Liu (2003: 29) describe a number of issues relating to research limitations and practical considerations, claiming that *'it is useful to be demonstrably aware of the limitations of the research and of the results and conclusions drawn from it. Such limitations etc. are occasioned by various facets of the work – sampling, methods of collecting data, techniques of analysis – as well as the, perhaps more obvious, restrictions of time, money and other constraints imposed by the resources available'*. In conducting the study the following practical issues were considered:

- The nature of the problem, the identification of the research problem and the selection of research methods was seen as an interactive process;

- The time and limitations of resource was considered as previously stated by Fellows and Liu (2003), there was a time window during which the research design, collection of data and write up had to be completed;
- The time and resource of the informants and the information required from them throughout the study period.

In addition, in selecting a research approach, Creswell (2003: 21-22) describes three main practical considerations that affect a choice of one approach over another

- the research problem
- the personal experiences of the researcher
- the audience for whom the report will be written

In relation to the research problem, Creswell (2003: 22) states that '*qualitative research is exploratory and useful when the researcher does not know the important variables to examine. This type of approach may be needed because the topic is new, the topic has never been addressed with a certain sample or group*'. In connection with the researcher's own personal experiences, the researcher had experience in writing, conducting interviews and observation. This experience was aligned with the recommendations of Creswell (2003: 22), '*qualitative approach incorporates much more of a literary form of writing, and experience in conducting open-ended interviews and observations'*. Finally the audience for the report would be academics and colleagues in the field, these would be experienced in a qualitative approach.

4.3.6 Research type

The literature provides some debate on how research is classified, with a significant degree of overlapping in many of the research types. The research type used in the three phases was qualitative in nature which combined the use of group interviews, case study and semi-structured interviews.

This section presents how the information was collected. Two expert group interviews, three case studies and three semi-structured interviews were conducted with three offsite organisations so that sufficient data would be obtained with a view to understanding the research problem.

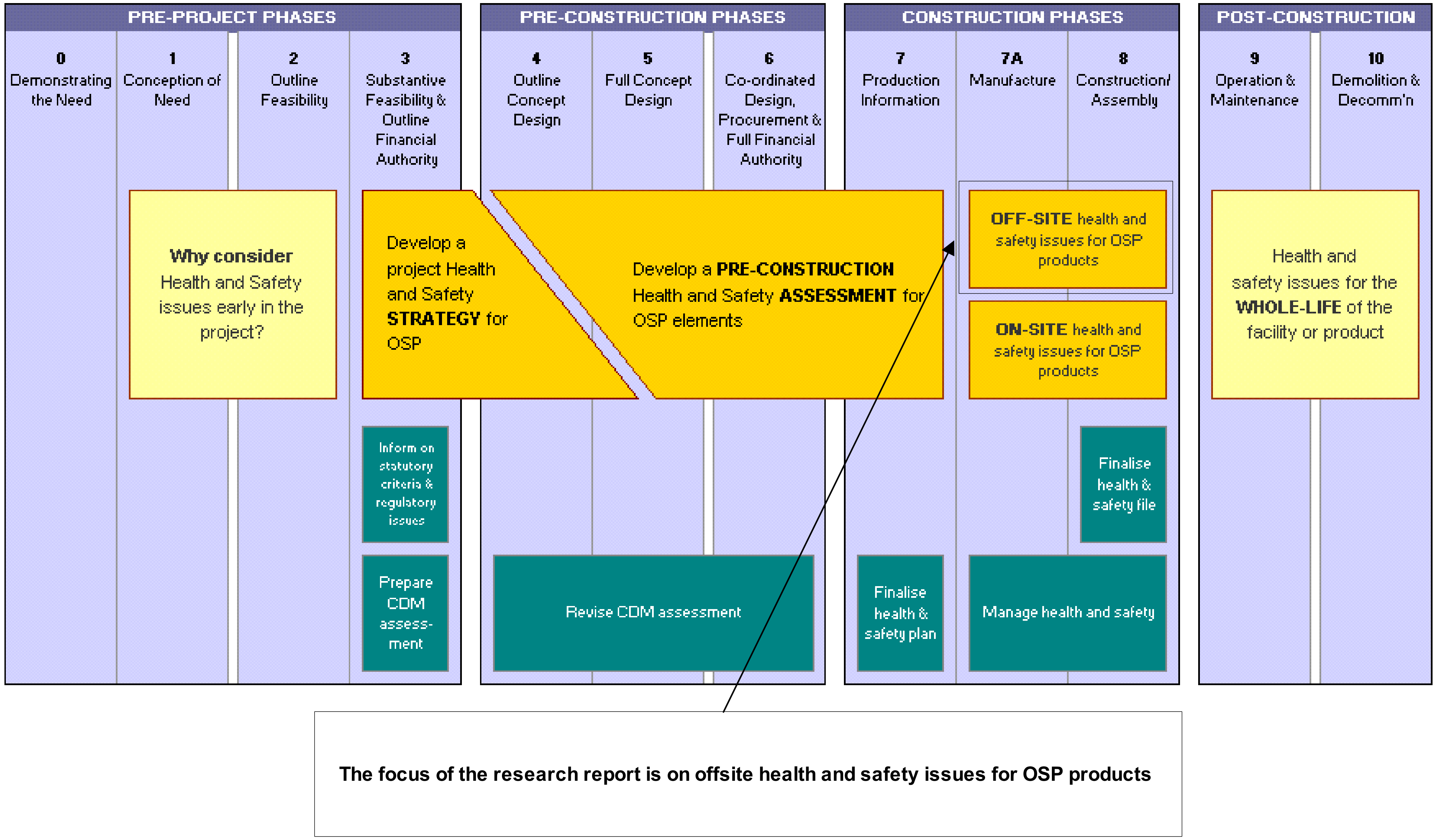
Four steering group meetings were conducted involving industrial collaborators and key experts from industry, in particular health and safety personnel from offsite manufacturers.

An ergonomic tool was developed, which was used to determine health and safety hot spots in the offsite manufacturing facilities which formed part of the study and to verify the initial findings.

The supplementary work of the research output were mapped using the project process protocol; a generic process-mapping tool designed by Loughborough and Salford University. The focus of this research report concentrates on construction phases section 7a and 8 of the generic process map; specifically the research output "*offsite health and safety issues for OSP products – principal contractor or other party inspecting offsite works*", see Figure 4.2.

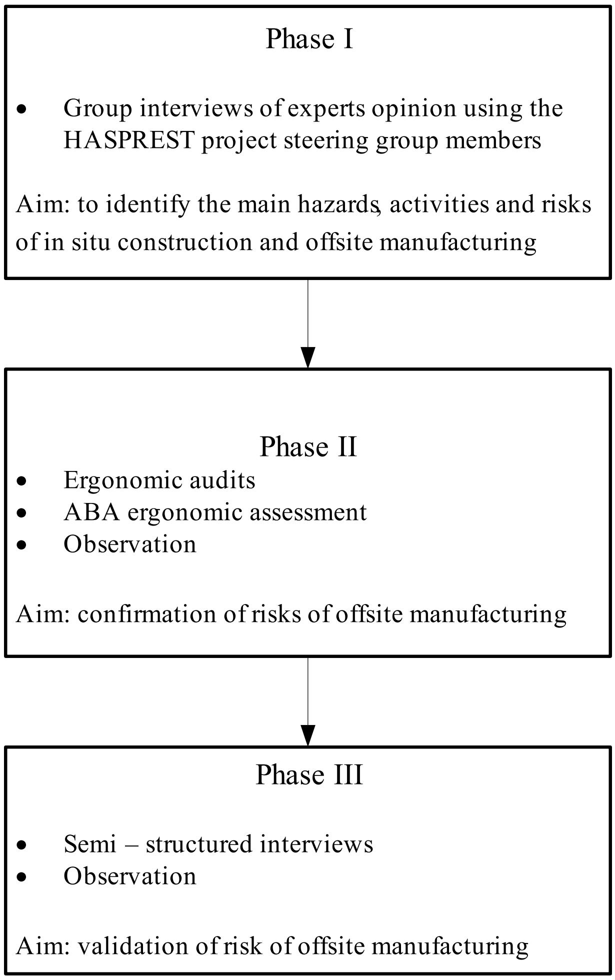
Fellows and Liu (2003: 112, 149-159) describe a number of methods of collecting data ranging from semi-structured interviews, case studies and questionnaires. In the use of semi-structured interviews, Bryman (2004: 45, 113) states that '*it typically refers to a context in which the interviewer has a series of questions that are in general form of an interview schedule but is able to vary the sequence of questions. The questions are frequently somewhat more general in their frame of reference from that typically found in a structured interview schedule. Also, the interviewer usually has some latitude to ask further questions in response to what are seen as significant replies*'. The use of semi-structured interviews as a means of asking further questions to significant replies to access knowledge and opinion was a determining factor in this research to evaluate the data obtained from the group interviews and ergonomic audits.

Figure 4.2 HASPREST the generic process protocol



In order to meet the research objectives the data collection approach was as indicated in Figure 4.3.

Figure 4.3 Data collection process



Three phases of investigation were formulated to establish the following main objectives:

- to identify the main risks, for insitu construction and for the offsite equivalent;
- to undertake ergonomic audits using the ABA ergonomic checklist (*Anforderungs- und Belastbarkeits- Analyse*) is an assessment tool used by BMW[5];

[5] **Bayerische Motoren Werke AG** (**BMW**), (*Bavarian Motor Works*) is a German automobile and motorcycle manufacturing company. Founded in 1916, it is known for its performance and luxury vehicles.

- to verify the risks, identify process change and risk elimination or reduction and gain an understanding of the residual risks associated with offsite.

The research carried out in 2003 lead to the need for the information gathered to be verified and to gain an understanding if the risks have changed due to process change since the initial launch of the tool. In order to do so, opinions from three of the offsite manufacturers investigated in 2003 provided verification and gained an added important understanding of residual risks. The methods as illustrated in Figure 4.3 were chosen to gather the relevant information. The next section discusses each phase of the investigation, the expert panel, ergonomic audit and semi-structured interviews.

4.4 Phase I - Group interviews

4.4.1 Research context

The first phase, the group interviews, was carried out on eleven of the steering group participants. In order to maintain confidentiality, the participants names have been replaced with an alphabetic character to remain anonymous. This main data collection of the phase was completed during the period March 2002 to September 2002.

An extensive study was carried out to identify and list the activities, and main risks for insitu construction and offsite on a range of building elements. The task of determining the list of building elements for consideration was conducted through literature reviews, suggestions from previous research and existing systems at Loughborough. The list of building elements is shown in section 5.3.5 (Table 5.3).

4.4.2 Phase I aims and objectives

Phase I contributes to the achievement of the objectives by:

- providing a background to offsite and health and safety;
- the identification of participants for detailed case study; and,
- the identification of activities and risks.

In order to determine the activities and risks the method used knowledge elicitation techniques by a group interview of experts in safety issues in construction and offsite manufacturing. This is discussed in the following section.

4.4.3 The expert group

Phase I used eleven experts from the HASPREST steering group. Adler and Ziglio (1996: 14) states that '*with a homogenous group of experts, good results could be obtained even with small panels of 10-15 individuals'*. In addition Adler and Ziglio (1996: 14) claims that '*the selection of "appropriate experts" must not, of course, be a matter of mere personal preference. On the contrary, it must follow a procedure governed by explicit criteria'*. Adler and Ziglio (1996: 14) lists a number of criteria; '*knowledge and practical engagement with the issues under investigation. Another criterion is the capacity and willingness of selected experts to contribute to the exploration of a particular problem'*.

In this research the HASPREST steering group members were chosen. The members were key safety individuals in many cases representing their organisation in the area of safety. They were committed to the research project and had experience, and credibility in this area of safety. Table 4.1 indicates the experience of each member.

Table 4.1 Expert participation in Phase I

Name*	Position/organisation	Role/Experience
A	**Reid Architecture (now 3D Reid)**	• architect responsible for health and safety issues • experience in health and safety • 10 years experience in the use of offsite products
B	**Revolutionary Pod Modules**	• Director of production services • responsible for health and safety • 12 years experience in the offsite manufacture of pods
C **D**	**Caledonian Building Systems Ltd**	• Director of production services • responsibility for health and safety • 20 years experience in the offsite manufacture of modular buildings
E **F**	**Trent Concrete Ltd**	• Managing Director responsible for health and safety • experience of production operations • 20years experience of precast cladding manufacture
G	**UMIST**	• Senior lecturer in health and safety • construction health and safety consultant and advisor • 20 years experience in construction health and safety
H	**Structherm Building systems**	• Structural designer of composite wall panels • responsible for health and safety • 5 years experience of offsite manufacture of pre-cast wall panels
I	**Trades Union Congress (TUC)**	• Senior Trades Union Representative with health and safety expertise • experience of construction health and safety issues • 10 years experience construction trades health and safety matters
J	**Innogy Plc**	• Project Manager responsible for health and safety • experience of construction health and safety • 15 years experience of offsite for the petrochemical industry
K	**Innogy Plc**	• Site manager responsible for health and safety • experience of construction health and safety • 10 years experience of offsite for the petrochemical industry
L	**Carillion Construction Ltd**	• Senior manager responsible for construction health and safety • 20 years experience of construction health and safety
M	**Crown House Engineering**	• Manager responsible for health and safety • 10 years experience in the production of offsite mechanical and electrical modular units

*Abbreviated for anonymity.

Notes: List of group interview members (August 2003), changes may have taken place since this date. F replaced E (March 2006), D replaced C (July 2006).

4.4.4 The expert opinion approach

Tomlinson (1994: 179-185) discusses four techniques that can be considered in addition to expert opinion, these techniques use multiple experts, they include consensus-decision making, brainstorming, nominal group technique and Delphi method. They are briefly outlined in the following sections.

4.4.5 Consensus decision making

This technique utilises a workshop where the experts discuss issues in a similar approach to brainstorming, except each expert votes for a decision. The process undergoes a series of rounds, in the first round each expert has three votes, but only one vote can be used for each solution. Those options with less than a certain number of votes are deleted. In the second round, the experts have two votes instead. The rounds continue until two options are remaining. During the final round, each expert votes for the final options. After the choice has been reached, a period of discussion follows to ascertain everyone's agreement with the choice. This technique requires all experts to be present at one meeting, but has the advantage that an agreed decision can be reached (Tomlinson 1994: 179-185).

4.4.6 Brainstorming approach

The discovery of new ideas and new approaches through discussion and interaction between two or more experts is known as brainstorming. The brainstorming activities takes place in a comfortable constructive group setting. In this kind of discussion there is no "right" or "wrong" answer. The experts are either asked to call out ideas as they occur to them or participate in turn. The facilitator records the decisions (Tomlinson 1994: 179-185).

4.4.7 Nominal group technique

The nominal group technique is administered to a group of experts considering a single specific task at each meeting. This technique requires strong involvement and interaction of the group as a whole. It requires the group to write down ideas about the problem, have a round-robin feedback from the group. Lastly, individuals vote on the priority idea with the group decision being mathematically derived from rank ordering or ratings (Tomlinson 1994: 179-185).

4.4.8 Delphi method

Adler and Ziglio (1996: 3) states that '*the objective of most Delphi applications is the reliable and creative exploration of ideas or the production of suitable information for decision-making. The Delphi method is based on a structured process for collecting and* *distilling knowledge from a group of experts by means of a series of questionnaires interspersed with controlled opinion feedback'*. In addition, Adler and Ziglio (1996: 9) goes on to state that '*the Delphi Method is an exercise in group communication among a panel of geographically dispersed experts. The technique allows experts to deal systematically with a complex problem or task*'. Thus the Delphi method, unlike the three methods previously described, does not require the experts to be present in the same room discussing the issues. The Delphi technique is fairly straightforward, Adler and Ziglio (1996: 9) outlines the two phases of the process. *'in virtually every use of the Delphi Method, two phases can be identified. The first phase can be labelled as the "exploration phase". It usually characterises Q1, sometimes Q2, where the subject under discussion is fully explored and additional information is provided. The second phase (the "evaluation phase") involves the process of assessing and gathering the experts' views (there may be consensus or disagreement) on various ways of addressing the issues under investigation'.* (Q1 relates to the first questionnaire and Q2, the second questionnaire which presents the results of Q1). Delphi method requires at least two phases of surveys. The first being the exploration phase and the second a more finer focus of the response to the first phase.

Phase I used a consensus decision making approach. The approach was considered most suitable in that the group could reach an agreed decision after a period of discussion to ascertain all experts' agreement. The group were most comfortable and familiar with this approach.

4.4.9 The research sample

The research sample for phase I is a non-probability sample using quota sampling. Bryman (2004: 102) states that, *'the aim of quota sampling is to produce a sample that reflects a population in terms of the relative proportions of people in different categories, such as gender, ethnicity, age groups, socio-economic groups, and region of residence, and in combinations of these categories. However, unlike a stratified sample, the sampling of individuals is not carried out randomly, since the final selection of people is left to the interviewer'*. In addition, Bryman (2004: 102) advises that '*once the categories and the number of people to be interviewed within each category (known as quotas) have been decided upon, it is then the job of the interviewers to select people who fit these categories. The quotas will typically be interrelated. In a manner similar to stratified sampling, the population may be divided into strata in terms of, for example, gender, social class, age, and ethnicity'*. Quota sampling is about choosing a set of key informants, people who are knowledgeable or expert in a particular field or subject. In phase I, the informants were from the HASPREST steering group. This provided dual efficiency, it was both a cost-effective approach and provided a representative group of health and safety and offsite manufacturing experts. At the first steering group meeting, a briefing was carried out before discussion on the key data gathering activities. The briefing outlined the format of the discussions, the timescale involved and the expectations from them. All present agreed to participate and facilitate access to data, construction sites and offsite manufacturing facilities. The response was very positive with all participants committed and enthusiastic to contribute to the research.

4.5 Phase II

Phase I assisted in identifying the activities and risks for insitu construction sites and offsite manufacturing. Phase II involved a number of site visits to offsite manufacturing facilities, involving an ergonomic audit to confirm those risks identified in phase I and direct observation. A significant amount of time was spent in contact with the activities and process operations of each case. During the fieldwork, guided work site visits were performed to directly observe and document the identified and problematic jobs, tasks, work stations, equipment and tools in use. Photographs (where permitted) were taken for documenting purposes.

Three preliminary site visits to those offsite manufacturers selected for detailed study (see section 5.3.1), were carried out which involved talking to the managerial staff, operatives and suppliers. An orientation of the production methods and discussion of the technology provided additional background support prior to the ergonomic audits. This also assisted in gaining commitment for the study by ensuring that the people involved who may be affected by the ergonomic audit process understood the reason for the study and could contribute in its development. This involvement and participation in the ergonomics process has been frequently stated in the literature see (Eason 1988: 25, Imada and Robertson 1987: 1019), in addition Wilson (1991: 72) describes other benefits from such an approach, '*at its simplest, a better (healthier, safer, more effective, more satisfying) design solution — and not merely a more implementable one — should result from the involvement of job holders or system users, who should know most about the problem or situation*'. Thus it was important that during the ergonomic audits, the involvement of the operatives and staff within each case study was required during the phase.

In carrying out the ergonomic audits, the approach of the author was as facilitator rather than ergonomics expert. Advice during the audits was from an external ergonomics consultant, the consultant provided guidance on the development of the ergonomic tool (see section 5.3.3) and on the collection of field data when performing the ergonomic audits at each offsite facility. The approach of adopting an expert role can lead to problems. Wilson and Corlett (1995) states, *'the expert too readily assumes solutions to the client's problem, recommending prescriptions which the system either rejects or may implement in only in amended form'*. Thus the approach adopted in each ergonomic audit was:

- having a background and understanding of each offsite manufacturing facility, including its culture;
- involving the staff and operatives in a participative approach to any ergonomic changes or suggestions;
- acting as an ergonomic facilitator.

Time spent during the ergonomic audits involved observing the operatives on the production of offsite products and units, at their workstations or while they worked within the modules. This allowed an understanding of the ergonomic risks from the "shop-floor" and allowed the organisation and staff to benefit from any ergonomic advice to reduce risk. The next section describes the offsite manufacturing facilities involved in the ergonomic audits.

4.5.1 Case study research

The second phase of the investigation involved case study research. The case studies commenced in May 2002 after meetings with representatives of each of the three offsite manufacturing companies.

4.5.1.1 Case study – overview

Bryman (2004: 48-49) states that *'the basic case study entails the detailed and intensive analysis of a single case'*. The method can be used to confirm findings in other studies, such as interviews and questionnaires. The case study method can provide further insights into less investigated areas. *'The most common use of the term associates the case study with a location, such as a community or organisation. The emphasis tends to be upon an intensive examination of the setting'*.

Yin (2003: 13-14) defines a case study as *'a case study is an empirical inquiry that investigates a contemporary phenomenon within its real-life content, especially when the boundaries between phenomenon and context are not clearly evident'*. In the context of this research, three case studies aimed to identify activities and risks in the manufacture of offsite products. *'The case study inquiry copes with the technically distinctive situation in which there will be many more variables of interest than data points, and as one result relies on* *multiple sources of evidence, with data needing to converge in a triangulating fashion, and as another result'*.

Bryman (2004: 49) argues that most qualitative research is a form of case study, but not all case studies can be described as qualitative because they often use quantitative research methods. *'There is a tendency to associate case studies with qualitative research, but such an identification is not appropriate. It is certainly true that exponents of the case study design often favour qualititative methods, such as participant observation and unstructured interviewing. ...However, case studies are frequently sites for the employment of both quantitative and qualitative research'*. Glathorn and Joyner (2005) argue that case studies *'more often take a qualitative perspective, concerned with exploring, describing, and explaining a phenomenon'*.

In this thesis, the term case study is used to include the whole study of the three offsite manufacturing organisations, including the ergonomic audits, document analysis and interviews with management and operatives.

4.5.1.2 Selection of case studies

In case study research Yin (2003: 24) suggests that the unit of analysis is an important component of a research design. The definition of what a case is has been a basic problem for investigators at the outset of case studies. A case may be an individual and can also be some event or entity. *'As a general guide, your tentative definition of the unit of analysis (and therefore the case) is related to the way you have defined your initial research questions. ...Each unit of analysis would call for a slightly different research design and data collection strategy'*. Yin (2003: 26) also discusses the importance of specifying the geographic and time boundaries of the case, *'if the case is about local services in a specific geographic area, decisions need to be made about those services whose district boundaries do not coincide with the area. Finally, for almost any topic that might be chosen, specific time boundaries are needed to define the beginning and end of the case'*. These questions need to be considered to define the unit of analysis, and thereby to determine the limits of the data collection and analysis.

The literature presents two general approaches to case sampling, these are termed randomised and theoretical. Eisenhardt (1989: 537) states *'the cases may be chosen to replicate previous cases or to extend emergent theory, or they may be chosen to fill theoretical categories and provide examples of polar types. While the cases may be chosen randomly, random selection is neither necessary nor even preferable'*. Miles and Huberman

(1984) suggest that a small number of cases may cause bias. In the theoretical approach, cases are chosen either to literally or theoretically replicate other cases (Yin, 2003).

The selection of the case studies in this study observed these theoretical considerations and practical considerations as described below;

- The case study organisations were well known to the author and a good relationship had been developed, this assisted in obtaining access to the companies for detailed study;
- The case study companies reflected current use of offsite. They covered the material range steel, concrete and timber across non-volumetric, volumetric and modular production methods;
- The case study companies had developed their production methods and were active in seeking health and safety performance improvement.

The case study research participants are presented in Table 4.2. The table also presents details regarding the offsite description applicable to the participants.

Table 4.2 The offsite case studies

Case study 1	**Trent Concrete Limited,– non-volumetric, concrete** Pre-cast concrete cladding - heavy commercial face finished
Offsite description	• manual construction of timber moulds • manual assembly of reinforcement • placing of concrete • mechanical storage of units
Case study 2	**Revolutionary Pod Modules, volumetric light steel** Washroom pods
Offsite description	• manual assembly of light gauge steel frame • manual assembly of gyproc wall panels • manual fixing of wall and floor tiles • manual installation of fittings and washroom components and finishes
Case study 3	**Caledonian Building Systems Ltd Modular** Steel frame, steel sheet, timber panel and gyproc panel lined modular buildings
Offsite description	• manual welding and assembly of steel frame modules • manual installation of insulation • manual installation of galvanised steel sheet wall • manual installation of medium density fibreboard wall and ceiling panels • manual installation of gyproc wall and ceiling panels • manual fixing of joinery and accessory internal fittings and fixings

The research sample for phase II was directly related to the type of data required. The investigation required ergonomic risk data from offsite manufacturers. Therefore, the sample selected was those offsite manufacturers from the HASPREST steering group members. During the steering group meetings, agreement was reached on which offsite manufacturers would form cases, for the ergonomic audits.

4.5.1.3 The number of cases

Yin, (2003: 46) argues that *'multiple-case designs have distinct advantages and disadvantages in comparison to single-case designs. The evidence from multiple cases is often more compelling, and the overall study is therefore regarded as being more robust'.* The number of cases is debated in the literature with no ideal number stated. Eisenhardt (1989) argues that a number of between four and ten usually suffices. Miles and Huberman (1994) state that more than 15 cases is not advised as they can result in unwieldy volumes of data with a loss of detail. A number greater than 15 is suggestive of a survey research approach.

Three case studies were chosen for this study. This was partly because they were a convenient sample and were available and in order to cover a spectrum of offsite technologies. The intention was not to specify an ideal number of cases but to ensure the data gathered reached saturation and to enable the sufficient generalisations of the findings. In addition, the author was aware of practical consideration of time and resource constraints. There was a limited period of time to conduct and complete the research.

4.5.2 The ergonomic tool

The ergonomic audits were conducted, with the presence of an external ergonomic consultant with the aid of an ergonomic assessment tool, this formed the ergonomic “tool”. These had originated from several sources, their development and history is outlined in the following sections.

4.5.3 ABA assessment tool

The ABA ergonomic assessment tool was developed by the external consultant and was used for assessing ergonomic risks in the case study areas. The background expertise of the external consultant comprised six years expertise in conducting ergonomic audits in manufacturing combined with competence in implementing ergonomic change programmes in a major UK car manufacturing plant. The tool (Appendix K) is in the form of a checklist, with sections (e.g. “extension of arms”, “high/overhead work”). The assessor ticks one box in each section depending on the situation for that task or workplace. Each section is scored either “green”, “amber” or “red”[6] depending on the extent of any ergonomic problem, thus indicating any action required. These scores are combined to give an overall score for the whole assessment. The ABA tool is designed to give an appraisal of the situation to highlight problems for detailed analysis.

4.5.4 Revising the tool

The use of checklists as an approach to workstation assessment was considered by the author and it was decided that the checklist approach was suitable for the following reasons: they had been trialled in the past and the ergonomics training received by the author had emphasised the use of checklists and included practice in using them. The checklists were useful for reminding the assessor of the ergonomic aspects to be considered when assessing a workstation or task. They also achieve a consistent approach across different workspaces and have the advantage of giving the offsite facility managers confidence in that the assessment is being conducted in a formal manner. Thus the main form of assessment was using the checklist tool. The following section discuss the changes to the content, the procedure adopted and the pilot test.

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[6] Green = design objective met, amber = action required, red = high priority action required.

4.5.4.1 Content and layout

The ergonomic tool as supplied, was adapted to suit the requirements of this research. The revision process involved checking the content, and accuracy of the tool; conducting pilot activity to test usability and provide notes to ensure consistent use. This led to the final tool that was used in each of the case study facilities.

The tool as supplied was revised to ensure that:

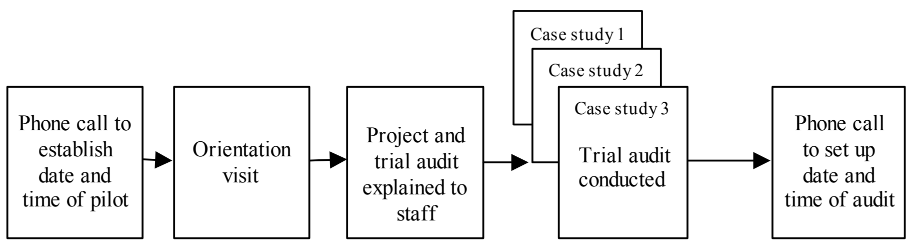
- it was easy to use;
- it was appropriate for offsite manufacture and was ergonomically correct;
- it served the purpose in identifying ergonomic risks; and,
- it could be used without any changes across the offsite facilities.

Notwithstanding the revisions made, the author was aware of some deficiencies in the ABA checklist; there was no provision for physical injury (cuts, bruises etc); head and neck positions; arm or elbow extension (except reaching). The vibration section did not cover hand/arm and whole body vibration separately. However, these limitations are covered in the ABA guidelines (see Appendix L) of notes of what to consider when considering each section. Relevant notes were taken by the author during the assessment.

4.5.5 Pilot test

The author arranged the trial audits and accompanied the ergonomic expert in the ergonomic assessments of tasks. The diagram Figure 4.4 shows the process of the pilot ergonomic audits.

Figure 4.4 Process of the pilot ergonomic audits



The trial of the ABA tool was carried out with three offsite manufacturing companies who were nominated at the second steering group meeting and would make up the main investigation of phase II see section 5.4. They were selected based on the range of offsite manufacturing tasks, and the coverage of non-volumetric and volumetric offsite categories.

This was used as it was seen as a practical approach, giving the time and resource constraints of the project. The trials followed a similar process in each offsite facility an initial phone call to the offsite facility enabled the time and date for the trial audit to be determined. This was followed by a factory orientation visit to discuss the research project and audit assessment approach with the management team, introduce the ergonomic consultant and discuss the role of the facilitator in the use of the tool. Health and safety induction was completed at the start of each visit. The staff working at each assembly line that would be used for the pilot were introduced and the location of the auditor during the audit process established to minimise any disruption to production. The trial audit was then conducted.

The factory trial and testing activities of the ABA checklist was devised in order to:

- find out how the facilitator and experts role would interact with the operatives in the factory;
- discover any problems or barriers in using the checklist;
- gain an understanding of how to involve the operatives at the workstation.
- understand the authors' role as facilitator;
- understand any potential barriers that may occur;
- pilot the tool.

This allowed the wording and layout of the checklist to be tested to see how effective and useful it was when used in combination. In addition, re-formatting of the sections enabled a more logical wording flow. A number of points from the pilot activities were:

- the wording of some of the questions needed to be changed, to remove ambiguity;
- some of the questions were repeated in different sections;
- the restriction of "yes" or "no" was inappropriate in some instances, e.g. "the work requires twisting or bending the torso", needs to be changed to specify the frequency of such twisting or bending;
- some sections needed additional questions, e.g. more on the environmental section;
- not all questions were applicable.

Finally, each trial audit was completed with a phone call to discuss follow up meetings with managers on areas of interest for the main phase of investigation.

4.6 Phase III

Phase I identified the activities and risks for insitu construction. Phase II verified the offsite risks from phase I and identified offsite residual risks in the offsite manufacturing facilities studied. These combined to inform the database within the HASPREST CD. Phase III verified the risks and residual risks identified and examined process changes within the three case study organisations to determine if they had changed since the initial investigation.

Phase III used three semi-structured interviews and direct observation from three of the case study organisations as described in section 4.5.1. Interviews, similar to questionnaires may have varied formats, for example they can range from informal interviews, exploratory interviews, standardised interviews, semi-structured interviews and group interviews (Oppenheim 1992: 65-79). In the unstructured informal interview, a series of open ended questions are used to explore issues around a central theme. Oppenheim (1992: 66-67) discusses interviews, '*the purpose of the exploratory interview is essentially heuristic: to develop ideas and research hypotheses rather than to gather facts and statistics. It is concerned with trying to understand how ordinary people think and feel about the topics of concern to the research'*. Standardised interviews are used in large surveys '*the purpose of standardised interviews in the typical large-scale survey is essentially that of data collection'*. The semi-structured interview is suitable for collecting more specific data and Bryman (2004: 113) states that *'this is a term that covers a wide range of instances. It typically refers to a context in which the interviewer has a series of questions that are in the general form of an interview schedule but is able to vary the sequence of questions. The questions are frequently somewhat more general in their frame of reference from that typically found in a structured interview schedule. Also, the interviewer usually has some latitude to ask further questions in response to what are seen as significant replies'*. The use of semi-structured interviews was selected because it allowed the activity and risks topics identified in phase I and II to be discussed, while still allowing flexibility for the respondents to discuss issues that they felt were important. Bryman (2004: 113) argues that '*some writers see this term (group interviews) as synonymous with the focus group, but a distinction may be made between the latter and a situation in which members of a group discuss a variety of matters that may be only partially related'*.

4.7 Summary

This chapter has described the research approach and methodology. A qualititative approach was used for the study. Phase I involved expert opinion and involved two expert group interviews. The participants were selected using non-probability quota sampling. The experts were selected from the HASPREST steering group members. Phase II involved three case studies of offsite manufacture facilities using observation and ergonomic risk assessment using an ergonomic toolset. The ergonomic assessment of risks was conducted with an ergonomic consultant. Pilot testing of the toolset ensured that the checklists were designed to be as manageable as possible. Phase III involved semi-structured face to face interviews and observation with the same three case study offsite manufacturers. These together have provided a methodological framework for the design of the research and collecting the data. The analysis and results are outlined in the next chapter

5 OFFSITE AND RISKS: RESULTS AND EVALUATION

5.1 Introduction

The previous chapter outlined the methodology. This chapter reports the results and evaluation of the three main phases of investigation. The chapter is organised in accordance with the sequence of the phases. Chapter 6 presents the supplementary work of the thesis which combined to produce the HASPREST risk management tool (see Appendix A). Together, they disclose an impression of risk in the case study factories with regard to offsite manufacture. The main findings suggest significant risk mitigation using offsite in place of insitu construction. Chapter 8 concludes the thesis by suggesting further in-depth study of offsite risk in the wider offsite manufacturing organisational context. The discussion of the results in relation to the existing body of knowledge is presented in Chapter 7.

5.2 The phases

The investigation commenced with two expert panel group interviews (phase I) to identify the main activities and risks associated with the designated insitu construction elements and the equivalent offsite manufactured element and or module. The group interview used expert opinion drawn from the project steering group members. The findings from phase I, the activities and risks, were taken to a series of ergonomic audits (phase II) in the offsite manufacturing facilities that formed the case study organisations. The results of phase I and II combined to inform the *offsite health and safety issues for OSP (offsite) products* section of the HASPREST risk management tool. The use of specific examples indicating how the data was translated into the tool are included for clarity in section 5.3.7, 5.3.8, 5.3.9 and 5.4.5.1, 5.4.5.3 and 5.4.5.5. Phase III, used a series of face-to-face follow-up semi-structured interviews, with selected respondents from three of the case study offsite manufacturing companies. The interviewees were senior managers responsible for health and safety. Phase III evaluated the results from phase I and II to determine if the risks had changed. The phase investigated if the offsite manufacturers had changed production processes in the last six years, what risks identified in phases I and II had been addressed and also gained an understanding of residual risks. This approach, enhanced the overall investigation, yielded rich data and provided a review of offsite risk and residual risk over an extended time period. There was a six year period between the data obtained from phases I and II, and that obtained in phase III. Bryman (2004: 186) discusses sampling dates, '*one important factor is whether the focus will be on an issue that entails keeping track of representation as it happens, in which case the researcher may begin at any time and the key decision becomes when to stop, or whether it is necessary to go backwards in time to select media from one or* *more time periods in the past*'. As phase III intended to examine if there was a marked change in the risks identified in phases I and II, the chosen sampling dates can assist in identifying any risk changes over time. These sampling dates were considered justified as they addressed concerns expressed by Bryman (2004: 187) *'First, there is the concern, with being able to establish change by tracking back in time to earlier issues of the mass medium being analysed'*. Comparison of earlier results assisted in the identification of offsite risk change in the case study companies.

The phase objectives (4.4.2) and the research design (4.3) were reviewed, prior to the analysis of the data. The results are presented in the order of the group interview schedule, ergonomic audit checklist and semi-structured interview headings as specified in the interview proforma. The presentation of each discrete phase (I, II and III) follows a regular pattern namely, results, discussion or learning points and key conclusions and aims to provide a logical flow to the argument. Discussion of the results in relation to the existing body of knowledge is presented in chapter 7. The results of phases I and II have been published in the industry version of the HASPREST risk management tool (McKay et al. 2004), which combined with the supplementary work contributed to the funded research project.

5.3 Phase I

There were two group interviews, in addition to the four project steering group meetings held as part of the research project management and administration. The agendas used at the project steering group meetings is provided in Appendix B. The intention of the group interviews was to expand on the data gathered during the literature review and to identify the main activities and risks associated with the designated insitu construction and the equivalent offsite manufactured unit/element. The group interviews gathered qualitative information about the activities and risks for insitu construction and offsite manufacturing. The data used for analysis involved a combination of completed schedule forms distributed during the meeting and collected at the end, interview notes taken by the author, the observation notes of meetings, workshop notes, minutes from the group meetings and information and documents from the offsite manufacturing companies. Because the group can be tailored to meet the needs of the data to be gathered, it is a very flexible tool which provides a rich source of information on specified topics (Bryman 2004: 353).

5.3.1 Group interview attendants

Experts in their field were selected from the steering group committee, this was an essential part of the group interview. They were chosen based on their ability to interact with other group members and that they had an interest in the research. The number of group participants was controlled, this ensured that the group interacted in a complimentary fashion in the group session see (Bryman 2004: 357-358). The group interviews involved representatives from offsite manufacturing, construction and health and safety. These included offsite production personnel, consultants, designers and health and safety construction managers. Throughout the course of the project, key members of the group were interviewed several times for varying research purposes and were contacted on a regular basis for specific research issues during the study period. Table 5.1 indicates the group attendants and their expertise.

Table 5.1 Group interview attendants (reproduced for convenience)

Name*	Position/organisation	Role/Experience
A	**Reid Architecture (now 3D Reid)**	• architect responsible for health and safety issues • experience in health and safety • 10 years experience in the use of offsite products
B	**Revolutionary Pod Modules**	• Director of production services • responsible for health and safety • 12 years experience in the offsite manufacture of pods
C **D**	**Caledonian Building Systems Ltd**	• Director of production services • responsibility for health and safety • 20 years experience in the offsite manufacture of modular buildings
E **F**	**Trent Concrete Ltd**	• Managing Director responsible for health and safety • experience of production operations • 20years experience of precast cladding manufacture
G	**UMIST**	• Senior lecturer in health and safety • construction health and safety consultant and advisor • 20 years experience in construction health and safety
H	**Structherm Building systems**	• Structural designer of composite wall panels • responsible for health and safety • 5 years experience of offsite manufacture of pre-cast wall panels
I	**Trades Union Congress (TUC)**	• Senior Trades Union Representative with health and safety expertise • experience of construction health and safety issues • 10 years experience construction trades health and safety matters
J	**Innogy Plc**	• Project Manager responsible for health and safety • experience of construction health and safety • 15 years experience of offsite for the petrochemical industry
K	**Innogy Plc**	• Site manager responsible for health and safety • experience of construction health and safety • 10 years experience of offsite for the petrochemical industry
L	**Carillion Construction Ltd**	• Senior manager responsible for construction health and safety • 20 years experience of construction health and safety
M	**Crown House Engineering**	• Manager responsible for health and safety • 10 years experience in the production of offsite mechanical and electrical modular units

*Abbreviated for anonymity.

Notes: List of group interview members (August 2003), changes may have taken place since this date. F replaced E (March 2006), D replaced C (July 2006).

5.3.2 Offsite activity of group interviewees'

This section summarises the main offsite activity of each of the offsite manufacturers present in the group. This provides background information, that informs the reader about aspects of the decision-making process within the group. The offsite manufacturers in the group selected elements and topics that were relevant to their experience and current offsite production.

The group interviews were limited to the eleven participants as indicated in Table 5.1, this was to ensure that each participant was able to voice their opinion and contribute to the discussion. The offsite manufacturers involved were active across the following levels of offsite: non-volumetric, volumetric and modular production systems. The manufacture of the units and elements used the main types of materials, including timber, steel and concrete (Table 5.2). This cross-section of offsite assists in the development of an offsite risk management tool by providing coverage of offsite use across a broad material range.

Table 5.2 Summary of offsite level and production systems

Offsite manufacturer and build system	Production system
Trent Concrete Ltd **Non-volumetric, concrete** Pre-cast concrete Cladding - heavy commercial face finished	• manual construction of timber moulds • manual assembly of reinforcement • placing of concrete • mechanical storage of units
Structherm Building Systems **Non-volumetric, concrete** Prefabricated non-load bearing wall panels	• manual assembly of steel moulds • manual assembly of light steel mesh reinforcement • manual assembly of light foam infill core • placing of concrete • manual finishing of units
Revolutionary Pod Modules **Volumetric, light steel** Washroom pods	• manual assembly of light gauge steel frame • manual assembly of gyproc wall panels • manual fixing of wall and floor tiles • manual installation of fittings and washroom components and finishes
Crown House Engineering **Volumetric, light steel** Steel frame mechanical and electrical service modules, horizontal service distribution units	• manual assembly of steel frame • manual assembly and fitting of all plant and equipment
Caledonian Building Systems Ltd **Modular** Steel frame, steel sheet, timber panel and gyproc panel lined modular buildings	• manual welding and assembly of steel frame modules • manual installation of insulation • manual installation of galvanised steel sheet wall • manual installation of medium density fibreboard wall and ceiling panels • manual installation of gyproc wall and ceiling panels • manual fixing of joinery and accessory internal fittings and fixings

Notes: Data supplied by group members (August 2003). Categories and production systems condensed for use in this thesis.

5.3.3 The group interview schedule

The first group interview

This section summarises the group interview schedule. The schedule used for the first group interview was as indicated in Appendix C, this was developed by discussion with the project group and was guided by the need for the identification of activities and risks associated with insitu and offsite manufacture. The issues were discussed in depth, and the schedule aimed to reach saturation in identifying those activities and risks relevant to the topics discussed. The following points were covered:

- participant introduction, background and interest in the research;
- particular area of construction and or offsite manufacture;
- identification of the main building elements for analysis;
- list of activities associated with the methods of each insitu construction phase;
- list of risks associated with each insitu construction phase;
- list of activities associated with the methods of each offsite manufacture phase;
- list of risks associated with each offsite manufacture phase;
- opinion/evidence for each risk;
- in-depth information on issues which arise from the findings from the steering group meetings.

The second group interview schedule

The schedule used for the second group interview was as indicated in Appendix D. The second group interview reviewed the results from the first group interview and discussed how the risk changes from insitu to offsite for each activity. The interview compared the risks identified for insitu and offsite, discussed what risks were removed by offsite, what risks were similar, what risks were reduced and what were considered new risks particular to offsite. The discussion of how the risk change from the insitu situation to offsite for each activity adopted a risk change code. The following points were discussed;

- verify activities associated with the methods of each insitu construction phase;
- verify risks associated with each insitu construction phase;
- verify activities associated with the methods of each offsite manufacture phase;
- verify risks associated with each offsite manufacture phase;
- discussion on evidence for each risk;
- provide key comments on risk change;

- information on how the risk changes from insitu to offsite;
- codify how the risk changes from insitu to offsite, more likely or less likely risk.

The risk change from insitu to offsite was coded as follows; S (no change), R (risk removed), A (additional risk), LL (less likely), ML (more likely), LC (less serious consequence), MC (more serious consequence), C (more controllable). The group interview schedules were provided for the facilitator (the author), and notes were taken during the discussion. The next section reviews the actual procedure during the group interviews.

5.3.4 The group interview procedure

The group interviews were conducted at Loughborough University, on a week day afternoon. A quiet room was provided, chairs were provided around a large desk so that all participants could see the facilitator and overhead projector screen. A period before the beginning of the group interview allowed the participants the opportunity to introduce themselves to each other informally. The discussion lasted for approximately three hours, during which the participants were asked to explain their suggestions, notes were recorded by the facilitator of the key issues discussed and points agreed.

5.3.5 Phase 1 results - main building elements

Each participant was asked to list an appropriate element for inclusion in the analysis. The participants decided to use three main headings; major buildings, civil engineering and engineering construction (Table 5.3). Under these headings a list of elements were generated for subsequent discussion and analysis. The headings and element list was not exhaustive, and was deemed to provide sufficient coverage given the constraints of time and resource available. In addition, due to the small sample size the author was aware that the results were not conclusive enough to provide total coverage of all offsite. The participants discipline also reflected the choice of headings and building elements. For example a precast concrete offsite manufacturer, selected major building with cladding elements as this would be more appropriate to his discipline, whereas a pod manufacturer would select washrooms. Table 5.3 indicates the main headings and associated list of building elements selected for analysis as defined by the first expert group interview.

Table 5.3 Main heading categories and elements

Category heading		List of elements
Major building		
	Buildings - substructure	excavations inspection chambers piling pad foundations
	Buildings - structure	insitu concrete vs. steel & pre-cast brick/bockwork walls vs. concrete panels brick/bockwork walls vs. timber panels
	Buildings - cladding	insitu brick/bockwork walls vs. precast concrete (unfinished) insitu brick/bockwork walls vs. precast concrete (finished) stick vs. unitised curtain wall stick vs. panellised curtain wall built-up sheets vs. composite panels
	Buildings - roofing	asphalt/bitumen vs. composite panels built-up sheets vs. composite panels
	Buildings - internals	drylining vs. demountable partitions suspended ceilings washrooms/kitchens
	Buildings – services/ modules	mechanical and electrical – source units mechanical and electrical – vertical distribution mechanical and electrical – horizontal distribution
Civil engineering		excavations inspection chambers piling bridges A precast concrete bridges B steel bridges C hybrid culverts tunnels
Engineering construction		excavation inspection chambers piling pad foundations insitu concrete vs. steel and precast frame built up sheets vs. composite panel cladding process plant source process plant distribution

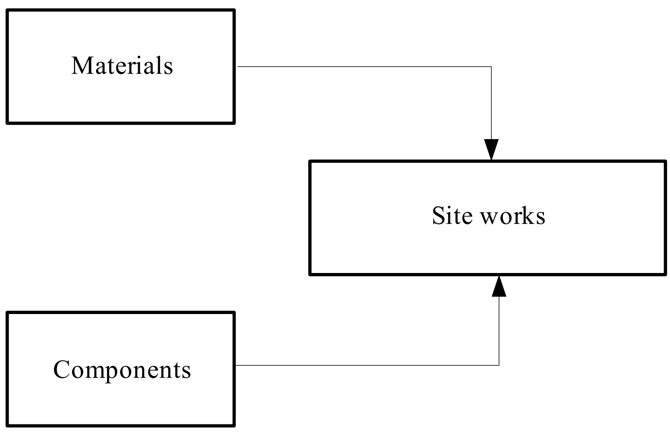
Notes: Categories and elements defined at the group interview, April 2002.

5.3.6 Phase I results - information required for each element

The participants of the group interview discussed the activities for the insitu solution and the equivalent offsite solution. The group was then asked to suggest information about the risks associated with each activity. Any comments were also recorded. Therefore the presentation of the results section is organised to include the product/unit under consideration and the sequence of activities associated with the production of that product/unit. The section presents examples from each major offsite category, non-volumetric, volumetric and modular building using the building elements/units; cladding heavy commercial, washrooms and modular building. Phases I and II activities and risks provide examples of how the combined data was translated to inform the risk management tool. The full database of building, civil engineering and engineering construction activities and risks for the remaining building elements/units (17 tables of elements) which formed the supplementary work are presented in Appendix J.

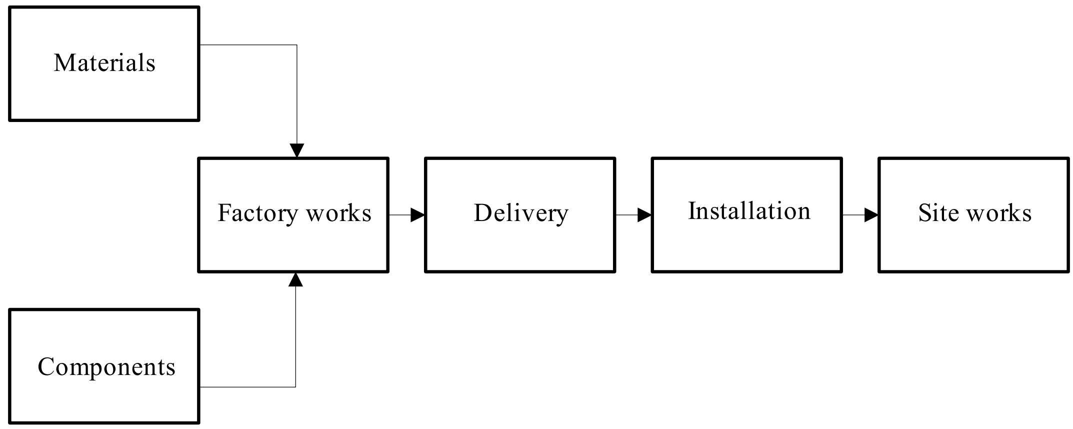
The process of presenting the data followed a similar pattern, first the activities and risks for insitu construction were listed these included components (fixtures and fittings), followed by the main insitu site works activities and risks see Figure 5.1.

Figure 5.1 Insitu situation



Then the equivalent main activities and risks for the offsite solution were presented, these included components (fixtures and fittings), factory works, delivery, installation and the main site works; ancillary work for example connection to adjacent units/buildings, activities and risks see Figure 5.2. The activities were based on the insitu construction of the unit "versus" the offsite manufactured equivalent. The first example discusses activities based on insitu brick/blockwork verses precast concrete face finished panels. The responses in the following sections are denoted by a reference code for example [B] which identifies the respondent see Table 5.1.

Figure 5.2 Offsite situation



5.3.7 Trent Concrete Ltd, non-volumetric cladding panels

Insitu brick/blocklaying components; fixtures and fittings activities and risks

The main insitu fixtures and fittings activities were discussed, the following activities were highlighted; delivery of base materials to brick/block ready mix suppliers. Mix clay, place in moulds and fire bricks at works, transport and deliver bricks and mortar to site [E]. The main risks were claimed to be those associated with the transport of the bricks/blocks to the site; road traffic, site access, site conditions and mechanical handling during off-loading [E]. Further discussion of the risks and the change in risks are presented in section 5.3.7.1.

The following section discusses the main offsite activities and risks for the manufacture of precast concrete cladding panels see Figure 5.3 (all photographs in this thesis were taken by the author unless stated otherwise).

Figure 5.3 Offsite manufactured precast concrete cladding panel

Precast concrete cladding panels main offsite activities and risks

Interviewee E described the main offsite activities as; delivery of base materials to site, setting up moulds, placement of brick slips or architectural finish in mould, the assembly of reinforcement and the placing of reinforcement in mould, form box-outs, mix concrete, vibrate and compact concrete in mould, remove mould and store cast cladding panel, transport and deliver panel to site, transport and deliver plant to site [E]. The offsite risks were highlighted as; mechanical handling and craneage of large moulds. The placing of concrete included, craneage, dermatitis, manual handling and musculoskeletal (MSDs) risks. In vibrating and compacting the concrete, the main risks highlighted were dermatitis, hand arm vibration (HAVS) and whole body vibration for large moulds on vibrating platforms. In forming box outs, risks discussed included dermatitis and MSDs. Mechanical handling and craneage risks were identified in moving and storing the panels. Transporting and delivering the panels to site incurred road traffic, mechanical handling and offloading risks [E]. Further discussion of the risks and the change in risks see section 5.3.7.1.

Insitu brick/blocklaying main site works activities and risks

The main insitu site works activities were discussed, the following activities were highlighted; placing and compaction of ground beam concrete, prepare the site for bricklaying/blocklaying, set out corners, transport bricks/blocks, carriage of bricks/blocks to workplace, erection of work platforms, mix mortar, cut bricks/blocks, laying mortar, laying of each course of bricks/blocks, fix wall ties, fix mesh reinforcement, place lintels and damp proof course (DPC), pointing and finishing and ancillary site risks [E]. The main risks were claimed to be those associated with; dermatitis and concrete burns, the repetitive task of transporting bricks/blocks which it was claimed can cause manual handling injury, (MSDs), cuts and dermatitis. In addition, the risk of falling bricks/blocks, working on unstable ground, trips and falls, walking into objects or projections and exposure to ultraviolet (UV) light from working in sunlight were noted. In the erection of platforms used in bricklaying, working at heights was flagged as an important risk. The mixing of mortar involves the risk of dermatitis, dust inhalation, contamination of eyes and skin, manual handling and exposure to UV light. Brick cutting risks included, struck by cut brick from saw, electric shock from the use of electric powered cutting tools, dust contamination, splinter contamination to eyes and skin, noise and exposure to (UV) light. It was claimed that the laying of mortar involved, manual handling, repetitive strain injury (RSI), musculoskeletal disorders (MSDs) and working at height. Bricklaying, may risk working at height, exposure to (UV) light, manual handling, work in confined space; resulting in the risk of strain injury, dermatitis and repetitive tasks (RSI). In the fixing of wall ties, mesh reinforcement and damp proof course (DPC) it was claimed that the risks include, repetitive tasks (RSI), cuts and splinters. Pointing and finishing had the following risks, working at height, work in confined space; resulting in the risk of strain injury (RSI), dermatitis. Ancillary site risks were claimed to be slips, trips and falls [E].

Precast concrete cladding panels main site works activities and risks

Interviewee E described the main site works activities as; preparation of site for panels, movement of panels to required position, connection of panel to frame, jointing of panels, jointing using mastic/sealant and finishing [E]. The associated main risks were highlighted as; mobile plant risks involving the craneage of large loads, with the possibility of crush and hand injury [E]. The next section discusses the risks providing a contextual understanding of the main risk change and the main benefits in the use of offsite over insitu construction.

5.3.7.1 Precast discussion

A number of observations were made from the second group interview in relation to the effect offsite had on risk. The second group interview verified and compared the risks identified for insitu and offsite, discussed what risks were removed by offsite, what risks were similar, what risks were reduced and what were considered new risks particular to offsite. The discussion of how the risks change from the insitu situation to offsite with selected activities providing examples are presented.

Risks removed by offsite

The group interview revealed key benefits of the usage of offsite where the risk is eliminated. The risk of working at height was emphasised within the activity of bricklaying from work platforms. As was explained by interviewee E, the use of pre-cast panels with brick slips[7] eliminated working at height as the slips could be positioned with the mould orientated horizontally at bench height, a major benefit in eliminating this serious risk type using offsite.

Risk changes – amelioration of risks

Furthermore, three risks were claimed to be more controllable and of a less serious nature in the transition from insitu to offsite, this helps to explain the changes in risk which the take-up of offsite has had on the manufacture of products/units. The placing of slips and architectural finishes were less likely to incur cuts, dermatitis and manual handling strains. Less trade overlap and a more controlled factory environment with moulds orientated to suit ease of installation.

Activities with similar risks

The group members stated strongly that in specific activities; the delivery of base materials; setting up moulds, mixing, placing and compaction of concrete and site preparation, the risk was claimed to be the same for both insitu construction and offsite. The suggestion is that there are certain activities where the risk remains unchanged regardless of the construction technique or technology used.

Additional risks

The group interview revealed a number of risks, that were apparent due to the offsite techniques and which were not present, at least to the same extent in insitu activities. These relate to the size and weight of the products/units. The vibration of large panels during

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[7] Brick slips - Thin bricks which can be applied, bedded, to stable backgrounds of concrete or masonry to simulate the appearance of conventional brickwork. Source: http://www.bricklogic.co.uk/brick_slips.asp [12/04/2009])

casting create a risk of whole body vibration during compaction and the movement and storage of large panels where hand injuries and panel fall or sling failure have a more serious consequence.

5.3.7.2 Key conclusions – precast concrete

The main risks associated with the insitu solution (components; fixtures and fittings) were claimed to be associated with the transport of materials, road traffic, site access, site conditions and mechanical handling. The main risks associated with insitu site works were claimed to be associated with dermatitis and concrete burns, repetitive tasks, manual handling and (MSDs) associated with transporting materials, cuts, falling material, working on unstable ground, trips and falls, exposure to UV light. It was claimed that working at height in the construction of brickwork for cladding was a key risk removed in the offsite solution using precast cladding panels. Dust inhalation, contamination of eyes and skin, electric shock, noise, work in confined space and the associated risk of repetitive strain injury (RSI) were recorded.

The main factory risks associated with the offsite solution were claimed to be mechanical handling associated with craneage of moulds, manual handling and cuts from reinforcement assembly, dermatitis and (MSDs), hand arm vibration, whole body vibration. These risks were claimed to be more controllable in the factory than on site. In transporting the precast units, the risks were claimed to be road traffic, mechanical handling and offloading risks. The risks associated with installation and site works of the finished offsite precast units were claimed to be the more serious consequence of panel fall, mobile plant risks and the possibility of crush injury in connection and jointing of the panels on site an additional risk compared to insitu.

The risks in the case studies were taken to a series of ergonomic audit and observations phase II (see 5.5). These combined results were then verified during the second group interview. The activities, risks, the risk change and comments were then summarised in tabular form to inform the risk management tool HASPREST (see 5.4.5.2).

5.3.8 Revolutionary Pod Modules, volumetric washrooms

Insitu washroom construction components; fixtures and fittings activities and risks

The main insitu components; fixtures and fittings activities were discussed, the following activities were highlighted; manufacture of base materials and fittings, these were claimed to be part of an industrialised process outside the scope of this study. Transport of materials and fittings to site, delivery to place of installation [B]. The main risks were claimed to be those associated with the transport of the materials and fittings to the site; road traffic and manual handling. The following section discusses the main offsite activities and risks for the offsite solution of a washroom toilet pod see Figure 5.4.

Figure 5.4 Offsite manufacture of washroom toilet pod

Washrooms (pods) main offsite activities and risks

The following main offsite activities were discussed by interviewee B as; manufacture of materials and fittings, these were claimed to be part of an industrialised process outside the scope of the study. Delivery of manufactured materials and fittings to factory, assemble pod structure; the cold rolled light steel frame, base and top are erected and made square. The 1st fix services are installed on supports and battens, the pre-cut internal gyproc partition and wall panels are installed, the internal fitting out begins with 2nd fix services and any internal partitions are installed. The installation of wall and floor tiles, the fittings are installed, the interior is decorated, final fix services; shelves and work units are installed, the fixing of plumbing and electrical services to the pod are installed, the commissioning and testing of the services; electrical services and plumbing is completed. The pod doors are installed. The pod is then prepared for transportation; wrapped in waterproof sheeting and loaded onto transport before transported and delivered to site [B].

The associated main risks were highlighted as; manual and mechanical handling, (MSDs), cuts from the assembly of the steel channels that form the frame, overhead work, MSDs and cuts from working inside the pod during tiling operations and fitting services, crouching and work in restricted areas. In the commissioning of the pod the risks were electrocution and work in congested areas. The risks associated with loading the pod onto transport included (MSDs) and craneage. Transporting and delivering the pods to site incurred road traffic, offloading risks; craneage [B]. Further discussion of the risks and the change in risks is discussed in section 5.3.8.1.

Insitu washrooms main site works activities and risks

The main insitu site works activities were discussed, (the following activities relate to the construction of a washroom within an existing building), the blockwork and brickwork forming the partition walls are erected, a floor screed is applied, plaster to walls and ceiling is applied, the 1st fix joinery, plumbing and electrical wiring are installed. The tiling to walls and floor is applied, the 2nd fix joinery and plumbing and electrical work is carried out, a suspended ceiling (if required) is installed, the accessories are installed, the 3rd fix joinery, plumbing and electrical work is completed. Commissioning of the washroom is carried out [B, E]. The main risks were claimed to be those associated with; manual handling of materials, dermatitis from handling the blockwork, the repetitive task of transporting blocks which it was claimed can cause manual handling injury, (MSDs) and cuts. In addition, the risk of working at height from step ladders and high overhead work were noted in the installation of suspended ceilings. In the installation of each stage of joinery, plumbing and electrical work, cuts, crouching in restricted work areas, congested work areas with trade overlap were flagged as important risks [B, E].

Washrooms main offsite site works activities and risks

During the installation of the pod the main site works activities were identified as: installation of pod to floor level, movement of the pod across the floor, placement of pod in position, service connection, commissioning and ancillary site work [B]. The associated main risks were highlighted as; craneage of the pod, with the possibility of crush and hand injury. The movement of the pod, it was claimed risks (MSDs), cuts, slips, trips and falls from the pod and temporary works [B]. The next section discusses the risks providing a contextual understanding of the main risk change and the main benefits in the use of offsite pod manufacture over insitu construction.

5.3.8.1 Pod discussion

The responses from the second group interview in relation to the effect offsite had on risk with selected activities providing examples are presented.

Risks removed by offsite

The group interview revealed key benefits of the usage of offsite where the risk is eliminated. The risk of working at height from step ladders was emphasised within the activity of fixing plaster to walls and ceiling. As was explained by interviewee B, the manufacture of pods eliminates work at height as the pods can be positioned and orientated to eliminate work at height, a major benefit in eliminating this serious risk type using offsite.

Risk changes – amelioration of risks

Three of the risks were claimed to be more controllable and of a less serious nature in the transition from insitu to offsite pod manufacture. The assembly of the pod structure is more controllable in the factory, thus the risk of MSDs, cuts and strains from manual handling were less likely. The installation of fittings and decoration was stated as having less trade overlap a benefit of a more controlled production approach in a factory environment. In addition, it was claimed that the commissioning of the pods services would be easier to control in a factory.

Activities with similar risks

The group members stated that in specific activities; the manufacture of materials and fittings were claimed to have the same risk for both insitu construction and offsite. The operations involving site preparation, tiling of the floor and ceiling of the pod was considered to involve similar risks to insitu. The suggestion is that there are certain activities where the risk remains unchanged regardless of the construction technique or technology used.

Additional risks

The group interview revealed three additional offsite risks, these relate to the size and weight of the pod, the risk of MSDs, cuts, slips, trips, falls and temporary works collapse from pushing and pulling the pod into position and the risk of a more serious consequence should the pod fall during the transport, delivery and installation phase.

5.3.8.2 Key conclusions – toilet pods

The main risks associated with the insitu solution (components; fixtures and fittings) were claimed to be associated with the transport of materials, road traffic and manual handling. The main risks associated with insitu site works were claimed to be associated with the manual handling of the blockwork, (RSI), dermatitis, overhead work and working at height from step ladders. The overlap of trade work, joinery and plumbing gave rise to congested areas with the risks associated with crouching and working in confined areas.

The main factory risks associated with the offsite solution were claimed to be manual handling and mechanical handling, (MSDs), cuts from the assembly of the steel channel, overhead work, and crouching and working in confined spaces inside the pod during tiling. In transporting the pods, the risks were claimed to be road traffic, craneage and manual handling. The risks associated with installation and site works of the finished pod were claimed to be slips, trips and temporary work collapse and the possibility of cuts injury in connection of the pods on site.

5.3.9 Caledonian Building systems, modular buildings

Gibb (1999: 155), provides a useful definition of modular buildings; *'Modular building units differ from volumetric units in that they form all or part of the complete building or facility. Most units are fully fitted out, requiring only minimal site works, however others form the main structure but require finishes to be added after installation'*.

Insitu building construction components; fixtures and fittings activities and risks

The main insitu components; fixtures and fitting activities were discussed, the following activities were highlighted; manufacture of base materials and fittings, these were claimed to be part of an industrialised process. Transport of materials and fittings to site, delivery to place of installation [C]. The main risks were claimed to be those associated with the transport of the materials and fittings to the site; road traffic and craneage. The following section discusses the main offsite activities and risks for the manufacture of modular buildings see Figure 5.5

Figure 5.5 Offsite manufactured modular building

Modular building main offsite activities and risks

The following main offsite activities were discussed by interviewee C as; delivery of manufactured materials and fittings to factory, assemble steel frame structure for the module; the steel channel sections are welded together, the frame is then painted, the box sections for services are installed, main plant items (if required) are installed including pumps, control equipment, electrical cables and pipework. The rock wool insulation is installed. The galvanised steel wall sheets are installed, the medium density fibreboard (MDF) wall and ceiling panels are installed, then the gyproc wall and ceiling boards are glued and screwed into position. The services are installed. The interior is decorated, shelves and work units are installed. The external work to the module includes cladding, roof tiles, installation of upvc window units and doors. Once the modules are complete, the commissioning and testing of the plumbing and electrical services is carried out. The module is then wrapped in waterproof sheeting and loaded onto transport before transported and delivered to site [C]. The associated main risks were highlighted as; manual handling from lifting the steel frame sections, mechanical handling, (MSDs), cuts from the assembly of the steel channels that form the frame, fumes from welding operations. Overhead work and manual handling during the installation of wall and ceiling boards. The fitting out of services resulted in work in restricted areas, MSDs, cuts and hand arm vibration from power tools. The risks associated with loading the module onto transport included, (MSDs), craneage and road traffic risks. Transporting and delivering the modules to site incurred road traffic risks [C]. Further discussion of the risks and the change in risks is discussed in section 5.3.9.1.

Insitu building main site works activities and risks

The main insitu site works activities were discussed, (the following activities relate to the construction of a brick clad building), the preparation of the site including, the excavation of the foundations, determination if land is contaminated and location of services e.g. gas, formwork construction; timber shoring and shuttering, placing of reinforcement and concrete strip foundations. Site service trenches are excavated. The erection of scaffolds and platforms for the blockwork and brickwork forming the external and internal walls are erected, the floor concrete is poured, the internal walls are erected, the roof trusses are installed and lathing, sheeting and roof tiles are installed. The plaster to walls and ceiling is applied, the 1st fix joinery, plant and equipment, plumbing and electrical wiring are installed. The tiling to walls and floor is applied, the 2nd fix joinery and plumbing and electrical work is carried out, a suspended ceiling (if required) is installed, the accessories are installed, the 3rd fix joinery is carried out. The commissioning of the plant and equipment is completed [C, E]. The main risks were claimed to be those associated with; manual handling of materials (MSDs), work in contaminated land, cuts, hand injuries and dermatitis from working with formwork and placing concrete. The repetitive task of transporting blocks/bricks which it was claimed can cause manual handling injury, (MSDs) and cuts. In addition, the risk of working at height from scaffolding and ladders and high overhead work were noted in the installation of suspended ceilings, brickwork and roofing work. In the installation of each stage of joinery, plumbing and electrical work, cuts, crouching in restricted work areas, trips, falls, hand arm vibration (HAVs) from using power tools, repetitive strain injury (RSI), electrocution, congested work area with trade overlap were flagged as important risks [C].

Modular building main site works activities and risks

During the installation of the modules it was claimed that the main onsite activities are; installation of the modules to the required floor level, movement into the required position to align with services and adjacent connecting modules, connection of modules to services and drainage infrastructure [C]. The associated main risks were highlighted as; craneage of modules, with the possibility of crush and hand injury. The movement of the modules and ancillary site work; service connection risks (MSDs), cuts, slips, trips and falls [B]. The next section discusses the reduction in risks using offsite manufactured modules in relation to insitu construction of buildings.

5.3.9.1 Modular building discussion

The responses from the second group interview in relation to the effect offsite had on modular building risk with selected activities providing examples are presented.

Risks removed by offsite

The group interview revealed key benefits of the usage of offsite where the risk is eliminated. The risk of excavation of contaminated land, contact with gas, electrical services, concrete works; formwork, placing and compacting concrete are eliminated. In addition, the elimination of working at height from scaffolding and work platforms was emphasised, as was explained by interviewee C, the manufacture of modules eliminates work at height as the module can be positioned and orientated to allow ease of access.

Risk changes – amelioration of risks

Furthermore, six risks were claimed to be more controllable and of a less serious nature in the transition from insitu to offsite module manufacture. The assemble of the module structure is more controllable and can be mechanised in the factory, thus the risk of MSDs, cuts and strains from manual handling were less likely. Less trade overlap, and a more controlled, clean factory environment with less contamination were noted during the discussion.

The group participants claimed that the risks relating to plant equipment were more controllable and of a less serious nature in the transition from insitu to offsite module manufacture. The installation of plant, pipework, cables and services were stated as having less trade overlap, a benefit of a more controlled production approach in a factory environment. In addition, it was claimed that the commissioning of the modules services would have better power-on control in a factory.

Activities with similar risks

The group members stated that in specific activities; the manufacture of materials and fittings were claimed to have the same risk for both insitu construction and offsite. The suggestion is that there are certain activities where the risk remains unchanged regardless of the construction technique or technology used.

Additional risks

The group interview revealed a number of additional offsite risks, these relate to the size and weight of the module, with risk of a more serious consequence should the module fall during the transport, delivery and installation phase.

5.3.9.2 Key conclusions – modular building

The main risks associated with the insitu solution (components; fixtures and fittings) were claimed to be those associated with the transport of the materials and fittings to the site; road traffic and craneage. The main risks associated with insitu site works were claimed to be associated with the manual handling of materials (MSDs), work in contaminated land, cuts, hand injuries and dermatitis from working with formwork and placing concrete. The repetitive task of transporting blocks/bricks which it was claimed can cause manual handling injury, (MSDs) and cuts. In addition, the risk of working at height from scaffolding and ladders and high overhead work were noted in the installation of suspended ceilings, brickwork and roofing work. In the installation of each stage of joinery, plumbing and electrical work, cuts, crouching in restricted work areas, trips, falls, hand arm vibration (HAVs) from using power tools, repetitive strain injury (RSI), electrocution, congested work area with trade overlap manual handling of the brickwork, (RSI), dermatitis, falling material and working at height. The overlap of trade work, joinery and plumbing gave rise to congested areas with the risks associated with crouching and working in confined areas.

The main factory risks associated with the offsite solution were claimed to be; manual handling from lifting the steel frame sections, mechanical handling, (MSDs), cuts from the assembly of the steel channels that form the frame, fumes from welding operations. Overhead work and manual handling during the installation of wall and ceiling boards. The fitting out of services resulted in work in restricted areas, MSDs, cuts and hand arm vibration from power tools. The risks associated with loading the module onto transport included, (MSDs), craneage and the road traffic risks. Transporting and delivering the modules to site incurred road traffic risks craneage of modules, with the possibility of crush and hand injury. The movement of the modules and ancillary site work; service connection risks (MSDs), cuts, slips, trips and falls manual handling and mechanical handling, (MSDs). The risks associated with installation and site works of the finished module were claimed to be cuts, slips and falls and the possibility of crush injury in connection of the module on site.

To sum up, the respondents provided detailed information on the activities and risks for the insitu and offsite building, civil engineering and mechanical services elements under consideration. These results were taken to the next phase of the research. Phase II involved in-depth observation and the use of ergonomic analysis. Three of the case study organisations; Trent Concrete Ltd (non-volumetric, cladding heavy commercial face finished), Revolutionary Pod Modules (volumetric washrooms) and Caledonian building Systems (modular buildings) are presented in the next section.

5.4 Phase II Ergonomic audits

This section outlines the ergonomic audit assessment using the ABA tool as detailed in section 4.5. The case studies, Table 5.4 were selected from the steering group members who participated in the research project. The selection of the three case study companies has been explained in section 4.5.1.

5.4.1 Aims of the audit

The aims of the ergonomic audit were as follows:

- to verify the activities and risks as identified in phase I;
- to systematically identify critical ergonomic issues associated with the production of the selected offsite elements;
- to gain an expert perspective on the ergonomics of offsite production;
- to provide additional information to back up the data collected in phase I.

The ergonomic audit was developed to provide ergonomic opinion of offsite tasks and operatives work practice. They provided supporting information about problems discussed at the group interviews and in the steering group meetings. They also provided more depth to the understanding of operatives risk issues and residual risks.

5.4.2 The ergonomic auditor

An ergonomist with six years experience acted as the expert evaluator, having a background in ergonomics and having formed an ergonomics consultancy to provide expert ergonomic advice. The ergonomist accompanied the author on every audit and provided expert opinion and guidance.

5.4.3 The format of the ergonomic audit

The ergonomic audit followed the format as advised by the ergonomic consultant and used the ABA tool (Appendix K). This tool takes the form of a checklist, with a number of sections (e.g. 'lifting and carrying', 'overhead work') where the auditor ticks one box in each section to indicate the situation for that job or workplace (see Table 5.5). A brief explanation of each section indicating why each section is required is presented in Appendix L. According to the degree of ergonomic problem, each section is scored either 'green' (g) = no action required, 'amber' (a) = action required or 'red' (r) = high priority action required to indicate the urgency of action, these scores combining to give an overall score for the whole assessment. The score is calculated by summing the number of "greens", "ambers" and "reds" for the activity under investigation. Space was provided on the ABA form for notes and comments regarding the ratings awarded. In the text the following definitions apply; occasional: less than 5% of shift time, frequent: between 5% and 30% of shift time and very frequent: over 30% of shift time. The ergonomic audit provided a sophisticated approach which is rarely used in construction and in most manufacturing for construction factories, its main use has been in highly advanced manufacturing e.g., BMW.

5.4.4 The ergonomic audit procedure

The audits were carried out at the following three offsite manufacturing facilities; Trent Concrete Ltd, Revolutionary Pod Modules and Caledonian Building systems. The offsite products were manufactured for the projects as detailed in Table 5.4. The audits were conducted by the author and the ergonomic consultant on the tasks and operations at each offsite manufacturer (see sections 5.4.5.1, 5.4.5.2 and 5.4.5.3).

Table 5.4 List of offsite systems* and projects list during the research project

Offsite manufacturer and build system	**Projects list**
Trent Concrete Ltd Non-volumetric, concrete	
Pre-cast concrete balconies	Kew housing, precast balconies, since 2001
Cladding - heavy commercial face finished	City gate Newcastle, office/mixed/cladding with contractor Amec, since 2002
Stone faced cladding panels	Cheltenham, new accommodation products, with contractor Carillion, commencing 2003
Cladding, pre-cast concrete	Birmingham, accommodation units with contractor R McAlpine, since 2000
Revolutionary Pod Modules Volumetric, light steel	
Bedroom pods	Apex Hotels, Dundee, commencing 2004/5
Washroom pods	Hosier Lane, London, commencing 2004
Bedroom pods	Radisson Hotel, Liverpool, with contractor Carillion, commencing 2004
Bedroom/Washroom pods	Flats, Edinburgh, Leith Docks, commencing 2004
Caledonian Building Systems Ltd Modular	
Steel frame, timber panel and gyproc lined modular buildings	Weaver Court, East Midlands Airport, since 2001

*Original data provided by the Steering Group members in March 2002, categorised for use in this thesis.

The audit form was worked through in a systematic fashion by both the author and ergonomic consultant. The aspects of the tasks were assessed using each section and criteria on the form and where relevant discussion was conducted between the ergonomist, the author and the operatives. Photographs (where permitted) were taken of those tasks and situations, which was considered by the ergonomist to be of special interest or required close consideration.

The data produced from the audit, provided back-up and verification for those risks identified from the group interviews. The offsite risks were confirmed and residual risks identified. The data produced was used to assist in the compilation of the activity and associated risks for the HASPREST tool. The summary sheets are presented in Appendix J HASPREST sheets.

5.4.5 Ergonomic audit results

The results obtained from each of the activities and operations at each offsite facility are presented in the following sections. In each case, the analysis was limited to selected activities, this was as a result of the constraints of time and availability of the ergonomic consultant, and the practical considerations of the production schedule in each case study. These limitations have been discussed in section 4.3.3. The section describes a full example of the tool for one activity (construction of the timber moulds) in the first case study; Trent Concrete Ltd, the audit form is presented for clarity (Table 5.5), then the remaining tasks are summarised in Table 5.6, the remaining two case studies are summarised in Tables 5.7 and 5.8. The risks and learning points are then discussed for each case study. The case study audit sheets are presented in Appendix M. A full set of risks are available in Appendix J HASPREST sheets.

5.4.5.1 Trent Concrete Ltd, non-volumetric, cladding panels

Four activities were examined in the production of the cladding panels these included: construction of the timber moulds, assembly and placing of the steel reinforcement, placing and compaction of concrete and storage of the finished precast units. The number of operatives ranged from two to three depending on the activity. This section describes the results of the assessment.

Construction of timber moulds - two operatives

The ABA assessment was completed see Table 5.5, the assessment revealed problems in frequent constrained standing, trunk movement and hazaourdous waste (trip hazards) in and around the moulds. The moulds are often deep and wide for access (causing uncomfortable bending and reaching).

Table 5.5 Ergonomic audit for case 1

Analysis conducted by:

LJM

Date:_15/08/2002

Work Place Data: **No: 1**

Site: Colwick, Notts

Building: Workshop 1

Work place: Factory workshop

Remarks: Construction of timber moulds for precast concrete face finished cladding panels

Number of workers involved: 2

Note: *the definitions used in the checklist are as follows:*
occasional: *less than 5% of shift time*
frequent: *between 5% and 30% of shift time*
very frequent: *over 30% of shift time*

1 Required height

Activity suitable for workers between 5' and 6'5'' in height	g	✓	
Activity more suitable for workers taller than 5' 5''	g		
Activity more suitable for workers shorter than 6'	g		
Activity more suitable only for workers with a height between 5' 5'' and 6'	**a**		

Notes:

2 Extension of arms (including shoulder joint)

Movements required for a reach up to 30cm (1')	g	✓	
Movements required for a reach up to 56cm (1'10")	g		
Reaching required beyond 56cm (1'10")	**a**		

Notes:

3* Frequent muscle load on arms and shoulders during activities when <u>sitting</u> *(nb lifting/carrying is a separate category)*

Little or no effort required (forces exerted under 10 N*)	g	✓	
Medium effort required (forces exerted under 50N)	g		
Large effort required (forces under 80 N)	**a**		
Excessive effort required (forces over 80N)	**r**		

** Example: To open a door with automatic closer takes approx. 50 N*

Notes:

4* Frequent muscle load on arms and shoulders during activities when <u>standing / walking</u> (NB not lifting/carrying)

little or no effort required (forces exerted under 25 N)	g		
Medium effort required (forces exerted under 120N)	g	✓	
Large effort required (forces exerted under 180 N)	**a**		
Excessive effort required (forces exerted over 180N)	**r**		

** Effort: Ex. To push a Rover Mini takes approx. 150*

Notes:

Confidential – not to be reproduced

5 Risk to wrist / lower arms (turning, twisting, wrist deviation, forceful movements)

occasional	g	✓	
frequent	**a**		
very frequent	**r**		

6 High / overhead work (122cm or 4')

No handling above 122cm (4')	g	✓	
occasional overhead handling with little effort (forces exerted under 10 N)	g		
frequent overhead handling with little effort (forces exerted under 10 N)	**a**		
occasional overhead handling with effort (forces exerted over 10 N)	**a**		
frequent overhead handling with effort (over 10N) or prolonged holding work	**r**		

Notes:

7 Grip

power grip only (with neutral wrist position) or occasional pinch grip	g	✓	
frequent / very frequent pinch grip	a		
difficult / awkward gripping required	**a**		

Notes:

8 Trunk movement

slight twisting and bending movements	g		
twisting under 15°, bending under 30°	g		
large movements (twist under 35°,bend under 90°)	**a**	✓	
prolonged / difficult large movements <u>or</u> full movement (twist over 35°,bend over 90°)	**r**		

9 Movement of the hip *Distinct from trunk movement*

slight movement , e.g. walking	g	✓	
moderate movement (bending angle under 90°	g		
full movement (bending angle over 90°)	**a**		
frequent or prolonged movement (bending over 90°)	**r**		

Notes:

10 Movement of the knee

slight movement, e.g. walking	g	✓	
moderate movement (bending angle under 90°), e.g. sitting	g		
full movement (bending angle over 90°)	**a**		
frequent or prolonged bending (over 90°) and/or twisting	**r**		

Notes:

11 Movement of the ankles

slight movement, e.g. walking	g	✓	
infrequent full movement of ankles e.g. reaching	g		
very frequent ankle movement <u>or</u> frequent / prolonged twisting	**a**		

Notes:

12 Lifting and carrying

no lifting or lifting of weights under 1 kg	g		
frequent lifting under 5 kg occasionally under 10 kg	g	✓	
frequent lifting under 10 kg occasionally under 18 kg	**a**		
frequent lifting under 18 kg occasionally under 25 kg	**a**		
frequent lifting over 18 kg occasionally over 25 kg	**r**		
very frequent lifting over 10 kg	**r**		

Notes:

13 Lifting and carrying (ergonomic conditions)

ergonomically favourable conditions	g	✓	
unfavourable conditions: occasional lifting and carrying	**a**		
unfavourable conditions: frequent lifting and carrying	**r**		

Notes:

14 Standing

standing with freedom to move or alternate with sitting/walking	g		
frequent constrained standing	**a**	✓	
frequent static (over half hour) standing	**a**		
continuous (over 90% of shift) static or constrained standing	**r**		

Notes:

15 Walking

walking with freedom to alternate with sitting/standing	g	✓	
constant walking	g		
walking not possible or only occasional	**a**		
constant walking in unfavourable conditions	**r**		

Notes:

16 Sitting

sitting with freedom to alternate with walking/standing	g	✓	
continuous sitting (over 90% of shift)	**a**		
sitting preferable but not possible	**a**		
continuous sitting (over 90% of shift) in ergonomically unfavourable conditions	**r**		

Notes:

17 Noise

Assessment level under ceiling value*	g	✓	
Assessment level under 90 dB(A) but over ceiling value	**a**		
Assessment level over 90 dB(A) or 85 dB(A) incl. pulsed noise	**r**		

*Ceiling value:- 55 dB(A) for mental activity
70 dB(A) for some mental/ some physical activities
85 dB(A) for mainly physical activities

Notes:

18 Climate

Climatic conditions in comfort range	g	✓	
climatic conditions outside comfort range, depending on season	**a**		
climatic conditions continuously(over 90% of shift) outside the comfort range	**r**		

Notes:

Measured values:	
illumination: Lux	________
noise : dB(A)	________
max. weights: kg	________

19 Lighting - *see reference values

Lighting at least at reference value for task at all times of day	g	✓	
Lighting below reference value for task but over 50% of level	**a**		
Lighting under 50% of reference value	**r**		

*reference values simple visual tasks over **250 Lux**
higher visual tasks over **500 Lux**
fine visual tasks over **750 Lux**

Notes:

20 Vibration

no particular discomfort caused by vibration	g	✓	
discomfort caused by vibration	**a**		

Notes:

21 Hazardous materials in the working area (E.g., corrosive, flammable, toxic substances etc.)

not present	g		
present and assessed as under 50% of **O**ccupational **E**xposure **S**tandard (OES)	g		
50% - 100% of OES or causing discomfort	**a**	✓	
over Occupational Exposure Standard	**r**		
present and not tested	**r**		

Notes:

22 Wet

not exposed	g	✓	
exposed	**a**		

Notes:

23 Driving and steering activity

no driving and steering activity	g	✓	
driving and steering activity	g		

Notes:

24 Production Incentive

time to stop (for quick break) without affecting others	g	✓	
can stop but affects others	**a**		
no time to stop	**r**		

Notes:

25 Shift work

no shift work or permanent day shift	g	✓	
2 shift work-rotated (e.g. 6am-2pm, 2pm-10pm)	g		
permanent night shift	**a**		
3 shift work	**a**		

Notes:

26 Risk (safety risks present)

no special risk in the execution of the job	g		
possible risk in execution of job, but adequate control measures taken	g	✓	
possible risk in execution of job, precautions not taken	**r**		

Notes:

KEY: the abbreviations used in the second column mean:
g = no action required (green)
a = action required (amber)
r = high priority action required (red)

NB ALL REDS SHOULD BE INVESTIGATED	
No. of ambers:3 No. of reds: 0	**Total Ergonomic Score (TES)**
no red items	**GREEN** 23
max. 2 red items and under 5 amber	**AMBER** 3
2 red items and over 5 amber **or** 3 or more red items	**RED** 0

Ergonomic assessment of mould construction - two operatives

The following explanation and commentary of the audit form is presented. Sections 1-7, 9-13 and 15-26 were considered acceptable aspects of the activities of timber mould construction for instance in sections 1-7; the operatives were working at a suitable height between 5' and 6'5", the extension of the arms and movements were acceptable for a reach of 1'. It was considered that there was little or no effort required (forces under 10N), little or no frequent muscle load on arms and shoulders during mould construction activities when sitting. The review showed that there was medium effort required (forces exerted under 120N), medium frequent muscle load on arms and shoulders during mould construction activities when standing/walking. The operatives were considered to exhibit occasional turning, twisting, wrist deviation to the wrist/lower arms. There was observed to be no standing above 4' required and the observed grip, power grip was considered to have a neutral wrist position or occasional pinch grip in handling mould elements and using hand tools see Figure 5.6.

Figure 5.6 Offsite manufacture of panel moulds; *trunk movement*

Section 8, *trunk movement* was considered to have an element of risk, this was because the operatives were considered to have large movements of the trunk (twist under 35 degrees and bend under 90 degrees) when installing architectural features and elements to the mould. The moulds are often deep and wide for access causing uncomfortable bending.

Sections 9-13 were considered acceptable aspects of the activities of mould construction. Examples include; movement of the operatives hip, knee and ankles were considered slight (e.g. walking) in carrying out their activities. The assessment considered the lifting and carrying of mould elements to be under 5kg and occasionally under 10kg, with ergonomically favourable conditions (conditions that allow natural human behaviour).

Section 14, *standing* was considered to have risk, frequent constrained standing in carrying out mould construction activities was observed.

Sections 15-20 were considered acceptable aspects of the activities of mould construction, for instance, the operatives were observed to be able to walk with the freedom to alternate with sitting/standing and sitting with the freedom to alternate with walking/standing. In the factory environment; the noise assessment was considered under ceiling value, the climate was considered within the comfort range and the lighting was at least at reference value for activities at all times of day.

Section 21 *hazardous materials in the working area* was considered to have some element of risk, off cuts and debris was noted inside the moulds. The moulds were large and required activity within the mould (Figure 5.7).

Figure 5.7 Offsite manufacture of panel moulds; *debris in area*

In sections 22-26, it was noted during the audit that there was no particular discomfort caused by vibration and no exposure to wet conditions during mould construction activities. No driving and steering activity was necessary on transporting mould elements. The production incentives used allowed time to stop (for quick breaks) without affecting others and no shift work was used as the factory operated a permanent day shift. There was possible risk in the execution of the mould construction, but adequate control measures were taken.

Learning points

The risks suggest that there still exists significant potential for injury (MSDs) due to prolonged standing and large trunk movements. The use of automation in assembly of reinforcement and the pre-assembly of architectural finishes may assist in reducing these residual risks. The poor *housekeeping* which contributes to the amount of trip hazards in the base area of the mould was noted during the assessment exercise. Further discussion on the risks in offsite is presented in chapter 7 discussion.

Key conclusions precast audit

The construction of the timber moulds suggests that several risks remain, these include; frequent constrained standing in and around the moulds, debris inside the mould causing trip risks and uncomfortable bending and reaching, these may contribute to MSDs injury. Table 5.6 presents the audit results for the remaining three activities analysed in this case, namely; fabrication of rebar, placing of concrete and storage of the completed precast face finished cladding panels. The results are presented in the context of the activities examined for the offsite manufacture of precast face finished cladding panels at Trent Concrete Ltd.

Table 5.6 Case study 1; Trent Concrete Ltd precast panels; analysis of activity

Case study 1: Trent Concrete Ltd Precast Concrete Face Finished cladding panels		Activity			
Section		Mould[1]	Rebar[2]	Concrete[3]	Store[4]
1 Required height					
Activity suitable for workers between 5' and 6'5'' in height	g	✓	✓	✓	✓
Activity more suitable for workers taller than 5' 5''	g				
Activity more suitable for workers shorter than 6'	g				
Activity more suitable only for workers with a height between 5' 5'' and 6'	a				
2 Extension of arms (including shoulder joint)					
Movements required for a reach up to 30cm (1')	g	✓	✓	✓	
Movements required for a reach up to 56cm (1'10'')	g				
Reaching required beyond 56cm (1'10'')	a				✓
3* Frequent muscle load on arms and shoulders during activities when <u>sitting</u> *(nb lifting/carrying is a separate category)*					
Little or no effort required (forces exerted under 10 N*)	g	✓	✓	✓	✓
Medium effort required (forces exerted under 50N)	g				
Large effort required (forces under 80 N)	a				
Excessive effort required (forces over 80N)	r				
4* Frequent muscle load on arms and shoulders during activities when standing / walking (NB not lifting/carrying)					
little or no effort required (forces exerted under 25 N)	g		✓		
Medium effort required (forces exerted under 120N)	g	✓		✓	✓
Large effort required (forces exerted under 180 N)	a				
Excessive effort required (forces exerted over 180N)	r				
5 Risk to wrist / lower arms (turning, twisting, wrist deviation, forceful movements					
occasional	g	✓			
frequent	a		✓	✓	✓
very frequent	r				
6 High / overhead work (122cm or 4')					
No handling above 122cm (4')	g	✓	✓	✓	
occasional overhead handling with little effort (forces exerted under 10 N)	g				
frequent overhead handling with little effort (forces exerted under 10 N)	a				✓
occasional overhead handling with effort (forces exerted over 10 N)	a				
frequent overhead handling with effort (over 10N) or prolonged holding work	r				
7 Grip					
power grip only (with neutral wrist position) or occasional pinch grip	g	✓	✓	✓	✓
frequent / very frequent pinch grip	a				
difficult / awkward gripping required	a				
8 Trunk movement					
slight twisting and bending movements	g		✓		
twisting under 15°, bending under 30°	g			✓	✓
large movements (twist under 35°,bend under 90°)	a	✓			
prolonged / difficult large movements <u>or</u> full movement (twist over 35°,bend over 90°)	r				
9 Movement of the hip *Distinct from trunk movement*					
slight movement , e.g. walking	g	✓	✓		
moderate movement (bending angle under 90°	g			✓	✓
full movement (bending angle over 90°)	a				
frequent or prolonged movement (bending over 90°)	r				
10 Movement of the knee					
slight movement, e.g. walking	g	✓	✓		
moderate movement (bending angle under 90°), e.g. sitting	g			✓	✓
full movement (bending angle over 90°)	a				
frequent or prolonged bending (over 90°) and/or twisting	r				
11 Movement of the ankles					
slight movement, e.g. walking	g	✓	✓		
infrequent full movement of ankles e.g. reaching	g			✓	✓
very frequent ankle movement <u>or</u> frequent / prolonged twisting	a				

Notes: 1 Timber mould construction, 2 Reinforcement assembly (Rebar), 3 Place concrete, 4 Storage of finished unit

Section		mould	Rebar	Concrete	Store
12 Lifting and carrying					
no lifting or lifting of weights under 1 kg	g				
frequent lifting under 5 kg occasionally under 10 kg	g	✓	✓		
frequent lifting under 10 kg occasionally under 18 kg	a			✓	✓
frequent lifting under 18 kg occasionally under 25 kg	a				
frequent lifting over 18 kg occasionally over 25 kg	r				
very frequent lifting over 10 kg	r				
13 Lifting and carrying (ergonomic conditions)					
ergonomically favourable conditions	g	✓	✓	✓	✓
unfavourable conditions: occasional lifting and carrying	a				
unfavourable conditions: frequent lifting and carrying	r				
14 Standing					
standing with freedom to move or alternate with sitting/walking	g				✓
frequent constrained standing	a	✓	✓	✓	
frequent static (over half hour) standing	a				
continuous (over 90% of shift) static or constrained standing	r				
15 Walking					
walking with freedom to alternate with sitting/standing	g	✓	✓	✓	✓
constant walking	g				
walking not possible or only occasional	a				
constant walking in unfavourable conditions	r				
16 Sitting					
sitting with freedom to alternate with walking/standing	g	✓	✓	✓	✓
continuous sitting (over 90% of shift)	a				
sitting preferable but not possible	a				
continuous sitting (over 90% of shift) in ergonomically unfavourable conditions	r				
17 Noise					
Assessment level under ceiling value*	g	✓	✓	✓	✓
Assessment level under 90 dB(A) but over ceiling value	a				
Assessment level over 90 dB(A) or 85 dB(A) incl. pulsed noise	r				
18 Climate					
Climatic conditions in comfort range	g	✓	✓	✓	✓
climatic conditions outside comfort range, depending on season	a				
climatic conditions continuously(over 90% of shift) outside the comfort range	r				
19 Lighting - *see reference values					
Lighting at least at reference value for task at all times of day	g	✓	✓	✓	✓
Lighting below reference value for task <u>but</u> over 50% of level	a				
Lighting under 50% of reference value	r				
20 Vibration					
no particular discomfort caused by vibration	g	✓	✓		✓
discomfort caused by vibration	a			✓	
21 Hazardous materials in the working area (e.g., corrosive, flammable, toxic substances etc.)					
not present	g				
present and assessed as under 50% of **O**ccupational **E**xposure **S**tandard (OES)	g				✓
50% - 100% of OES or causing discomfort	a	✓	✓	✓	
over Occupational Exposure Standard	r				
present and not tested	r				
22 Wet					
not exposed	g	✓	✓		
exposed	a			✓	✓
23 Driving and steering activity					
no driving and steering activity	g	✓	✓		✓
driving and steering activity	g			✓	
24 Production Incentive					
time to stop (for quick break) without affecting others	g	✓	✓	✓	✓
can stop but affects others	a				
no time to stop	r				
25 Shift work					
no shift work or permanent day shift	g	✓	✓	✓	✓
2 shift work-rotated (e.g. 6am-2pm, 2pm-10pm)	g				
permanent night shift	a				
3 shift work	a				
26 Risk (safety risks present)					
no special risk in the execution of the job	g				
possible risk in execution of job, but adequate control measures taken	g	✓	✓	✓	✓
possible risk in execution of job, precautions not taken	r				
Totals					
	g	**23**	**23**	**20**	**21**
	a	**3**	**3**	**6**	**5**
	r	**0**	**0**	**0**	**0**
Total risk areas		**17**			

Ergonomic assessment of rebar assembly - two operatives

The items considered to have an element of risk for the assembly of reinforcement (rebar) were wrist deviation and frequent constrained standing in tying the reinforcement bars to form assembled cages. Hazardous material in the workplace was noted, off cuts from reinforcement and tying wire (Table 5.6).

Learning points

The risks suggest that there still exists significant potential for injury to wrists; repetitive strain injury (RSI) from tying rebar, MSDs risks due to prolonged standing and large trunk movements. Slips, trips and falls from debris in the work area.

Ergonomic assessment of placing concrete in moulds - three operatives

The assessment revealed problems in working in wet conditions, exposure to concrete and injury associated with dermatitis (hazardous material in work area), vibration and non-neutral wrist positions from the use of pokers during compaction of the concrete. Frequent constrained standing was observed in and around the moulds. The moulds are often deep and wide for access; causing uncomfortable bending and reaching during placing, vibration and compaction of concrete (Table 5.6).

Learning points

The risks suggest that there still exists significant potential for injury (MSDs) due to prolonged standing and large trunk movements. The exposure to wet concrete and associated risk of dermatitis and concrete burns was evident during the assessment. Vibration and injury to wrists (RSI) was noted (Figure 5.8). Further discussion on the risks in offsite is presented in chapter 7.

Figure 5.8 Offsite manufacture of precast panels; *placing concrete in moulds*

Ergonomic assessment; storage of precast concrete panels - two operatives

The assessment revealed problems in extension of arms, risk to wrist and high/overhead work. The need to reach beyond 1'10" and the frequent overhead handling with effort (forces exerted over 10N) and frequent lifting under 10 kg occasionally under 18 kg of slings and lifting gear required for the craneage of the panels. Exposure to wet was evident, the panels were immersed in water or sprayed in the yard to assist curing (Table 5.6).

Learning points

The risks suggest that there exists the potential for repetitive strain injury (RSI) as a result of extension of arms and high overhead work with frequent wrist turning. The exposure to water during the curing process and associated risk of slips and trips (Figure 5.9). Further discussion on the residual risks in offsite is presented in chapter 7 discussion.

Figure 5.9 Offsite manufacture of precast panels; *storage of units*

Key conclusions

The combined results of the analysis of the activities in the offsite manufacture of precast face finished cladding panels at Trent Concrete Ltd indicate that 17 items on the checklist were considered to exhibit an element of risk (Table 5.6). The risks are summarised as follows; in the construction of the timber moulds, the assessment considered that the risks relating to frequent constrained standing in and around the moulds, debris inside the mould and uncomfortable bending and reaching, may contribute to injury.

Assembly of the steel reinforcement cages placed inside the moulds exhibited the same risk as mould construction namely, risk due to prolonged standing and slips and trips due to debris in the work area. In addition, it was considered that there is still significant potential for injury to wrists through repetitive strain injury (RSI) from manual tying of rebar.

The placing of the concrete into the timber moulds had similar risks to mould construction and reinforcement assembly namely; frequent constrained standing in and around the moulds, uncomfortable bending and reaching and hazardous material in the work area. In addition, the risk of vibration injury was observed.

The loading and storage of the concrete panels had risks associated with extension of the arms, reaching and high overhead work. The learning from the data is drawn from the existing body of knowledge and is presented in chapter 7 discussion

5.4.5.2 Translation into HASPREST

This section details the steps in the collection and analysis of the empirical data. The data from phases I and II informed the HASPREST risk management tool. The section begins with the contribution of both expert group interviews which formed phase I. Then, the steps in the data collection and analysis for phase II is presented. Finally the section concludes with the steps in analysis of the combination of phase I and II which combined in the development of the HASPREST CD.

Phase I: Expert Group Interview One

The flow diagram Figure 5.10 illustrates the steps in data collection during Phase I. The first step 1.1 involved setting up the expert group interview with collaborators. Step 1.2 involved identification of the building elements that would be considered during the research. The example shown in the figure is for buildings cladding; insitu brick/blockwork vs precast concrete panels. A similar process was adopted for the remaining elements (Table 5.3) under the headings major buildings, civil engineering and engineering construction. The elements chosen were obtained using a consensus decision making approach (Appendix E). The next step (1.3) involved the creation of a list of the activities and risks for each building element for insitu construction. Similarly step 1.4 involved the creation of a list of the activities and risks for each building element for offsite manufacture. In order to structure the discussion, a list of issues were developed, by the author, these were based on the literature and input from the research team (Appendix F).

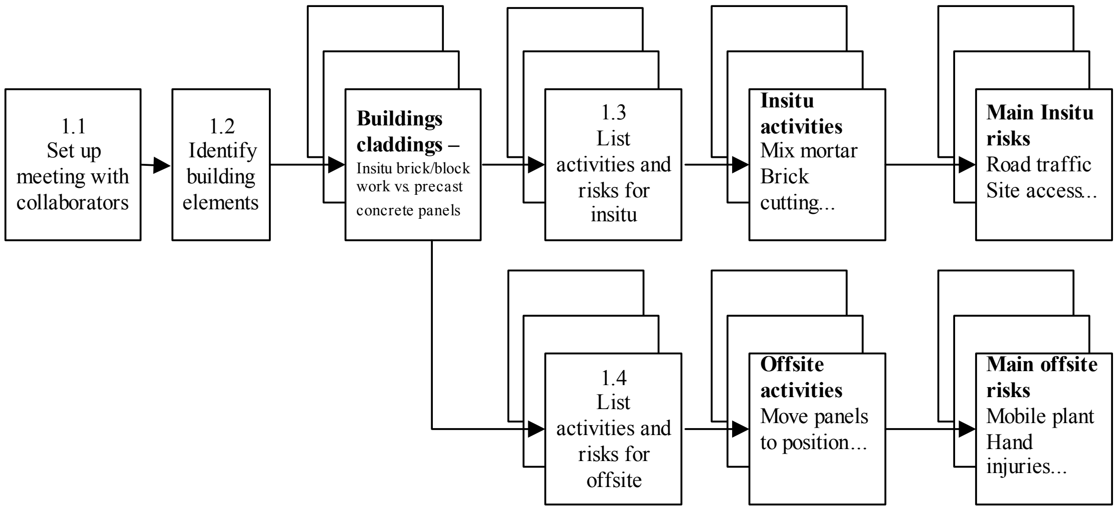
Phase I: Expert Group Interview Two

The second group interview involved step 1.5 verification of the activities and risks generated from group interview one. Step 1.6 involved a discussion on how the risk changes from insitu to offsite. Step 1.7 considered how the risks change from insitu to offsite for each activity and element and step 1.8 considered how the risks change from offsite to insitu for each activity and element. The researcher notes from the group interviews describes what the activities were for onsite and offsite what the risks were and how they changed from insitu to offsite (Appendix G).

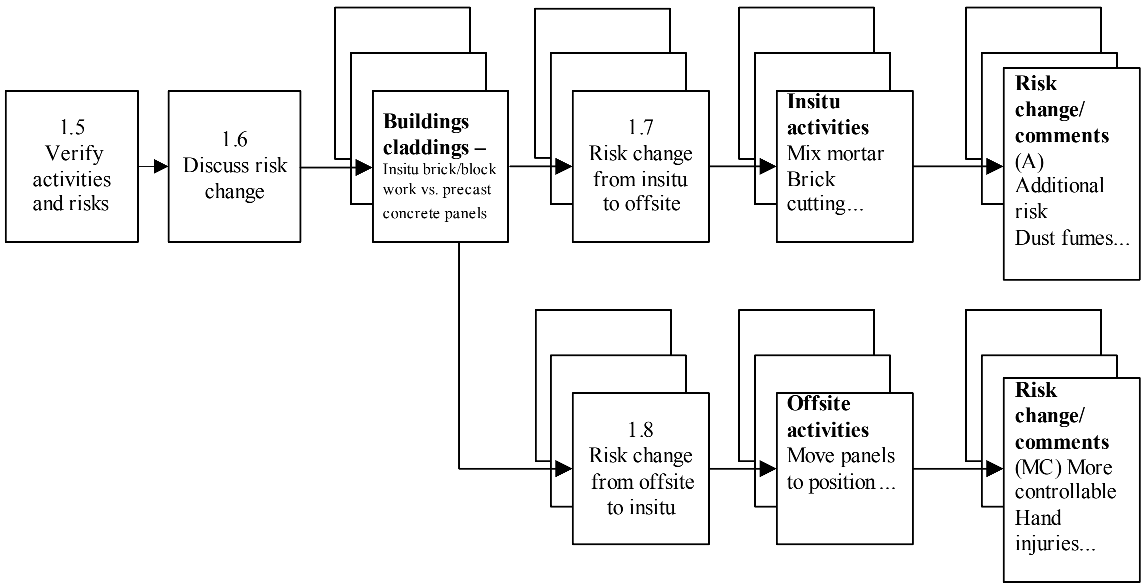
The flow diagram (Figure 5.10) illustrates the steps in the data collection and analysis for Phase I of the research.

Figure 5.10 Steps in data collection for Phase I

Expert Group One : Sample data collection and analysis



Expert Group Two: Sample data collection and analysis

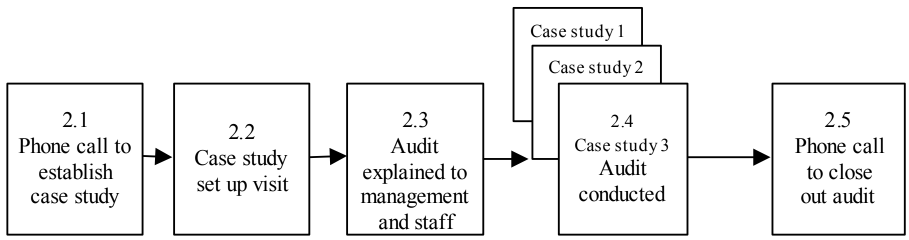


The data was then reviewed by the expert group, the activities, risks, risk change were denoted by a code as follows; the risk change code (insitu to offsite) was coded as follows S=same (no change), R= risk removed, A= additional risk, LL= less likely, ML= more likely, LC= less serious consequence, MC= more serious consequence, C = more controllable. The group provided key comments related to the risk change.

Phase II: Ergonomic Audits

The flow diagram Figure 5.11 illustrates the steps in data collection and analysis of Phase II of the research.

Figure 5.11 Steps in data collection for Phase II

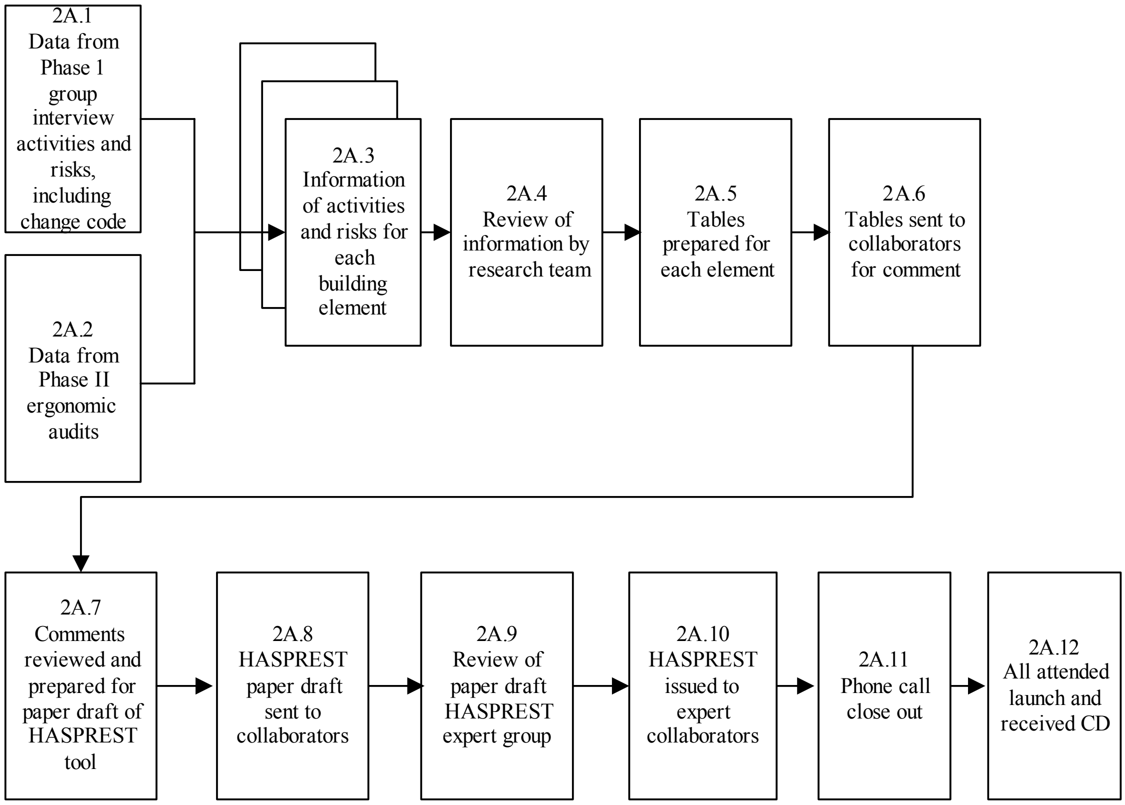


Phase II involved step 2.1, a phone call to each of the case study offsite facilities to arrange for a case study set up visit. At the set up visit the research team was introduced and the project described. The next step involved explanation of the ergonomic audit process to management staff. Then a tour of the offsite facility was conducted which included health and safety orientation and discussion with line operatives regarding their work task. The tasks for ergonomic analysis were identified and a date for the audit detailed (step 2.3). Step 2.4 involved conducting an ergonomic audit with the expert ergonomist at each of the offsite facilities. The activities examined and risks identified are as shown in Appendix H. Finally, step 2.5 involved a phone call after the audit to discuss any outstanding issues.

Phase I and Phase II: combined results to develop HASPREST CD

The development of the HASPREST tool involved using the data from phase I and phase II. The flow chart Figure 5.12 illustrates the steps in the tool development. A description of each step is detailed to give the reader an account of the work.

Figure 5.12 Steps in HASPREST tool development



The data from phase I the building elements, activities and risks for insitu and offsite and the changes in risks were reviewed by the research team (step 2A.1). The data from phase II the ergonomic audits were reviewed (2A.2). This data was then combined (2A.3) and reviewed by the research team (step 2A.4). Tables of activities and risks for each element were prepared by the research team (step 2A.5). Step 2A.6 involved sending the tables to the collaborators for comment (Appendix I). Step 2A.7 reviewed the comments from the returned sheets and prepared a paper draft version of the HASPREST tool. The draft HASPREST tool was then sent to collaborators (step 2A.8). The comments from the collaborators were then reviewed and discussed as part of the 4th steering group meeting (step 2A.9). The HASPREST tool was then developed and a CD version reviewed by the collaborators as a working tool (step 2A.10). A series of telephone calls were conducted to discuss any final changes to the tool (step 2A.11). Step 2A.12 was the launch of the HASPREST tool. An example of the final table for precast concrete face finished panels excerpt from the tool (Table 5.7) summarises the results from phases I and II.

Table 5.7 Cladding –heavy commercial face Finished

Cladding –heavy commercial face Finished (Commercial)
These activities are based on insitu brick/blockwork vs PC concrete face finished panels
Main H& S Issues: working at height, craneage, reduction in manual handling (eg bricklaying)

Brick/blocklayings				Pre-cast concrete cladding panel Face Finished			
Comments	**cf OSP**	**Main Hazards**	**Main Off-Site Activities**	**Main Off-Site Activities**	**Main Hazards**	**cf insitu**	**Comments**
	S	Various but same as OSP factory	Delivery of base materials to brick ready mix suppliers	Delivery of base materials to factory	Various but same as for insitu	S	
	S	Various but same as OSP factory	Mix clay place in moulds and fire bricks at works	Set up Moulds	Mechanical handling, craneage	S	
	A	Road traffic, site access, site conditions	Transport & deliver bricks and mortar to site	Place slips or Architectural finish	Cuts, dermatitis, MH	LL, C	
	S	Road traffic, mechanical handling, offloading etc		Reinforce, fix inserts etc	Mechanical handling, craneage	A	
Comments	**cf OSP**	**Main Hazards**	**Main On-Site Activities**	Mix concrete	Various but same as ready mix	S	
	S	Concrete burns, dermatitis	Ground beam concrete	Place concrete	Craneage, dermatitis, MH, MSDs	C	
	S	Various but same as OSP	Prepare site for bricklaying	Vibrate	HAVS, dermatitis, whole body vibration	C, A	Large panels often result in whole body vibration during compaction. (See Trent)
			Set out corners	Form box-outs	MSDs, dermatitis	LL, C	
.	A	Repetitive tasks, MH, Cuts, Dermatitis, MSD, falling material, unstable ground, exposure to UV.	Transport bricks				
The use of a heightened level of set out pile of bricks and mortar decreases the workload for high brick rows	C in OSP	MH, falling material, unstable ground	Moving bricks/blocks to workface	Remove/store	Mechanical handling, craneage	A, MC	Consequence of panel fall or sling failure more series consequence (ref Trent)
	C in OSP	MH, MSD, working at height, overhead work, walking into objects or projections.	Erecting work platforms	Transport and deliver panels to site	Road traffic, mechanical handling, offloading etc	A, MC	Consequence of panel fall or sling failure more series consequence (ref Trent)
				Transport & deliver plant to site	Road traffic, mechanical handling, offloading etc	A, MC	Mobile crane risks
	A	Dermatitis, breathing dust fumes, mortar splashes in eyes, rash allergies, exposure to UV .MH	Mix mortar	**Main On-Site Activities**	**Main Hazards**	**cf insitu**	**Comments**
	A	Struck by cut brick from saw, electric cutting equipment-electric shock, dust grit or brick splinters, noise, exposure to UV. MH	Brick cutting	Prepare site for panels	Various but same as insitu	S	Design could allow for internal working. Therefore no external access required.
	A	Dermatitis, repetitive tasks, MSD, MH working at height	Laying mortar	Move panels to required position	Mobile plant risks, hand injuries, large loads	A, MC	Hand injuries more serious (Ref. Trent)
				Connect panel to frame	Plant, hand injuries	A,	Hand injuries more serious (Ref. Trent)
	A	Working at height, exposure to UV, MH, confined space work, Dermatitis, clearing away mortar overspill, cleaning mortar from tools	Bricklaying				
	A	Repetitive tasks, cuts splinters	Fix wall ties, mesh reinforcement place lintels & DPC	Jointing in Mastics			
	C in OSP	Working at height, confined space, repetitive tasks, dermatitis	Pointing/finishing	Finishing		LL	Less finishing work required
More site labour required	ML	Slips, trips, falls	Ancillary site risks	Ancillary site risks	Slips, trips, falls	LL	Less site labour

Note – Pre cast cladding finished panels

Risk change code (insitu>>pre-assembled): S = same (no change) R = Risk removed A = Additional (new) risk LL = Less likely ML = More likely LC = less serious consequence MC = more serious consequence C = more controllable

5.4.5.3 Revolutionary Pod Modules, volumetric washroom pods

Four activities were selected for analysis these were; erection of the pod frame which involved: screw fixing of galvanised steel channels to form the floor, wall and roof panels. Installation of gyproc lining to the walls and ceiling. Tiling of the walls and floor and the fitting of washroom appliances and services. The manufacture involved a minimum of two and a maximum of three operatives depending on the activity. This section describes the risks identified from the ergonomic assessment. The results have been combined for the four activities and are presented in Table 5.8.

Case study 2:Revolutionary Pod Modules

Ergonomic assessment of steel frame erection – two operatives

The risks considered to be associated with the erection of the pod frame were overhead handling of the steel channel sections while they were held in the correct orientation prior to being screwed into position to form the base, wall and top of the pod. The review noted the occasional high overhead work in screw fixing steel sections to the top of the pod and the frequent lifting and carrying of the steel channel sections from the storage location to the pod assembly area. The presence of hazardous materials in the work area, for example trip hazards from cut steel channel lengths was observed (Table 5.8).

Learning points

The risks suggest that there exists the potential for repetitive strain injury (RSI) as a result of high overhead work and (MSDs) lifting and carrying. The risk of slips and trips as a result of trip hazards in the pod floor was evident during the assessment. Further discussion on the risks is presented in chapter 7 discussion.

Table 5.8 Case study 2; Revolutionary Pod Modules; analysis of activity

Case study 2: Revolutionary Pod Modules, washroom pods		Activity			
Section		Erect[1]	Gyproc[2]	Tile[3]	Services[4]
1 Required height					
Activity suitable for workers between 5' and 6'5'' in height	g	✓	✓	✓	✓
Activity more suitable for workers taller than 5' 5''	g				
Activity more suitable for workers shorter than 6'	g				
Activity more suitable only for workers with a height between 5' 5'' and 6'	a				
2 Extension of arms (including shoulder joint)					
Movements required for a reach up to 30cm (1')	g	✓	✓		
Movements required for a reach up to 56cm (1'10")	g			✓	✓
Reaching required beyond 56cm (1'10")	a				
3* Frequent muscle load on arms and shoulders during activities when <u>sitting</u> *(nb lifting/carrying is a separate category)*					
Little or no effort required (forces exerted under 10 N*)	g	✓	✓	✓	✓
Medium effort required (forces exerted under 50N)	g				
Large effort required (forces under 80 N)	a				
Excessive effort required (forces over 80N)	r				
4* Frequent muscle load on arms and shoulders during activities when standing / walking (NB not lifting/carrying)					
little or no effort required (forces exerted under 25 N)	g				
Medium effort required (forces exerted under 120N)	g	✓	✓	✓	✓
Large effort required (forces exerted under 180 N)	a				
Excessive effort required (forces exerted over 180N)	r				
5 Risk to wrist / lower arms (turning, twisting, wrist deviation, forceful movements					
occasional	g	✓	✓		✓
frequent	a			✓	
very frequent	r				
6 High / overhead work (122cm or 4')					
No handling above 122cm (4')	g				
occasional overhead handling with little effort (forces exerted under 10 N)	g		✓		
frequent overhead handling with little effort (forces exerted under 10 N)	a				✓
occasional overhead handling with effort (forces exerted over 10 N)	a	✓		✓	
frequent overhead handling with effort (over 10N) or prolonged holding work	r				
7 Grip					
power grip only (with neutral wrist position) or occasional pinch grip	g	✓	✓	✓	✓
frequent / very frequent pinch grip	a				
difficult / awkward gripping required	a				
8 Trunk movement					
slight twisting and bending movements	g		✓		
twisting under 15°, bending under 30°	g	✓		✓	✓
large movements (twist under 35°,bend under 90°)	a				
prolonged / difficult large movements <u>or</u> full movement (twist over 35°,bend over 90°)	r				
9 Movement of the hip *Distinct from trunk movement*					
slight movement , e.g. walking	g				
moderate movement (bending angle under 90°	g	✓	✓	✓	✓
full movement (bending angle over 90°)	a				
frequent or prolonged movement (bending over 90°)	r				
10 Movement of the knee					
slight movement, e.g. walking	g				
moderate movement (bending angle under 90°), e.g. sitting	g	✓	✓	✓	✓
full movement (bending angle over 90°)	a				
frequent or prolonged bending (over 90°) and/or twisting	r				
11 Movement of the ankles					
slight movement, e.g. walking	g	✓	✓		
infrequent full movement of ankles e.g. reaching	g			✓	✓
very frequent ankle movement <u>or</u> frequent / prolonged twisting	a				

Notes: 1 Erection of light steel frame, 2 Install ply sheets to pod wall and ceiling, 3 Tiling of floor and walls, 4 Services and accessory installation

Section		Erect	Gyproc	Tile	Services
12 Lifting and carrying					
no lifting or lifting of weights under 1 kg	g				
frequent lifting under 5 kg occasionally under 10 kg	g				
frequent lifting under 10 kg occasionally under 18 kg	a		✓	✓	✓
frequent lifting under 18 kg occasionally under 25 kg	a	✓			
frequent lifting over 18 kg occasionally over 25 kg	r				
very frequent lifting over 10 kg	r				
13 Lifting and carrying (ergonomic conditions)					
ergonomically favourable conditions	g	✓	✓	✓	✓
unfavourable conditions: occasional lifting and carrying	a				
unfavourable conditions: frequent lifting and carrying	r				
14 Standing					
standing with freedom to move or alternate with sitting/walking	g	✓	✓	✓	✓
frequent constrained standing	a				
frequent static (over half hour) standing	a				
continuous (over 90% of shift) static or constrained standing	r				
15 Walking					
walking with freedom to alternate with sitting/standing	g	✓	✓	✓	✓
constant walking	g				
walking not possible or only occasional	a				
constant walking in unfavourable conditions	r				
16 Sitting					
sitting with freedom to alternate with walking/standing	g	✓	✓	✓	✓
continuous sitting (over 90% of shift)	a				
sitting preferable but not possible	a				
continuous sitting (over 90% of shift) in ergonomically unfavourable conditions	r				
17 Noise					
Assessment level under ceiling value*	g	✓	✓	✓	✓
Assessment level under 90 dB(A) but over ceiling value	a				
Assessment level over 90 dB(A) or 85 dB(A) incl. pulsed noise	r				
18 Climate					
Climatic conditions in comfort range	g	✓	✓	✓	✓
climatic conditions outside comfort range, depending on season	a				
climatic conditions continuously(over 90% of shift) outside the comfort range	r				
19 Lighting - *see reference values					
Lighting at least at reference value for task at all times of day	g	✓	✓	✓	✓
Lighting below reference value for task <u>but</u> over 50% of level	a				
Lighting under 50% of reference value	r				
20 Vibration					
no particular discomfort caused by vibration	g	✓	✓	✓	✓
discomfort caused by vibration	a				
21 Hazardous materials in the working area (e.g., corrosive, flammable, toxic substances)					
not present	g				
present and assessed as under 50% of **O**ccupational **E**xposure **S**tandard (OES)	g			✓	
50% - 100% of OES or causing discomfort	a	✓	✓		✓
over Occupational Exposure Standard	r				
present and not tested	r				
22 Wet					
not exposed	g	✓	✓		✓
exposed	a			✓	
23 Driving and steering activity					
no driving and steering activity	g	✓	✓	✓	✓
driving and steering activity	g				
24 Production Incentive					
time to stop (for quick break) without affecting others	g	✓	✓	✓	✓
can stop but affects others	a				
no time to stop	r				
25 Shift work					
no shift work or permanent day shift	g	✓	✓	✓	✓
2 shift work-rotated (e.g. 6am-2pm, 2pm-10pm)	g				
permanent night shift	a				
3 shift work	a				
26 Risk (safety risks present)					
no special risk in the execution of the job	g				
possible risk in execution of job, but adequate control measures taken	g	✓	✓	✓	✓
possible risk in execution of job, precautions not taken	r				
Totals					
	g	**23**	**24**	**22**	**23**
	a	**3**	**2**	**4**	**3**
	r	**0**	**0**	**0**	**0**
Total risk areas		**12**			

Ergonomic assessment; gyproc to wall and ceiling of pod – two operatives

The assessment revealed problems in frequent lifting and carrying of gyproc panel sheets (under 10kg and occasionally under 18kg) over unfavourable conditions. Trip hazards in floor of pod (Table 5.8).

Learning points

The gyproc panels although pre-cut were observed to require frequent lifting over storage materials.

Ergonomic assessment; tiling to wall and floor of pod - one operative

The review considered that the operative was frequently turning and twisting his wrist in applying tile adhesive and fixing tiles in position. The operative often used forceful movements to locate tiles in the correct orientation, this occasionally involved high overhead work. It was observed that frequent lifting under 10 kg occasionally under 18 kg was required when the operative collected boxes of stacked tiles, carried to the pod. It was noted that the tile adhesive on the pod floor resulted in exposure to wet.

Learning points

The tiling process was considered to have risks that would be similar to those for the in situ situation, theses were risk to the wrists, overhead work, frequent lifting of tile boxes and exposure to wet tile adhesive.

Ergonomic assessment; installation of services to pod - two operatives

The assessment observed frequent overhead handling of services, these were wiring looms and pipe-work. It was considered that the bathroom appliances required frequent lifting under 10 kg occasionally under 18 kg. The pod floor was observed to have tile off cuts and material debris (set adhesive) which contributed to hazardous material in the work area.

Learning points

The installation of services was considered to have risks that would be similar to those for the in situ situation, theses were risk from overhead work, lifting of tile appliances and slip and trip hazards.

Key conclusions

The combined results of the analysis of the activities in the offsite manufacture of washrooms at Revolutionary Pod Modules indicate that 12 items on the checklist were considered to exhibit an element of risk (Table 5.8). The risks are summarised as follows; for the erection of the steel frame, the assessment considered that risks relating to high overhead work and frequent lifting and carrying of the steel channel sections. Hazardous materials in the work area were noted.

Similarly, the assessment of the installation of gyproc panels revealed frequent lifting and carrying of gyproc panel sheets and trip hazards in the floor of pod.

Tiling to the pod floor and wall revealed the same risk of frequent lifting of tiles. In addition exposure to wet, frequent turning and twisting of the wrist, forceful movements to locate tiles and high overhead work were noted.

The installation of services had similar risks, overhead handling, frequent lifting and hazardous material in the work area.

5.4.5.4 Translation into HASPREST

The data from phases I and II informed the HASPREST risk management tool. The data was then reviewed by the expert group, the activities, risks, risk change were denoted by a code as follows; the risk change code (in situ to offsite) was coded as follows S=same (no change), R= risk removed, A= additional risk, LL= less likely, ML= more likely, LC= less serious consequence, MC= more serious consequence, C = more controllable. The group provided key comments related to the risk change. The excerpt internals/washrooms from the HASPREST tool (Table 5.9) summarises the results from phases I and II.

Table 5.9 Internals toilets/washrooms

Insitu Washrooms/Toilets

Opinions/Evidence		Main Hazards	Off Site Activities
Industrialised processes – outside HASPREST scope		Industrialised processes – outside the scope of this project	Manufacture of materials and fittings etc
Ad hoc		Road traffic etc	Transport
Ad hoc – often poorly controlled	ML	Manual handling etc	Delivery
Opinions/Evidence		**Main Hazards**	**On Site Activities**
	A	Man hand materials, MSDs, bending, dermatitis	Blockwork
As floor screed	A	Manual handling materials, MSD's, crouching, bending, dermatitis, pumping of screed	Floor Screed
	ML	MSD's, work overhead, step ladders, dermatitis	Plaster / render to walls / ceilings
Removing overlapping trades is the main benefit of pods	ML	Cuts, crouching, bending, congested work areas, overlapping interfacing trades	1st fix joinery / plumbing / electrical
	ML	Manual handling materials, MSD's, crouching, bending, restricted work areas, dermatitis	Tiling
Removing overlapping trades is the main benefit of pods	ML	Cuts, crouching, bending, congested work areas, overlapping interfacing trades	2nd fix Joinery / plumbing / electrical
As suspended ceilings	ML	Work overhead, cuts (hangers), step ladders	Suspended ceilings (if required)
	ML	MSD's, crouching, bending	Accessory fix
Removing overlapping trades is the main benefit of pods	ML/A	Cuts, crouching, bending, congested work areas, overlapping interfacing trades	3rd Fix Joinery / plumbing / electrical
	ML	Congested, restricted work areas, electrocution	Commissioning
More site labour	ML	Slips, trips, falls	Ancillary site risks
Major benefit of OSP	A	Especially overlapping trades issues	

Toilet Pods

Off Site Activities	Main Hazards	Cf insitu	Opinions/Evidence
Manufacture of materials and fittings etc	Industrialised processes – outside HASPREST scope		Industrialised processes – outside the scope of this project
Deliver materials etc to factory	Various	LL, C	More controlled as fixed location
Assemble pod structure	Manual / mechanical handling	LL, C	More chance to mechanise
	MSD's, cuts etc	LL, C	Should be easier to control in factory
	Overhead work	MC, C	Overhead craneage etc – but controllable
1st fix services??	MSD's, cuts etc	LL, C	Should be easier to control in factory
Wall/ceiling sheets to pod	MSD's, cuts	S	Same as site drylining but easier to control in factory
	Manual handling	LL	Materials mechanically handled right to
Install supports etc for fittings	MSD's, cuts etc	C	Should be easier to control in factory
2nd fix services	MSD's, cuts etc	C	Should be easier to control in factory
Internal partitions	MSD's, cuts etc	S, C	Same as site drylining but easier to control in factory
	Manual handling	LL	Materials mechanically handled right to workface
Wall and floor tiling	MSD's, crouching, restricted work area etc	C	Should be easier to control in factory Could consider pre-assembled pre-tiled panels
	Manual handling	LL	Materials can be mechanically handled right to workface
Install fittings	MSDs, HAVS, crouching, restricted work area etc	S, C	Should be easier to control in factory
Decoration	MSD's, step ladders etc	S, C	Should be easier to control in factory
Final fix services	MSD's, HAVS, cuts etc	S, C	Should be easier to control in factory
Commissioning	Congested/restricted work areas	C	Should be easier to control in factory
	Electrocution	LL	Better control of 'power-on' etc
Doors etc	MSD's, cuts etc	C	Should be easier to control in factory
Trade overlap, interfaces etc	Various, slips, trips, falls	LL, C	Less overlap, multi-skilling
Prepare for transportation	MSD's, cuts etc	C	Should be easier to control in factory
Load onto transport	MSD's, cuts etc	C	Should be easier to control in factory
	Craneage	MC, C	Heavier loads – however, more controllable and usually mechanically handled
Transport	Road traffic etc	S, C	Same as insitu but fewer, larger loads
Delivery	Craneage	MC, C	Heavier loads, more craneage but less ad-hoc
	Manual handling	LL	Craneage not man handling
On Site Activities	**Main Hazards**	**Cf insitu**	**Opinions/Evidence**
Installation of pod to floor level	Craneage	N, MC, LL, C	Onto loading platform or launched onto slab – heavier / more complex but very much fewer / more controllable
	Temporary works collapse	MC	Loading platform
Movement of pod across floor	MSDs, slips & trips	N	New risk as pulling/pushing heavy load across floor – but not ad hoc and should be controllable
Placement of modules	MSDs	N	New risk as pulling/pushing heavy load into place – but not ad hoc and should be controllable
Service Connection	Cuts, MSD's, Electrocution	LL	More straight forward with pods
Commissioning	Cuts, MSD's, Electrocution, congested work areas	LL	Less on-site commissioning needed
Ancillary site risks	Slips, trips, falls	LL	Significantly less onsite workers will reduce risk Significantly less trade overlap

Risk change code (insitu>>pre-assembled): S = same (no change) R = Risk removed N = New risk LL = Less likely ML = More likely LC = less serious consequence MC = more serious consequence C = more controllable

5.4.5.5 Caledonian Building Systems, modular buildings

Six activities were selected for analysis these included; welding of the universal steel channel sections to form the structural frame. Installation of insulation, installation of galvanised steel sheeting to the wall and ceiling. Installation of medium density fibreboard (MDF) to the walls and ceiling, installation of gyproc panels which were glued and screw fixed to the MDF. Installation and fitting of internal appliances and services. The manufacture involved a minimum of two and a maximum of four operatives depending on the activity. This section outlines the risks identified from the ergonomic assessments of the six activities as presented in Table 5.10. A code is adopted in the table to identify each activity; (F) erection of steel frame, (I) installation of rock wool insulation, (S) installation of galvanised steel sheeting to wall, (M) installation of MDF, (G) Installation of gyproc sheets to wall and (J) Joinery and accessory installation.

Case study 3: Caledonian Building Systems

Ergonomic assessment of steel structural frame erection - four operatives

The erection of the structural frame includes welding of the floor cassette, wall and roof elements (Figure 5.13). The assessment considered the turning, twisting and wrist deviation of the operative during welding operations was a risk to the wrist and lower arm. Overhead work; welding wall and roof channels were noted.

Figure 5.13 Modular building manufacture; *floor cassette and wall elements*

The observed frequent lifting and carrying of steel channels which were then clamped into position prior to welding, were considered a risk which may contribute to MSDs. The review noted the frequent constrained standing of the operative during welding was considered a risks. Carrying of the steel channel sections from the storage location to the module assembly area, was considered a risk (Figure 5.14). The presence of hazardous materials in the work area, for example fumes from the welding process of channel sections was observed (Table 5.10).

Figure 5.14 Modular building manufacture; *welding fumes from channels*

Learning points

The risks suggest that there exists the potential for repetitive strain injury (RSI) as a result of wrist deviation during welding and high overhead work. MSD risk from lifting, carrying and constrained standing was indicated. The risk of weld fume hazards during the welding process was noted during the assessment.

Ergonomic assessment of insulation to walls - two operatives

The presence of hazardous material inside the work area was considered a slip and trip risk in the installation of rock wool insulation to walls and ceiling.

Learning points

The installation of the rockwool insulation, during the review was considered to be non-problematic, the material was light and of a manageable size. The poor housekeeping of the module floor area which contributed to trip hazards was a recurrent observation during the assessment.

Table 5.10 Case study 3: Caledonian Building systems; analysis of activity

Case study 3: Caledonian Building Systems, modular buildings		Activity					
Section		F	I	S	M	G	J
1 Required height							
Activity suitable for workers between 5' and 6'5'' in height	g	✓	✓	✓	✓	✓	✓
Activity more suitable for workers taller than 5' 5''	g						
Activity more suitable for workers shorter than 6'	g						
Activity more suitable only for workers with a height between 5' 5'' and 6'	a						
2 Extension of arms (including shoulder joint)							
Movements required for a reach up to 30cm (1')	g						
Movements required for a reach up to 56cm (1'10'')	g	✓	✓	✓			✓
Reaching required beyond 56cm (1'10'')	a				✓	✓	
3* Frequent muscle load on arms and shoulders during activities when sitting *(nb lifting/carrying is a separate category)*							
Little or no effort required (forces exerted under 10 N*)	g	✓	✓	✓	✓	✓	✓
Medium effort required (forces exerted under 50N)	g						
Large effort required (forces under 80 N)	a						
Excessive effort required (forces over 80N)	r						
4* Frequent muscle load on arms and shoulders during activities when standing / walking (NB not lifting/carrying)							
little or no effort required (forces exerted under 25 N)	g						
Medium effort required (forces exerted under 120N)	g	✓	✓				✓
Large effort required (forces exerted under 180 N)	a			✓	✓	✓	
Excessive effort required (forces exerted over 180N)	r						
5 Risk to wrist / lower arms (turning, twisting, wrist deviation, forceful movements							
occasional	g		✓				✓
frequent	a	✓		✓	✓	✓	
very frequent	r						
6 High / overhead work (122cm or 4')							
No handling above 122cm (4')	g						
occasional overhead handling with little effort (forces exerted under 10 N)	g		✓				
frequent overhead handling with little effort (forces exerted under 10 N)	a	✓		✓	✓	✓	✓
occasional overhead handling with effort (forces exerted over 10 N)	a						
frequent overhead handling with effort (over 10N) or prolonged holding work	r						
7 Grip							
power grip only (with neutral wrist position) or occasional pinch grip	g	✓	✓	✓	✓	✓	✓
frequent / very frequent pinch grip	a						
difficult / awkward gripping required	a						
8 Trunk movement							
slight twisting and bending movements	g						
twisting under 15°, bending under 30°	g	✓	✓	✓	✓	✓	✓
large movements (twist under 35°,bend under 90°)	a						
prolonged / difficult large movements or full movement (twist over 35°,bend over 90°)	r						
9 Movement of the hip *Distinct from trunk movement*							
slight movement , e.g. walking	g		✓	✓			
moderate movement (bending angle under 90°	g	✓			✓	✓	✓
full movement (bending angle over 90°)	a						
frequent or prolonged movement (bending over 90°)	r						
10 Movement of the knee							
slight movement, e.g. walking	g	✓	✓	✓			
moderate movement (bending angle under 90°), e.g. sitting	g				✓	✓	✓
full movement (bending angle over 90°)	a						
frequent or prolonged bending (over 90°) and/or twisting	r						
11 Movement of the ankles							
slight movement, e.g. walking	g	✓	✓	✓	✓	✓	✓
infrequent full movement of ankles e.g. reaching	g						
very frequent ankle movement or frequent / prolonged twisting	a						
Section		F	I	S	M	G	J
12 Lifting and carrying							
no lifting or lifting of weights under 1 kg	g						
frequent lifting under 5 kg occasionally under 10 kg	g		✓				✓
frequent lifting under 10 kg occasionally under 18 kg	a	✓		✓	✓	✓	
frequent lifting under 18 kg occasionally under 25 kg	a						
frequent lifting over 18 kg occasionally over 25 kg	r						
very frequent lifting over 10 kg	r						
13 Lifting and carrying (ergonomic conditions)							
ergonomically favourable conditions	g	✓	✓	✓	✓	✓	✓
unfavourable conditions: occasional lifting and carrying	a						
unfavourable conditions: frequent lifting and carrying	r						
14 Standing							
standing with freedom to move or alternate with sitting/walking	g		✓				✓
frequent constrained standing	a	✓		✓	✓	✓	
frequent static (over half hour) standing	a						
continuous (over 90% of shift) static or constrained standing	r						
15 Walking							
walking with freedom to alternate with sitting/standing	g	✓	✓	✓	✓	✓	✓
constant walking	g						
walking not possible or only occasional	a						
constant walking in unfavourable conditions	r						
16 Sitting							
sitting with freedom to alternate with walking/standing	g	✓	✓	✓	✓	✓	✓
continuous sitting (over 90% of shift)	a						
sitting preferable but not possible	a						
continuous sitting (over 90% of shift) in ergonomically unfavourable conditions	r						
17 Noise							
Assessment level under ceiling value*	g	✓	✓	✓	✓	✓	✓
Assessment level under 90 dB(A) but over ceiling value	a						
Assessment level over 90 dB(A) or 85 dB(A) incl. pulsed noise	r						
18 Climate							
Climatic conditions in comfort range	g	✓	✓	✓	✓	✓	✓
climatic conditions outside comfort range, depending on season	a						
climatic conditions continuously(over 90% of shift) outside the comfort range	r						
19 Lighting - *see reference values							
Lighting at least at reference value for task at all times of day	g	✓	✓	✓	✓	✓	✓
Lighting below reference value for task but over 50% of level	a						
Lighting under 50% of reference value	r						
20 Vibration							
no particular discomfort caused by vibration	g	✓	✓	✓	✓	✓	✓
discomfort caused by vibration	a						
21 Hazardous materials in the working area (e.g., corrosive, flammable, toxic substances)							
not present	g						
present and assessed as under 50% of Occupational Exposure Standard (OES)	g						
50% - 100% of OES or causing discomfort	a	✓	✓	✓	✓	✓	✓
over Occupational Exposure Standard	r						
present and not tested	r						
22 Wet							
not exposed	g	✓	✓	✓	✓	✓	✓
exposed	a						
23 Driving and steering activity							
no driving and steering activity	g	✓	✓	✓	✓	✓	✓
driving and steering activity	g						
24 Production Incentive							
time to stop (for quick break) without affecting others	g	✓	✓	✓	✓	✓	✓
can stop but affects others	a						
no time to stop	r						
25 Shift work							
no shift work or permanent day shift	g	✓	✓	✓	✓	✓	✓
2 shift work-rotated (e.g. 6am-2pm, 2pm-10pm)	g						
permanent night shift	a						
3 shift work	a						
26 Risk (safety risks present)							
no special risk in the execution of the job	g						
possible risk in execution of job, but adequate control measures taken	g	✓	✓	✓	✓	✓	✓
possible risk in execution of job, precautions not taken	r						
Totals							
	g	21	25	20	19	19	24
	a	5	1	6	7	7	2
	r	0	0	0	0	0	0
Total risk areas		28					

Notes: 1 (F) erection of steel frame, 2 (I) installation of rock wool insulation 3 (S) installation of galvanised steel sheeting to wall, 4 (M) installation of MDF 5 (G) Installation of gyproc sheets to wall, 6 (J) Joinery and accessory installation

Ergonomic assessment; steel sheeting to wall and ceiling of module - two operatives

The risk of muscle load on arms and shoulders during the installation of the galvanised steel sheeting to the walls and ceiling of the module were noted during the assessment. The sheets required turning and twisting of the wrist and lower arm, with frequent overhead handling and thus were considered a repetitive strain injury (RSI) risk. The lifting and carrying of the steel sheets was observed, with possible MSD risk. The risk of frequent constrained standing, by the operative was noted. Material debris and hazaourdous material in the work area was noted, which contributed to trip hazards.

Learning points

The assessment suggest that there exists the potential of risks to extension of arms and for repetitive strain injury (RSI) as a result of wrist deviation during handling and high overhead work. MSD risk from lifting and carrying and constrained standing. The risk of trip hazards was noted during the assessment.

Ergonomic assessment; MDF to wall and ceiling of module - two operatives

The risk of muscle load on arms and shoulders during the installation of the MDF panels to the walls and ceiling of the module were noted during the assessment. The sheets required turning and twisting of the wrist and lower arm, with frequent overhead handling and thus were considered a (RSI) risk. The lifting and carrying of the MDF panels was observed, with possible MSD risk. The risk of frequent constrained standing, by the operative was noted. Material debris and hazardous material in the work area was noted.

Ergonomic assessment; gyproc to wall and ceiling of module – two operatives

The review indicated that extension of arms was considered a risk, reaching beyond 1'10". Frequent muscle load on arms was observed as a risk, large effort required (forces exerted under 180 N). Frequent turning and twisting of the wrist was noted in screw fixing the gyproc sheets in place. High overhead work was observed, frequent overhead handling of the gyproc sheets. Frequent lifting and carrying was considered a risk, this was because the operative was observed to carry large gyproc sheets to the module from the storage location 15 yards from the work area. In carrying out the installation process, frequent constrained standing was observed. Hazardous material inside the module was noted, these consisted of MDF and gyproc off cuts, pipe lengths and glue waste.

Learning points

The installation of MDF and gyproc were similar in activity in that the sheets were of similar size and weight. This is reflected in the analysis, the total risk areas were seven and the risk areas were the same on the checklist (Table 5.10).

Ergonomic assessment; joinery and accessory installation – two operatives

Frequent overhead handling of accessory units was considered a risk during the review. Material debris in the work area was noted.

Learning points

The assessment suggested that high overhead work and the risk of trip hazards were the main risk areas in this activity.

Key conclusions

The combined results of the analysis of the activities in the offsite manufacture of modular buildings at Caledonian Building Systems indicate that 28 items on the checklist were considered to exhibit an element of risk (Table 5.10). The risks are summarised as follows; for the erection of the steel frame, the assessment considered that risks relating to turning, twisting and wrist deviation during welding operations were indicated. The review revealed high overhead work in welding wall and roof channels. Frequent lifting and carrying of the steel channel sections and frequent constrained standing were observed. Hazardous materials in the work area were noted (fumes in work area). The risk of muscle load on arms (extension of arms), frequent overhead work with turning and twisting of the galvanised steel sheeting to walls and ceiling. Reaching beyond 1’ 10” with frequent lifting and carrying.

Similarly, the assessment of the installation of gyproc panels revealed frequent lifting and carrying of gyproc panel sheets and trip hazards in the floor of pod.

Tiling to the pod floor and wall revealed the same risk of frequent lifting of tiles. In addition exposure to wet, frequent turning and twisting of the wrist, forceful movements to locate tiles and high overhead work were noted.

The installation of services had similar risks, overhead handling, frequent lifting and hazardous material in the work area

5.4.5.6 Translation into HASPREST

The data from phases I and II informed the HASPREST risk management tool. The data was then reviewed by the expert group, the activities, risks, risk change were denoted by a code as follows; the risk change code (in situ to offsite) was coded as follows S=same (no change), R= risk removed, A= additional risk, LL= less likely, ML= more likely, LC= less serious consequence, MC= more serious consequence, C = more controllable. The group provided key comments related to the risk change. The excerpt from the HASPREST tool mechanical services source plant rooms was adapted with additional activities and risks to form modular building. Table 5.11 summarises the results from phases I and II. This was a project decision to reflect the categories selected as presented in section 5.3.5.

Table 5.11 Modular building

Traditional Building				Modular Building			
Opinions/Evidence	**cf OSP**	**Main Hazards**	**Off-Site Activities**	**Off-Site Activities**	**Main Hazards**	**cf insitu**	**Opinions/Evidence**
Industrialised process should be well organised with risks minimised		Various – but outside scope of HASPREST	Manufacture of base materials	Manufacture of materials and fittings etc	Industrialised processes – outside HASPREST scope		Industrialised processes – outside the scope of this project
Same for OSP factory		Transport, handling etc	Deliveries of base materials to suppliers	Deliver materials etc to factory	Various	LL, C	More controlled as fixed location
Should be well organised with risks minimised		Various – but outside scope of HASPREST	Manufacture of components	Assemble frame structure	Manual / mechanical handling	LL, C	More chance to mechanise
More ad hoc deliveries	ML	Road traffic	Transport components to site	Weld channels / box sections	MSD's, cuts etc burns, fumes	LL, C	Should be easier to control in factory
				Paint frame	Overhead work, COSHH		
More ad hoc deliveries	ML	Craneage, plant, access etc	Deliveries	Install plinth/box sections for switchgear	MH, mechanical handling	MC, C	More control, clean environment less risk of contamination, electrical shorts.
Opinions/Evidence	**cf OSP**	**Main Hazards**	**On-Site Activities**				
	S		Prepare site for foundations	Install main plant items, pumps, process control equipment			
	A	MH, MSD's, contaminated land. Electrocution, gas explosion. COSHH	Trial dig on site, excavation of strip foundations, determine location of services, gas, electric	Install pipework, fittings valves			
Details depend on formwork design –crane-handled pre-formed systems reduce many of these risks	A	MH, MSD's, cuts, hand injuries, power tools, falls from height, (concrete risks), (Rebar risks)	Foundation formwork (assume site-made timber shutters)	Install cable trays, and cables	MSD's, cuts etc	C	Should be easier to control in factory
				Install insulation			
				Install galvanised steel sheeting to walls	Overhead work, manual handling		
				Install MDF and gyproc to walls	Overhead work, manual handling		
	A	Craneage, skip (maybe pump), falls from height, dermatitis,	Place foundation concrete	Install services including switchgear, instrumentation and control panels	Manual handling	C	Should be easier to control in factory
	A	HAVS, MSD's, MH	Vibrate foundation concrete	Final fix services	MSD's, HAVS, cuts etc	S, C	Should be easier to control in factory
	A	Material falling, cuts from nails etc, MSD's, MH	Strike foundation formwork	Commissioning	Congested/restricted work areas	C	Should be easier to control in factory
	A	MH, MSD's, hand injuries, falls from height	Prepare site for erection of brickwork, erect scaffold, work platforms	------ " -------	Electrocution	LL	Better control of 'power-on' etc
	A	MH, MSD's, cuts, hand injuries, falls from height, power tools, material falling.	Bricklaying	Doors access covers, walkways etc	MSD's, cuts welds, burns fumes etc	C	Should be easier to control in factory
	A	Craneage, MH, MSD's, cuts, working in confined areas, trips, falls from height. HAVS (power tool usage)	Install main process plant equipment, pipework	Trade overlap, interfaces etc	Various, slips, trips, falls	LL, C	Less overlap, multi-skilling
Interaction of trades	ML	MH, MSD's RSI, HAVS (power tool usage)	Install taps, valves and instrumentation	Prepare for transportation	MSD's, cuts etc	C	Should be easier to control in factory
Inter-action of trades	ML	Falls from height, electrocution, confined space work	Install main cabling and test	Load onto transport	MSD's, cuts etc	C	Should be easier to control in factory
	ML	HAVS, MSD's, MH, trips, falls from height HAVS (power tool usage)	Miscellaneous components	------ " -------	Craneage	MC, C	Heavier loads – however, more controllable and usually mechanically handled
	S	MH, MSD's, HAVS (if power float), COSHH (curing agent), MSDs & slips (polythene to cure)		Transport	Road traffic etc	S, C	Same as insitu but fewer, larger loads. Overhead craneage etc – but controllable
	A	Material falling, cuts from nails etc, MSD's, MH, falls from height	Pressure testing	**On-Site Activities**	**Main Hazards**	**cf insitu**	**Opinions/Evidence**
	ML	MSD's, MH, COSHH (Release agent), cuts (scrapers)	Power on "live" tests	Installation of packaged plant room module to floor level	Craneage	N, MC, LL, C	Onto loading platform or launched onto slab – heavier / more complex but very much fewer / more controllable
		Material falling, MSD's, MH, falls from height	Final commissioning	------ " -------	Temporary works collapse	MC	Loading platform
	ML	Slips, trips, falls	Ancillary site risks	Movement of packaged plant room module across floor	MSD's, slips & trips	N	New risk as pulling/pushing heavy load across floor – but not ad hoc and should be controllable
				Service Connection	Cuts, MSD's, Electrocution	LL	More straight forward with modules
				Commissioning	Cuts, MSD's, Electrocution, congested work areas	LL	Less on-site commissioning needed
				Ancillary site risks	Slips, trips, falls	LL	Significantly less onsite workers will reduce risk Significantly less trade overlap

Risk change code (insitu>>pre-assembled): S = same (no change) R = Risk removed A = Additional (new) risk LL = Less likely ML = More likely LC = less serious consequence MC = more serious consequence C = more controllable

5.5 Phase III verification of risks

Phase III used a semi-structured interview schedule (Appendix N) to elicit information concerning the validation of the risks in offsite manufacture. There was a time lag of six years after phases I and II. The time lag was considered a significant advantage in that by returning to the same case study offsite manufacturers it was possible to investigate what changes had occurred post HASPREST. However, no claim of definitely attributing changes to the risk management tool is presented. The verification of the risks involved three senior managers from each of the three case studies, Trent Concrete Ltd, Revolutionary Pod Modules (Britspace-Gateway Pods[8]) and Caledonian Building Systems. Selected transcripts from the semi-structured interviews are presented in Appendix O. This section presents the results from the semi-structured interviews, they are presented under the themes developed from the order of the semi-structured interview schedule. The participants were asked to comment on the offsite risks as identified in phases I and II, what areas of risk have been addressed by significant changes in the factory processes, what areas of risk cannot be addressed and have to be managed and if they had used the risk management tool HASPREST. The interview schedule includes questions relating to the following topics;

The semi-structured interview schedule

- Comment on the original risks encountered during the manufacturing process in 2003;
- What areas of risk have been addressed by significant changes in the processes used in the last five years, please provide examples where appropriate?
- What areas of risk cannot be addressed and have to be managed, how are they managed?
- Have you used HASPREST?

5.5.1 Semi- structured interview procedure

The participants were interviewed in a quiet, comfortable area at the interviewees' offices. During the semi-structured interviews, the interviewer took notes. The interviews lasted

[8] As of August 2004, Revolutionary Pod Modules were acquired by Britspace-Gateway Pods. The Managing Director of Revolutionary Pod Modules (B) is the Sales Director for Britspace-Gateway Pods.

between ½-1 hour. The participants were given the opportunity to discuss any aspects of the offsite risks in the factory process, with the interview schedule acting as a guide. The conclusion of the interview was followed by a tour of the manufacturing facility, and an opportunity to ask further related questions and to clarify visually those points discussed at the interview.

5.5.2 Results

This section presents the results. The data for analysis included the semi-structured interview notes and observation notes during the inspection of activities and processes in each case study factory. Phase III was initialised by discussing with each respondent the activities analysed and offsite risks identified in the original phases I and II.

The HASPREST risk management tool had been used by all three of the case study organisations. The main use was where health and safety managers and production personnel attended a number of workshops and training sessions where the tool was demonstrated with specific examples relevant to their production process.

Case study 1: Trent Concrete Ltd

Comment on the original risks encountered during the manufacturing process in 2003

The risks identified in phases I and II during the manufacture of precast concrete cladding - heavy commercial face finished panels were concerned with the activities of mould construction, reinforcement assembly, placing of concrete and storage of the finished precast panel. The results were presented to the respondents and are summarised in Table 5.12.

Table 5.12 Risks areas identified from analysed activities in phases I and II

Activity	Phase I	Phase II
Mould construction	Mechanical handling	Trunk movement (MSDs), constrained standing (MSDs), slips and trips
Reinforcement assembly	Manual handling and cuts	Wrist injury (RSI), constrained standing (MSDs), slips and trips
Place concrete	Dermatitis, (MSDs), hand arm vibration, whole body vibration	Wrist injury (RSI), lifting (MSDs), constrained standing (MSDs), vibration (RSI), slips and trips, wet work (dermatitis)
Transportation/storage	Road traffic, mechanical handling and offloading risks	Extension of arms (RSI), wrist injury (RSI), overhead work (RSI), lifting (MSDs), wet work (dermatitis)
Installation	Panel fall, mobile plant, crush injury	

The activities and risks as identified in phase I and phase II were discussed with the respondent. Selected highlights from the interview (see Appendix O for selected transcripts), where the respondent perceived the offsite risks identified with the analysed activities remained problematic and were still inhibiting the factory process are presented. Interviewee F indicated that *'in general our processes have not changed over the last twenty years. The only process that has changed is in the type of concrete we use. We are using self compacting concrete as opposed to traditional grey concrete'* [F]. The placing of concrete was the only process that had changed. It was claimed that the process of mould construction, reinforcement assembly, transportation, storage and installation were exactly the same. One reason for this was suggested that '*there is no other way of doing it'* [F]. The following sections presents the discussion results.

What areas of risk have been addressed by significant changes in the processes used in the last five years, please provide examples where appropriate?

The placing of concrete in the moulds was identified as a significant process change. The use of self compacting concrete, discharged straight into the mould which does not require additional vibration or compaction, it was claimed has a major health and safety aspect. Self compacting concrete does not require distribution by hand, thus manual handling of concrete is eliminated, the concrete distributes itself and compacts itself under a chemical process. The labour required is significantly reduced, '*the chances of fatigue, tired, being worn out has gone completely, we have gone from four operatives around a mould to just two, there is no external vibration required, no poker vibration or hand held vibrators required, no vibration white finger, the noise from vibrating tables is eliminated. The self compacting concrete achieves higher strength and increased consistency'* [F].

The significance of this change is illustrated by the reduction in the frequent risk to wrist and lower arms, frequent lifting and carrying, constrained standing, discomfort caused by vibration, hazaourdous material (concrete) in work area and exposure to wet as revealed by the ergonomic audit (Table 5.6).

What areas of risk cannot be addressed and have to be managed, how are they managed?

In connection with the construction of the timber moulds, it was agreed that the offsite risks; trunk movement (MSDs), constrained standing (MSDs) and slips and trips remain. The use of steel moulds in place of timber was proposed as a consideration. It was claimed that timber is more suitable for the type of work undertaken. *'Steel is more expensive and less adaptable, steel moulds are used when there is considerable repetition, our average repetition is about six, a timber mould can be used and adapted to suit the quality requirements our clients demand at a suitable cost*' [F]. It was claimed that the trip hazards are managed by *'good housekeeping, these are achieved by instilling into the operative instruction on how to set up the moulds and the use of health and safety toolbox talks'* [F].

In connection with reinforcement assembly, the risks of manual handling, cuts, wrist injury (RSI), constrained standing (MSDs), slips and trips have to be managed. It was stated that '*everything is done by hand, there is no other way of doing it, we make a mould to suit a particular shape or panel'* [F]. The use of prefabricated reinforcement cages, was suggested, but it was claimed that *'the tolerance and the quality is not there, we tried it in the past, but the quality was low*' [F]. It was claimed that the risks of manual handling, cuts, wrist injury, constrained standing, slips and trips are managed by *'instruction on manual* *handling techniques, personal protective equipment (PPE), frequent breaks and good housekeeping'* [F]. It was claimed that '*The Health, Safety and Environmental manager oversees and implements safety for example, risk assessments and method statements, this instils a safety culture, we have a dedicated Health and Safety management system to keep on top of all these aspects'* [F].

The transportation, storage and installation of the completed panels use the same process, the activities and risks identified remain unchanged. The risks of road traffic, mechanical handling and offloading risks, extension of arms (RSI), wrist injury (RSI), overhead work (RSI), lifting (MSDs), wet work (dermatitis) remain and have to be managed. It was claimed that these risks are managed by *'regular safety checks and testing of mechanical handling equipment, load indicators on panels, designated transport areas, platforms and staging to minimise reaching, overhead work and wrist deviation. The use of PPE assists in reducing wet work exposure*' [F].

Case study 2: Revolutionary Pod Modules

Comment on the original risks encountered during the manufacturing process in 2003

The risks identified in phase I and II during the manufacture of washrooms were concerned with the activities of steel channel frame erection, installation of gyproc panels to walls and ceiling, tiling of the walls and floor of the washroom, installation of services, transport and installation of the washroom. The results were presented to the respondents and are summarised in Table 5.13.

Table 5.13 Risks areas identified from analysed activities in phases I and II

Activity	Phase I	Phase II
Steel channel frame erection	Manual handling (MSDs), cuts. overhead work (MSDs)	Overhead work (MSDs), lifting (MSDs), slips and trips
Gyproc panel installation	Manual handling (MSDs), cuts	Lifting (MSDs), slips and trips
Tiling	Restricted work area, (MSDs)	Wrist injury (RSI), overhead work (MSDs), lifting (MSDs), wet work (dermatitis)
Service installation	Restricted work area, (MSDs	Overhead work (RSI), lifting (MSDs), slips and trips
Transport	Road traffic, manual handling, craneage	
Installation	Cuts, craneage, MSDs, slips and trips	

The activities and risks as identified in phase I and phase II were discussed with the respondent. Selected highlights from the interview, where the respondent perceived the offsite risks identified with the analysed activities were reduced or removed and where risks remain problematic and were still inhibiting the factory process are presented. Interviewee B indicated that *'four of the risks have been reduced or removed for the processes used in the manufacture of washrooms. These include less manual handling of materials, less overhead work, less work inside the washroom and improved housekeeping and waste management to reduce slips and trips'* [B]. It was claimed that the processes relating to the assembly of the washroom frame and the craneage and transportation of the washroom remain the same.

What areas of risk have been addressed by significant changes in the processes used in the last five years, please provide examples where appropriate?

It was claimed that the risks relating to the installation of gyproc sheets have been significantly reduced, '*we now use pre-cut gyproc board, and supply enough for a complete washroom, the gyproc is cut at bench height, this reduces the amount of work inside the washroom, less crouching and reduced lifting, also trips and slips from debris and off cuts are reduced'* [B]. In addition, the tiling process was discussed, '*the process of tiling the* *inside of the washroom is basically the same, the only change is that the tiler does not do any grouting, this is done by another operative dedicated to grouting only'* [B]. Furthermore, it was claimed that *'significant changes relate to many more activities carried out on benches, less overhead work, less reaching and less wrist problems, for example services such as; plumbing, return valves are assembled on a bench outside the washroom. The electrics are done offline and brought to the washroom, very much like the car industry, we use wiring harnesses, and printed circuit boards, that plug into the washroom'* [B].

The significance of these process changes are illustrated by the following reduction in risks. Reduction in the risk of frequent lifting and carrying of gyproc panel sheets (under 10kg and occasionally under 18kg) over unfavourable conditions. Reduction in trip hazards in the floor of the pod. Reduction in the frequent risk to wrist and lower arms and high overhead work when tiling and handling services, reduction in lifting and carrying (tile boxes and bathroom appliances) and exposure to wet (tile adhesive) as revealed by the ergonomic audit (Table 5.8).

What areas of risk cannot be addressed and have to be managed, how are they managed?

Washroom frame assembly remains the same, the risks of manual handling (MSDs), cuts, overhead work, lifting (MSDs), slips and trips remain. It was claimed that the management of housekeeping has improved. The storage of materials and waste handling has improved with increased debris control. *'There is a significant reduction in trip hazards, delineated walkways and work areas have led to better discipline on housekeeping. We use bins for various waste categories, the joinery is now carried out in a joiner's shop with dedicated storage areas, better storage of materials with work performed at bench height, this reduces reaching and work inside the washroom*' [B].

The transportation and installation of the completed washrooms use the same process, the activities and risks identified remain unchanged. The risks of road traffic, manual handling (MSDs), craneage, cuts, slips and trips remain and have to be managed. It was claimed that these risks are managed by *'transport remains the same, we use fork lifts to place the washroom on the lorry, during delivery and installation, operatives stand on the washroom, now they must use a harness to attach themselves to something. The lifting of the washroom during craneage operations remains the same, if the lifting gear fails, and the washroom falls, the risk of serious injury remains'* [B]. All staff must have a Construction Skills Certification Scheme (CSCS) card, this results in improved awareness of health and safety. '*Introduction of CSCS cards has made everyone aware now of health and safety issues, all staff including salesman must have a CSCS card on site'* [B].

Case study 3: Caledonian Building Systems

Comment on the original risks encountered during the manufacturing process in 2003

The risks identified in phases I and II during the manufacture of building modules were concerned with the activities of steel frame assembly, insulation installation, steel sheeting installation, MDF installation, gyproc installation, services installation, transport and module installation on site. The results were presented to the respondents and are summarised in Table 5.14.

Table 5.14 Risks areas identified from analysed activities in phases I and II

Activity	Phase I	Phase II
Steel channel frame	Manual handling (MSDs), mechanical handling, cuts, fumes, overhead work (MSDs)	Wrist (RSI), overhead work (MSDs), lifting (MSDs), constrained standing (MSDs), slips and trips
Insulation to walls	Manual handling (MSDs), overhead work	Slips and trips
Steel sheeting to walls	Manual handling (MSDs), overhead work	Load on arms (RSI), wrist injury (RSI), overhead work (MSDs), lifting (MSDs), constrained standing (MSDs), slips and trips
MDF to walls ceiling	Manual handling (MSDs), overhead work	Extension of arms (RSI), load on arms (RSI), wrist (RSI), overhead work (RSI), lifting (MSDs), constrained standing (MSDs), slips and trips
Gyproc to walls ceiling	Manual handling (MSDs), overhead work	Extension of arms (RSI), load on arms (RSI), wrist (RSI), overhead work (RSI), lifting (MSDs), constrained standing (MSDs), slips and trips
Services	Manual handling (MSDs), cuts, hand arm vibration (HAVS),	Overhead work (RSI), slips and trips
Transport	Road traffic, (MSDs), craneage	
Module installation	Cuts, craneage, MSDs, slips and	

The activities and risks as identified in phase I and phase II were discussed with the respondent. Selected highlights from the interview, where the respondent perceived the offsite risks identified with the analysed activities were reduced or removed and where risks remain problematic and were still inhibiting the factory process are presented. Interviewee D indicated that *'ten of the risks have been reduced or removed for the processes used in the manufacture of modules. These include, less manual handling, less wrist injury (RSI), less overhead work, reduction in fumes, less extension of arms, less lifting, less constrained standing, less cuts, less hand arm vibration and improved housekeeping, less slips and trips'* [D]. It was claimed that the processes and risks relating to the installation of insulation, steel sheets, MDF and gyproc to the walls of the module have remained unchanged, the installation to the floor and ceiling of the module is carried out at bench height. The craneage and transportation of the module remain the same.

What areas of risk have been addressed by significant changes in the processes used in the last five years, please provide examples where appropriate?

The change in the process of module frame assembly has had a substantial impact on the activities and risks issues as explained by interviewee D, '*the production process has shifted markedly over the last five years, we as a group have acquired additional premises, the sequence and location of production has been re-designed. The fabrication of the steel frame is located in a dedicated fabrication shop. We now use a separate factory to assemble the floor and ceiling frames of the module at bench height, this eliminates work at height. We have installed two overhead cranes, this eliminates manual handling and lifting of the steel channel section, this reduces the risk of cuts. In addition, because the floor and ceiling units are assembled at bench height, we can now eliminate any need for overhead work in installing insulation, steel wall sheets, MDF and gyproc board to the ceiling inside the module. The fabrication shop reduces the risks associated with weld operations; wrist injury, constrained standing and weld fumes. All the welding is done in one place separate from other trades, we have no trade overlap. The weld area is equipped with a crane, so that the welding can be done at bench height. In addition the welding operatives are now fully equipped with breathing apparatus, these have filtration systems that deliver clean air via the face mask to the operative at all times. The filtration system indicates when the filters need replacing'*.

There has been a revision to the process of the installation of services to the module. The use of service units have removed four of the risks of manual handling (MSDs), cuts, hand arm vibration syndrome (HAVS) and slip and trips. This was explained as, '*we now use a service unit, this is a unit assembled offline on a bench that contains the plumbing, wiring and air handling ductwork for the module. These are then installed as a single unit, this eliminates manual handling, cuts the use of power tools (HAVS) and the chance of slips and trips from debris inside the module'* [D].

The re-organisation of the manufacturing facility after the acquisition of additional floor space, it was claimed has impacted on housekeeping in the overall module manufacturing process. This was explained by interviewee D as, *'the need to address the issue of housekeeping was re-considered. The investment in new building resource coupled with the* *introduction of extensive recycling and segregation of materials has improved housekeeping and waste management to reduce slips and trips'* [D].

The significance of these process changes are illustrated by the following reduction in risks. Reduction in the risk of work at height, reduction in the frequent risk to wrist and lower arms and high overhead work when welding the steel frame channel sections, reduction in lifting and carrying (steel channel sections) reduction in constrained standing and fumes during welding operations. Reduction in overhead work in installing insulation, steel wall sheets, MDF and gyproc board to the ceiling inside the module. Reduction in manual handling, cuts and the use of power tools (HAVS), reduction in trips from debris inside the module as revealed by the ergonomic audit (Table 5.8).

What areas of risk cannot be addressed and have to be managed, how are they managed?

The installation of insulation, steel sheeting, MDF and gyproc to the walls of the module remain unchanged. It was claimed that *'there is no other way of doing this, we still use the same process for the walls'* [D].

The transportation and installation of the completed modules uses the same process, the activities and risks identified remain unchanged. The risks of road traffic, manual handling (MSDs), craneage, cuts, slips and trips remain and have to be managed. It was claimed that these risks are managed by *'the lifting of the module form the factory during transport remains the same, we use fork lifts and the craneage operations remains the same, the risks of injury remain the same'* [D].

5.6 Summary

This chapter has presented the results and the analysis for the three discrete components of the study; namely phase I, the group interviews, phase II, the ergonomic audits and phase III, the semi-structured interviews and observation for the three case study offsite manufacturers. This has addressed the third objective and provided a platform for the achievement of the fifth objective (1.3.4). The presentation of the results has been arranged in three parts following each phase. The chapter has investigated and analysed the selected activities and risks for the manufacture of non-volumetric, cladding - heavy commercial face finished precast concrete panels, volumetric, washrooms and modular buildings. The chapter has also detailed the change in risks in moving from insitu to offsite. The chapter has also reviewed the changes to the risks in each of the case study organisations as a result of the changes in manufacturing process. This has unveiled an identification of the offsite residual risks that remain and an indication of how these risks are managed. The chapter has presented how the results were analysed and evaluated and subsequently translated into the risk management tool. The tool is presented in the next chapter.

6 HASPREST

6.1 Introduction

This chapter reviews the funded research project HASPREST, 'the effect of standardisation and pre-assembly on health, safety and accident causality'. In particular, it provides an overview of HASPREST; how it came into existence, the methodology behind the research and its deliverables. This formed the supplementary work, the focus of the thesis concentrates on the research output "*offsite health and safety issues for OSP products – principal contractor or other party inspecting offsite works*".

6.2 The Project

The HASPREST project was initiated after the Department for Environment, Transport and the Regions (DETR) highlighted health and safety as being under-represented in Government-funded research. The HSE acknowledges that offsite needs to be properly evaluated for its effect on health and safety.

The research team for this project was a unique, multi-disciplinary collaboration between the Civil and Building Engineering, Human Sciences and Design and Technology Departments at Loughborough University. The team was established and had completed a number of projects in collaboration with major industry players and produced several publications. The team had previously been involved with HSE in a major drive to reduce accidents by developing a fuller understanding of their causes. This work formed the health and safety link with the HASPREST project. The team applied the lessons learnt from previous HSE work and review strategies developed from the whole industry viewpoint to the more specific area of offsite.

The £200,000 research project was 50/50 industry/government funded through the LINK scheme, meeting clients needs through standardisation (MCNS). This scheme was jointly funded by the Engineering and Physical Sciences Research Council (EPSRC) and the Department of the Environment, Transport and the Regions (DETR).

There were seven industrial partners in the project: INNOGY, Trent Concrete Ltd, Crown House Engineering, Carillion Construction, Caledonian Building Systems, Geoffrey Reid Associates, Revolutionary Pod Modules. The steering group for the project comprised these organisations and the research team with additional input from the Health and Safety Executive (HSE), Trades Union Congress (TUC) and Roy Duff an academic from the

University of Manchester Institute of Science and Technology (UMIST). (Now retired and acting as an independent consultant).

The research project developed a strategy for the risk management of health and safety in offsite construction, covering selected elements of building and civil engineering.

6.3 Aim of HASPREST

The aim of the research was to provide an enhanced risk management tool, concentrating on the manufacture and installation of offsite construction. This was achieved through a comprehensive study covering, non-volumetric, volumetric and modular building approaches across engineering construction, civil engineering and building sectors, in order to establish the extent of the effect of Standardisation and Pre-assembly (offsite), on health, safety and accident causality in construction. At the first steering group meeting, the steering group members agreed to use the term offsite production (OSP) and this term is used throughout HASPREST. Subsequent to HASPREST, the more generic term 'offsite' has tended to replace OSP.

6.4 Objectives

There were four main objectives for the project:

1. To identify the nature and the extent of the effect of offsite on occupational safety and health in the construction industry
2. To apply the review strategies developed in the current Loughborough work with the HSE to offsite applications
3. To develop a health and safety risk model for offsite
4. To provide strategic and detailed guidance to enable project teams to exploit the techniques in a manner that ensures the safety and well being of all those involved in the process

6.5 Delivery of the project and resource

This section outlines the personnel involved in the research. The research was undertaken by a team from Loughborough University. Alistair Gibb led the project, Martyn Pendlebury (RA 1) coordinated the research and Lawrence McKay (RA 2), the author of this thesis, conducted the fieldwork. A steering group meeting quarterly and comprising the research team, industrial collaborators, the HSE and an academic (Roy Duff) from UMIST, guided the project.

The author of this thesis was responsible for the main data gathering phase. This required a significant number of visits to collaborators works and sites. The methodology for the thesis is described in chapter 4, the following section presents the method and main details of the research project, this formed the supplementary work which contributed to HASPREST.

The project was conducted over three years, with RA1 employed part-time and RA2 employed full-time throughout. RA2 spent the first six months of the project visiting several of the case study manufacturing sites. The rational being to observe live projects and gain a foundation of the technical aspects of the research. The next 18 months were spent at Loughborough University working with RA1. Both RAs were employed for a further 12 months on various projects related to HASPREST.

6.5.1 Research Associate 1

The literature review was an on-going process which continued throughout the project and ended at the last stage of writing-up the thesis. Experience on previous projects, coupled with the aid of the steering group members and the company collaborators provided opportunities for knowledge transfer from the manufacturing industry into the offsite industry.

A number of historical case studies were identified and reviewed, to provide support and background information on health and safety guidance. The steering group members were used as a basis for gathering knowledge on health, safety and accident causality in the areas of offsite manufacture and health and safety management. These experts were also used for a series of workshops in the development of the risk management tool.

6.5.2 Research Associate 2 (Thesis author)

Further literature review in collaboration with RA1, to ensure that the implications from the field data gathering stage were incorporated and embedded. In addition, collaboration with related health and safety projects, ensured the consistency and accuracy of the desk based study component of the project as detailed in the literature review chapters 2 and 3.

Additional semi-structured interviews were conducted with the project steering group as a basis for obtaining industry contacts. Additional contacts developed throughout the initial and formative stages of the project resulting in over 30 key experts in health and safety, offsite and accident causation. The experts were interviewed using a semi-structured approach. The questions were refined through discussions with leading researchers and the steering group members before the main interviews. The interviews were either face to face or by phone to obtain detailed complex answers to clarify unclear responses and explore issues in depth. During the interviews, notes were taken, this assisted in forming new questions, stimulating early insights for subsequent interviews and facilitating later analysis. A post interview log was kept of the authors reflections and elaborations and learning.

6.6 HASPREST methodology

The methodology linked work packages with the objectives, principal supervisors, main collaborators and deliverables. The following section outlines the HASPREST project methodology.

Work Package 1 Workplace ergonomic audits

Principal supervisor: Roger Haslam *Main collaboration:* Trent Concrete Ltd, Revolutionary Pod Modules and Caledonian Building Systems. *Data collection and analysis* Lawrence McKay

I. Ergonomic health and safety work-place audits for both conventional construction process and offsite pre-assembly processes were conducted by studying three cases for each sector under consideration. Aspects considered included manual handling, potential for musculoskeletal disorders, exposure to hazardous substances, noise, hand-arm vibration, as well as material and plant risks such as crane usage. Social, skills and training issues were also considered. Historical data from conventional site construction was used as a benchmark for data validation.

II. Case study research was expanded to develop key opportunities for improvement, using 30 semi-structured interviews with experts from manufacturers, installers, principal contractors and planning supervisors.

Work Package 2 Apply HSE causality review strategies

Principal supervisor: Alistair Gibb *Main collaboration:* HSE & Roy Duff, UMIST. *Analysis*: Lawrence McKay

I. Results from the concurrent HSE accident causality project were used to table and develop causal relationships for offsite. The HSE retained an involvement and contribution to this review.

Work Package 3 Health and safety risk model for offsite

Principal supervisor: Roger Haslam *Main collaboration:* BAA, Innogy, Trent Concrete, Crown House Engineering, Carillion, Caledonian. *Analysis*: Lawrence McKay

I. The existing risk assessments were developed to produce a health and safety risk-model using action research method with industrial collaborators for each sector. Key features drawn out by comparing and contrasting conventional and offsite fabrication approaches.

II. The model was tested using eight industrial experts to verify its integrity.

Work Package 4 Safe & Healthy implementation of offsite

Principal Supervisor: Alistair Gibb *Main collaboration:* BAA, Innogy, Trent Concrete, Crown House Engineering, Carillion, Caledonian. *Analysis*: Lawrence McKay

I. A strategic best practise guide for health and safety management of offsite in each sector was developed.

Work Package 5 Dissemination

Principal supervisor: Gibb. *CD Production and authoring*; Lawrence McKay

I. The HASPREST guidance CD and final report to EPSRC/DTI were produced.

II. Workshops and dissemination seminars were organised.

6.7 HASPREST strategy

HASPREST is an interactive CD ROM software risk management tool that provides a strategy for assessing the health and safety of offsite manufacturing, installing offsite products and developing risk assessment documents for offsite. A copy of the CD is appended to this thesis.

6.7.1 HASPREST

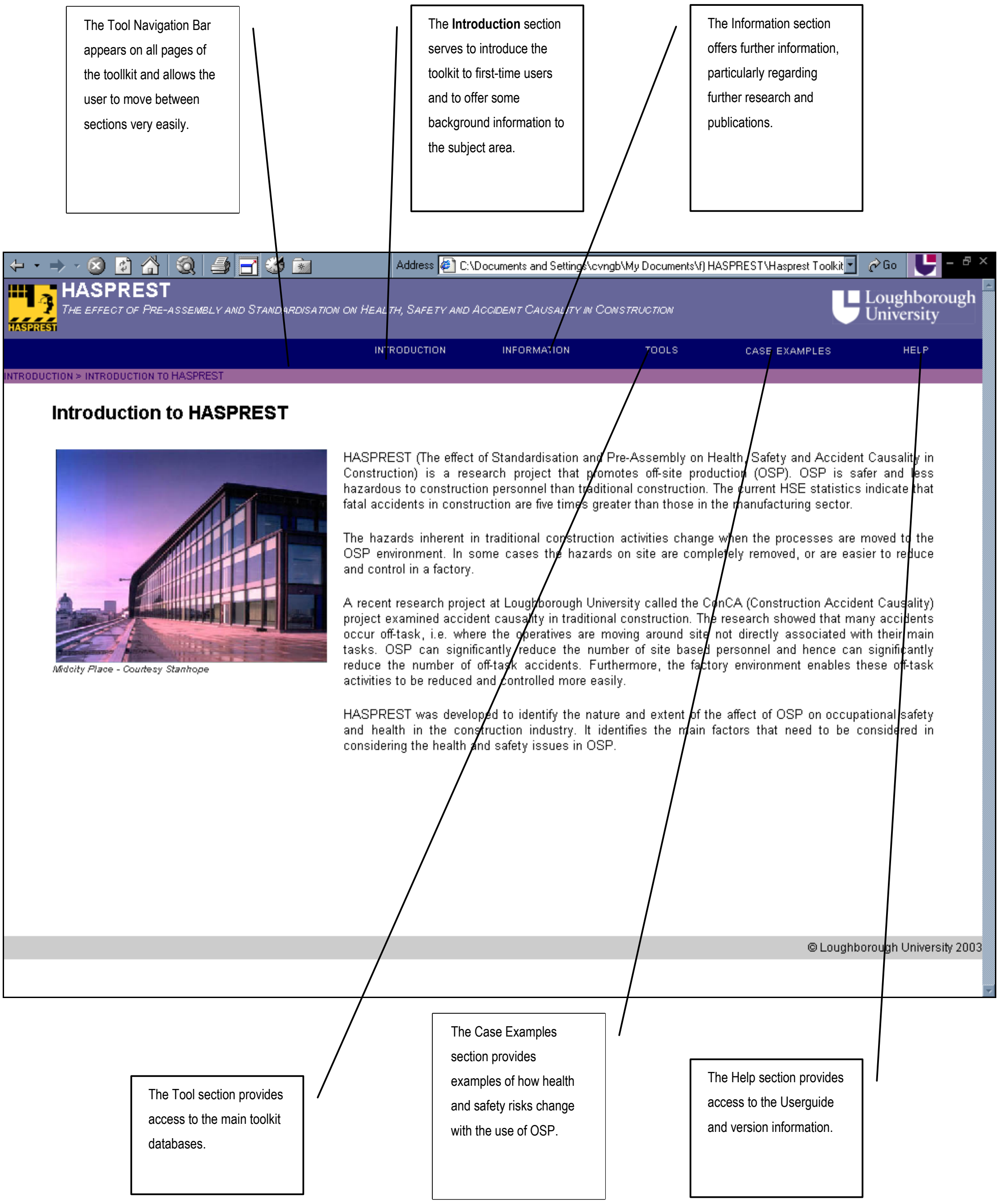
HASPREST is designed for use by anyone within the offsite construction supply-chain, although primarily for those assessing the health and safety risks to some aspect of the offsite construction process. The toolkit has not been designed to replace the functions of any member of the supply-chain, but rather to serve as a database of risks to be recognized when assessing different methods of construction.

HASPREST can assist in the formulation of risk assessment and offsite health and safety strategy. The toolkit;

- facilitates early design decisions by comparing the health and safety risks and issues of offsite methods against their traditional equivalents;
- provides prompts to assist in developing a health and safety plan for any works being done offsite;
- offers guidance for the management of the on and offsite aspects of product manufacture and installation;
- sets an agenda for continuous improvement of the offsite manufacturing supply-chain.

The HASPREST interface (Figure 6.1) pages are all based on a standardized template allowing access to any page in the tool from any other location. The main menu along the top of each page provides access through drop-down menus. All the pages in the tool are HTML files, however datasheets are PDF files that open in separate windows when activated. These have been formulated so as to ease the printing of the documents.

Figure 6.1 HASPREST main page interface



6.8 HASPREST Tools

HASPREST addresses the issues of offsite health and safety through six key stages:

Stage 1	Why consider health and safety issues early in the project
Stage 2	Develop a health and safety strategy for offsite
Stage 3	Develop a pre-construction health and safety assessment for offsite
Stage 4	Offsite health and safety issues for offsite products
Stage 5	On site health and safety issues for offsite products
Stage 6	Health and safety issues for the whole life of the facility or product

HASPREST superimposes the six key stages over the generic design and construction process protocol map. These identify significant management actions and decisions in a project, from the project inception through to demolition and decommission. The key stages, relating to health and safety have been positioned over the map indicating the phases of the project at which these issues should be considered. The Tools link in the Navigation Bar gives users various options for accessing the main data within the toolkit. Two main routes are provided, namely a generic process map (Figure 6.2) or a RIBA plan of work (Figure 6.3). The coloured boxes within the processes provide links to the various databases of the toolkit, as presented in the next section. The following screenshots demonstrate the type of information that is provided.

Figure 6.2 Generic Process Map[9]

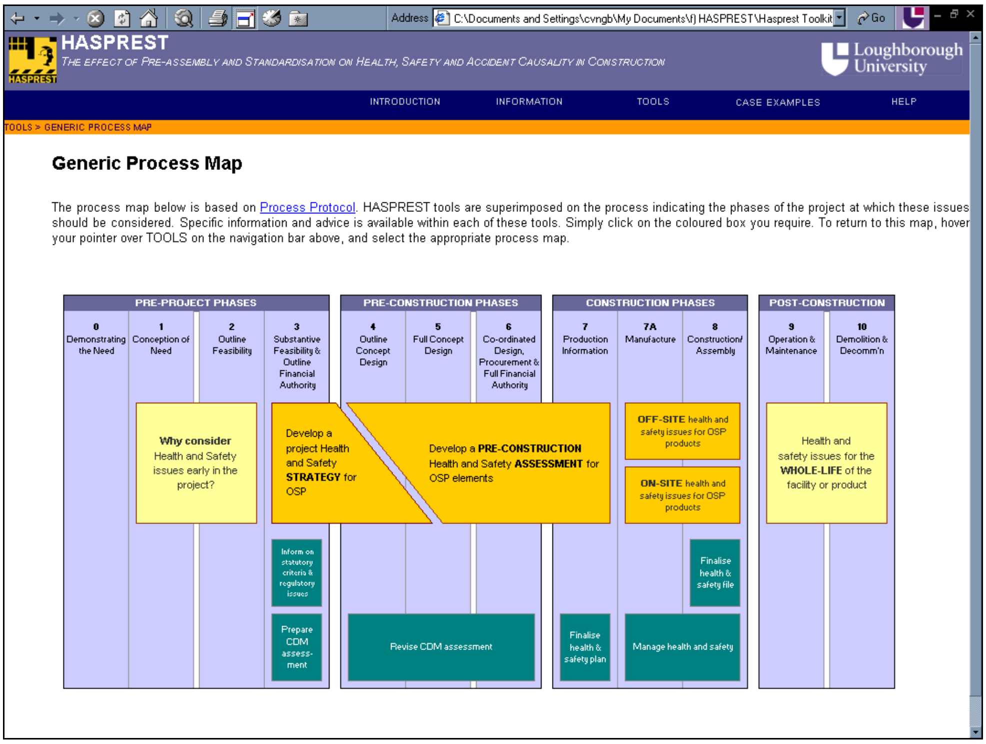
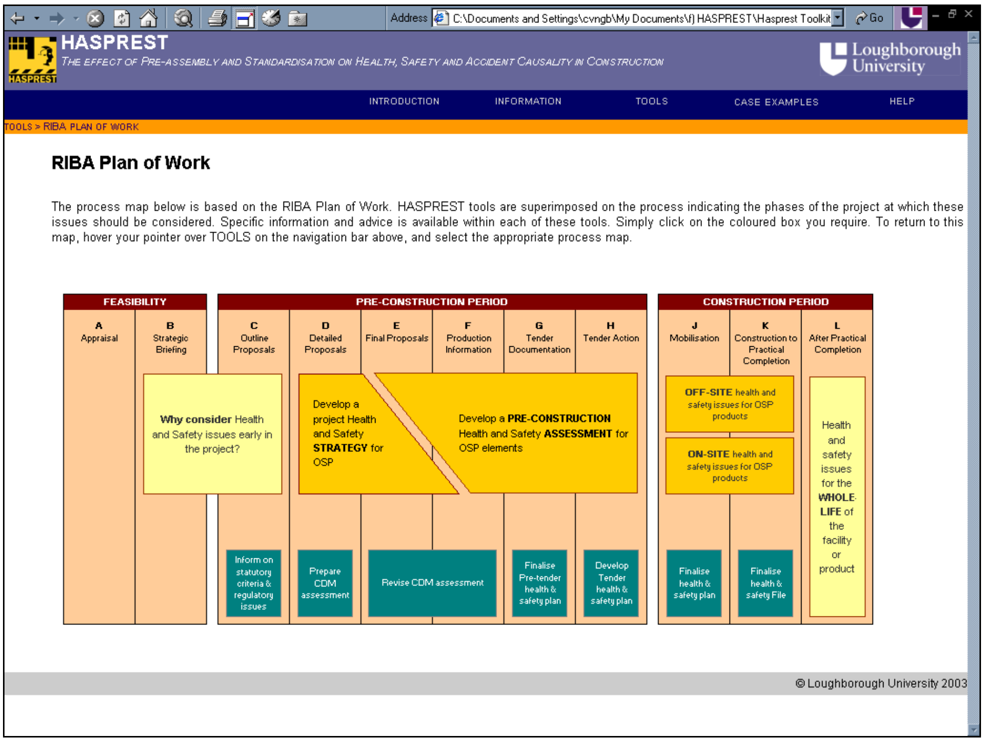


Figure 6.3 RIBA Plan of work[10]



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[9] Generic design and construction process protocol (1988), University of Salford

[10] Plan of work for design team operation. (1973), 2nd Edition RIBA

6.8.1 Why consider health and safety issues early in the project ?

This section, stage 1 of the tool, emphasises the importance of early consideration of offsite, in terms of the health and safety advantages of offsite manufacturing. The following advice was developed from the research and the supplementary work:

Factories are safer because:

- Risks are less and are easier to control;
- Training is easier to achieve;
- Less trade overlap;
- Workforce is more consistent;
- People 'look out' for one another;
- The weather factor is removed.

A discussion of what happens to the risk is included, in that generally the risk is moved to a place where it is easier to control. Some risks (especially the ad-hoc, off-task risks) on site are removed. Many traditional site risks have low potential consequences but a high likelihood. Often, these types of risks are overlooked by site management. Occupational health risks may have low consequences as single events, but when combined over a period, can produce very serious health problems.

Assembly risks connected to offsite production may have higher consequences (e.g. craneage collapse) but much less likelihood. Furthermore, these new risks are typically of the type that are more 'obvious' and can be better controlled as they 'should' be better planned (e.g. delivery and craneage of large units).

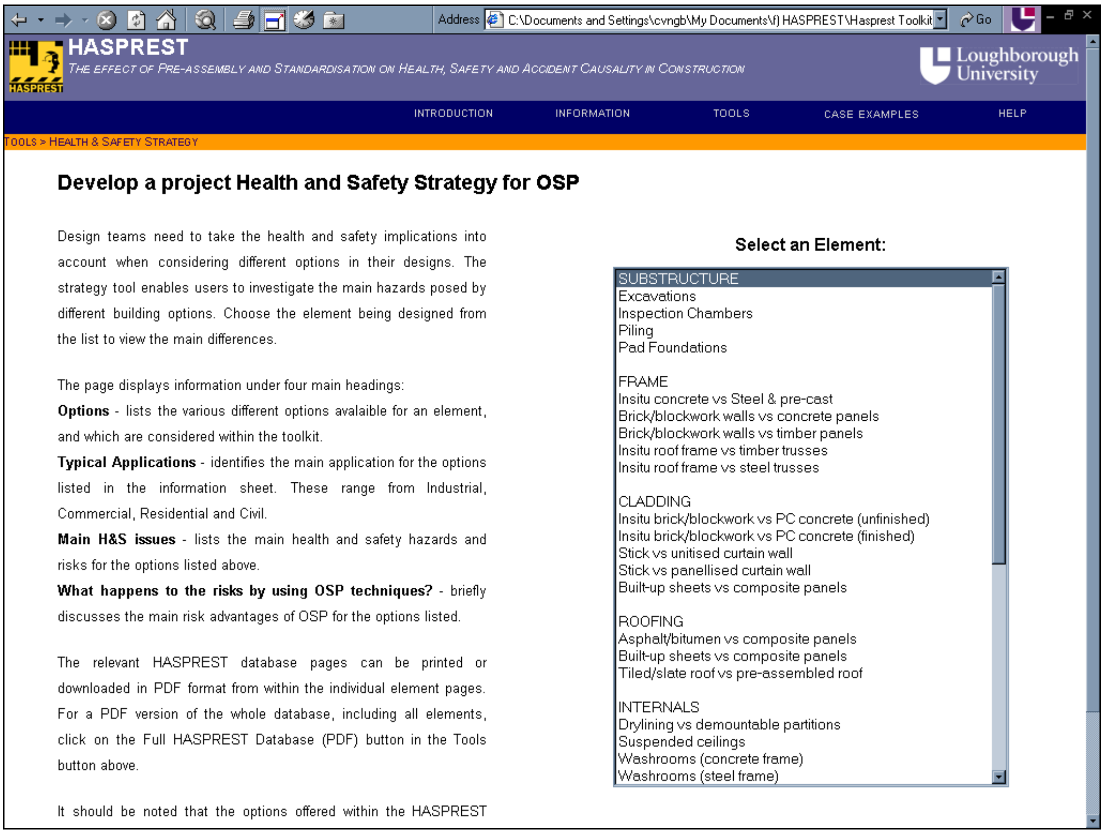
6.8.2 Develop a project Health and Safety Strategy for offsite

Stage 2 of the tool assists in the development of a project health and safety strategy for offsite. This section re-directs the user to a list from which an element can be selected (Figure 6.4). The list is reproduced in tabular form Table 6.1. Upon selection of an element, the information on Figure 6.5 is displayed.

Table 6.1 List of elements available in HASPREST

Category heading	List of elements
Major building	
Buildings - substructure	excavations inspection chambers piling pad foundations
Buildings - structure	insitu concrete vs. steel & pre-cast brick/bockwork walls vs. concrete panels brick/bockwork walls vs. timber panels
Buildings - cladding	insitu brick/bockwork walls vs. precast concrete (unfinished) insitu brick/bockwork walls vs. precast concrete (finished) stick vs. unitised curtain wall stick vs. panellised curtain wall built-up sheets vs. composite panels
Buildings - roofing	asphalt/bitumen vs. composite panels built-up sheets vs. composite panels
Buildings - internals	drylining vs. demountable partitions suspended ceilings washrooms/kitchens
Buildings – services/ modules	mechanical and electrical – source units mechanical and electrical – vertical distribution mechanical and electrical – horizontal distribution
Civil engineering	excavations inspection chambers piling bridges A precast concrete bridges B steel bridges C hybrid culverts tunnels
Engineering construction	excavation inspection chambers piling pad foundations insitu concrete vs. steel and precast frame built up sheets vs. composite panel cladding process plant source process plant distribution

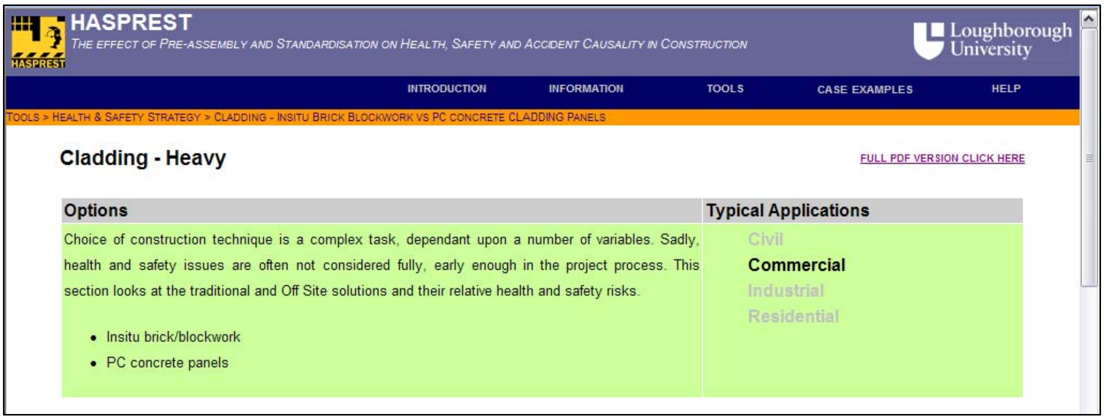
Figure 6.4 Develop a project health and safety strategy for offsite



Design teams need to take the health and safety implications into account when considering different options in their designs. The strategy tool enables users to investigate the main hazards posed by different building options. The element being designed can be selected from the list in order to view the main health and safety risks for insitu and offsite (OSP). For demonstration purposes the element "cladding- heavy commercial face finished" is chosen for discussion. The page displays information under four main headings:

Options - lists the various different options available for an element, and which are considered within the toolkit (Figure 6.5). In this case, cladding either insitu brick/blockwork or offsite PC concrete panels.

Figure 6.5 Develop a project health and safety strategy for offsite; cladding



Typical Applications - identifies the main application for the options listed in the information sheet. These range from Industrial, Commercial, Residential and Civil. In this case commercial (Figure 6.5).

Main H&S issues - lists the main health and safety hazards and risks for the options listed above. The main health and safety risks are listed with the element and a list of those risks significantly reduced using offsite techniques (Figure 6.6).

Figure 6.6 Project health and safety strategy, cladding; health and safety issues

What happens to the risks by using offsite techniques? - briefly discusses the main risk advantages of offsite for the options listed (Figure 6.7).

Figure 6.7 Project health and safety strategy, cladding; offsite risk advantages

What happens to risks by using OSP?

The main health and safety benefit from OSP heavy cladding units is that operatives spend less time working at height. The delivery and handling of base materials is more organised in a factory environment. The transport to site of the manufactured cladding units are fewer in number, less ad hoc and these must be effectively managed.

Site installation of bricks andblock elements create a number of risks to health and safety. However, because the operations are so common, these risks often get overlooked.

The use of precast concrete cladding panels removes the need for site installation of brick and blockwork. The risk of MSDs and dermatitis can be controlled. Transport to site of the manufactured precast cladding panels are fewer and can be controlled more easily.

The risk of hand injury is increased and has a more serious consequence. The use of precast panel elements involves much less work than insitu brick and block walls. The following risks are significantly reduced and can be controlled: wet work, manual handling, scaffolding. The movement and final positioning of the precast panel elements present a more serious risk if the load is not properly controlled.

The use of OSP reduces the number of personnel on site, thus reducing exposure to off-task risks.

The relevant HASPREST database pages are available for detailed inspection of each individual element (Table 6.2). The options offered within the HASPREST database are not exhaustive. The categories within the toolkit should however provide sufficiently similar elements for users to obtain an adequate indication of risks. This section of the tool is the main focus of this thesis and is presented in detail in chapter 5 and the discussion chapter 7.

Table 6.2 Cladding – heavy commercial face Finished

Cladding –heavy commercial face Finished (Commercial)
These activities are based on insitu brick/blockwork vs PC concrete face finished panels
Main H& S Issues: working at height, craneage, reduction in manual handling (eg bricklaying)

Brick/blocklayings				Pre-cast concrete cladding panel Face Finished			
Comments	**cf OSP**	**Main Hazards**	**Main Off-Site Activities**	**Main Off-Site Activities**	**Main Hazards**	**cf insitu**	**Comments**
	S	Various but same as OSP factory	Delivery of base materials to brick ready mix suppliers	Delivery of base materials to factory	Various but same as for insitu	S	
	S	Various but same as OSP factory	Mix clay place in moulds and fire bricks at works	Set up Moulds	Mechanical handling, craneage	S	
	A	Road traffic, site access, site conditions	Transport & deliver bricks and mortar to site	Place slips or Architectural finish	Cuts, dermatitis, MH	LL, C	
	S	Road traffic, mechanical handling, offloading etc		Reinforce, fix inserts etc	Mechanical handling, craneage	A	
Comments	**cf OSP**	**Main Hazards**	**Main On-Site Activities**	Mix concrete	Various but same as ready mix	S	
	S	Concrete burns, dermatitis	Ground beam concrete	Place concrete	Craneage, dermatitis, MH, MSDs	C	
	S	Various but same as OSP	Prepare site for bricklaying	Vibrate	HAVS, dermatitis, whole body vibration	C, A	Large panels often result in whole body vibration during compaction. (See Trent)
			Set out corners	Form box-outs	MSDs, dermatitis	LL, C	
.	A	Repetitive tasks, MH, Cuts, Dermatitis, MSD, falling material, unstable ground, exposure to UV.	Transport bricks				
The use of a heightened level of set out pile of bricks and mortar decreases the workload for high brick rows	C in OSP	MH, falling material, unstable ground	Moving bricks/blocks to workface	Remove/store	Mechanical handling, craneage	A, MC	Consequence of panel fall or sling failure more series consequence (ref Trent)
	C in OSP	MH, MSD, working at height, overhead work, walking into objects or projections.	Erecting work platforms	Transport and deliver panels to site	Road traffic, mechanical handling, offloading etc	A, MC	Consequence of panel fall or sling failure more series consequence (ref Trent)
				Transport & deliver plant to site	Road traffic, mechanical handling, offloading etc	A, MC	Mobile crane risks
	A	Dermatitis, breathing dust fumes, mortar splashes in eyes, rash allergies, exposure to UV .MH	Mix mortar	**Main On-Site Activities**	**Main Hazards**	**cf insitu**	**Comments**
	A	Struck by cut brick from saw, electric cutting equipment-electric shock, dust grit or brick splinters, noise, exposure to UV. MH	Brick cutting	Prepare site for panels	Various but same as insitu	S	Design could allow for internal working. Therefore no external access required.
	A	Dermatitis, repetitive tasks, MSD, MH working at height	Laying mortar	Move panels to required position	Mobile plant risks, hand injuries, large loads	A, MC	Hand injuries more serious (Ref. Trent)
				Connect panel to frame	Plant, hand injuries	A,	Hand injuries more serious (Ref. Trent)
	A	Working at height, exposure to UV, MH, confined space work, Dermatitis, clearing away mortar overspill, cleaning mortar from tools	Bricklaying				
	A	Repetitive tasks, cuts splinters	Fix wall ties, mesh reinforcement place lintels & DPC	Jointing in Mastics			
	C in OSP	Working at height, confined space, repetitive tasks, dermatitis	Pointing/finishing	Finishing		LL	Less finishing work required
More site labour required	ML	Slips, trips, falls	Ancillary site risks	Ancillary site risks	Slips, trips, falls	LL	Less site labour

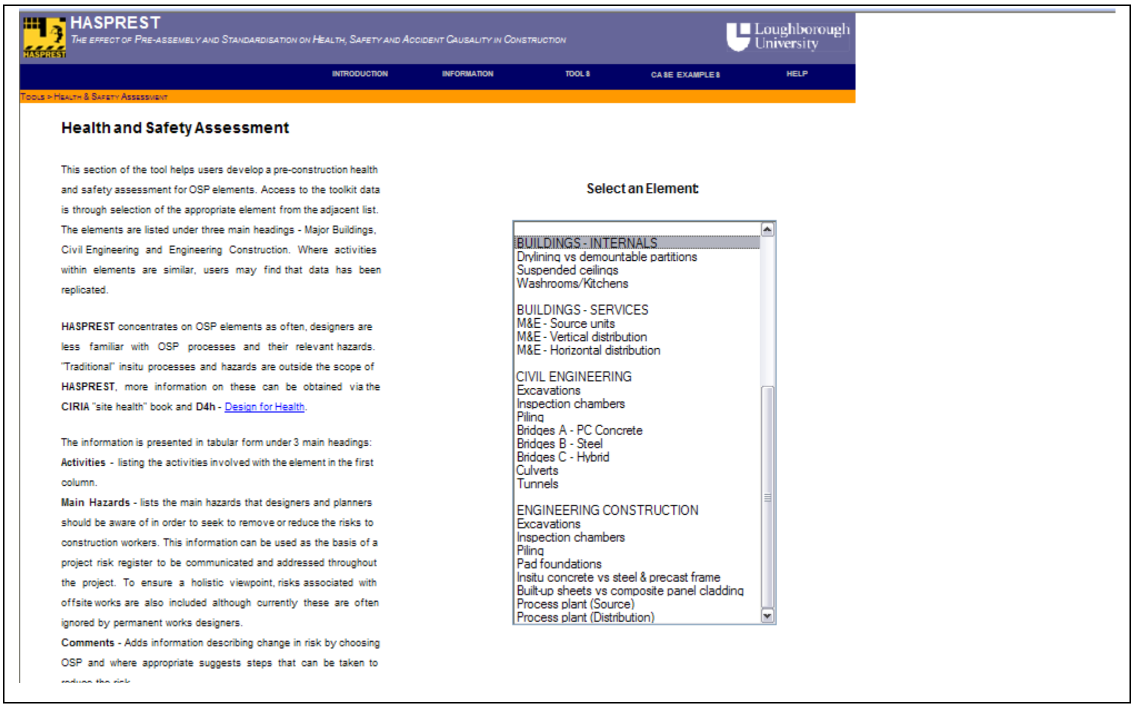
Note – Pre cast cladding finished panels

Risk change code (insitu>>pre-assembled): S = same (no change) R = Risk removed A = Additional (new) risk LL = Less likely ML = More likely LC = less serious consequence MC = more serious consequence C = more controllable

6.8.3 Develop a pre-construction health and safety assessment

Stage 3 of the HASPREST tool assists in the development of a pre-construction health and safety assessment for offsite elements. Access to the information is through selection of the appropriate element (Figure 6.8). The elements are listed under three main headings - Major Buildings, Civil Engineering and Engineering Construction. Where activities within elements are similar, the user may find that data has been replicated.

Figure 6.8 Pre-construction health and safety assessment; element selection



HASPREST concentrates on offsite elements as, often, designers are less familiar with offsite processes and their relevant risks. In this case the example chosen is inspection chambers, pre-cast concrete in place of insitu bricks and or insitu concrete. The information is presented in tabular form under three main headings (Figure 6.9).

Activities - listing the activities involved with the element in the first column.

Main Hazards - lists the main risks that designers and planners should be aware of in order to seek to remove or reduce the risks to construction workers. This information can be used as the basis of a project risk register to be communicated and addressed throughout the project. To ensure a holistic viewpoint, risks associated with offsite works are also included although currently these are often ignored by permanent works designers.

Comments - Adds information describing change in risk by choosing offsite and, where appropriate, suggests steps that can be taken to reduce the risk. The relevant HASPREST database pages are available for detailed inspection from within the individual element pages. The options offered within the HASPREST database are not exhaustive. The categories within the toolkit should however provide sufficient similar elements for users to obtain an adequate indication of risks.

Figure 6.9 Pre-construction H&S assessment; offsite/insitu inspection units

Substructure - Inspection Chambers Precast concrete or UPVC in place of insitu bricks and or concrete.

FULL PDF VERSION CLICK HERE

Having chosen an off site solution, it is essential that appropriate assessment of the health and safety risks are considered. This section considers the off site solution with reference back to the traditional technique.

OFF-SITE Works: for more advice on minimising off site risks see Off Site H & S issues		
Activity	**Main Hazards**	**Comments**
Deliveries to factory	Transport	More organised as single delivery location
Deliver materials and out-sourced sub-assemblies	Manual and mechanical handling	More controllable as fixed factory location. Likely to be more mechanical handling
Manufacture UPVC chamber	Manufacturing process	Industrialised process – should be well managed – outside HASPREST scope
Prepare units for transportation	Craneage, mechanical handling	More controllable risks as in factory environment
Transportation and delivery to site	Road traffic, site access, craneage etc	Fewer, larger more organised loads than insitu.
ON-SITE Works: for more advice on minimising on site risks see On Site H & S issues		
Activity	**Main Hazards**	**Comments**
Excavation	Confined spaces, Plant, Vibration, Open holes, Manual handling etc	Same as per insitu.
Concrete base	Dermatitis, Weil's disease	Usually only blinding concrete needed for OSP option– ie less work and less risk.
Position chamber (UPVC)	Manual Handling	Much lighter loads to manoeuvre compared to precast concrete.
OR………		
Position chamber rings (PC) in excavation	Craneage and MH (if large), crushing against excavation sides	More control over positioning and placing of PC units.
Haunching/benching (for PC only)	Confined spaces, dermatitis	Not needed for UPVC option
Install PC chamber lid	Craneage and MH (if large), MH (if small)	More control over positioning and placing of PC chamber lids.
Install UPVC chamber lid	Various minor	Very light loads etc
Install chamber access cover	MSDs, manual handling	More control over positioing of access cover.
Backfill etc	MSDs, manual handling	As insitu
Ancillary site risks	Slips trips falls etc	Less site labour therefore less risk.

6.8.4 Offsite health and safety issues

Stage 4 of the HASPREST tool provides information on offsite health and safety issues for offsite products. HASPREST provides advice and information both to those managing and inspecting offsite works.

5.6.1.1 Principal contractor or other party inspecting offsite works

This section offers recommendations and advice for those inspecting offsite works. The information is relevant to Principal Contractors and any other parties that may be inspecting the works of a supplier or manufacturer. The health and safety risks and hazards that are likely are highlighted, and what specifically should be inspected when visiting an offsite suppliers works.

Access to the toolkit data is through selection of the appropriate element from the given list. The elements are listed under three main headings - Major Buildings, Civil Engineering and Engineering Construction (Figure 6.10).

Figure 6.10 Advice for inspecting offsite works; demountable partitions

OFF-SITE Works		
Activities	**Hazards**	**What to look for**
Deliveries to factory	Transport	PPE typically employed on construction sites is not necessarily enforced in many manufacturing facilities (e.g. head protection is rarely used). However, the manufacturer should be able to demonstrate that the risks have been assessed and the appropriate hierarchy of risk elimination, reduction and control has been employed
Construct panels	Manual Handling	Industrialised process should be well organised with risks minimised. Inspection of insulation in some systems can involve particularly hazardous operations. Best practice companies will manage these processes efficiently and safely, look for specific controls in method statements.
Fabricate support framework	Cuts etc	Industrialised process should be well organised with risks minimised
Transportation & delivery	Plant, craneage	More organised as fewer, larger deliveries More likely to be mechanically handled Check that transport and delivery method minimise manual handling Weight and centre of gravity and safe lifting points should be clearly identified on each element to facilitate mechanical and manual handling where appropriate Review packaging and orientation to facilitate safe unloading without double handling
Transportation & delivery	Manual handling	More organised as fewer, larger deliveries More likely to be mechanically handled Check crane certification and driver competence both at works and at site

In this case the example chosen is demountable partitions. The information is presented in tabular form under 3 main headings. The table provides the following information.

Activities - lists the main activities associated with the construction of the selected element, e.g., transportation and delivery.

Main Hazards - lists the main hazards associated with the activities above e.g., cuts, plant and craneage.

What to look for - provides good and poor practice, suggesting what should be sought while inspecting works at a supplier's or manufacturer's production facilities e.g., more organised as fewer, larger deliveries.

The relevant HASPREST database pages can be printed or downloaded in PDF format from within the individual element pages. The options offered within the HASPREST database are not exhaustive. The categories within the toolkit should however provide sufficiently similar elements for users to obtain an adequate indication of risks.

5.6.1.2 Supplier/manufacturer of offsite works

This section presents the results from the thesis research. The advice provides guidance based on the phases from three offsite production facilities as explained in section 5.4. It is intended to act as a stimulus for continued improvement within the offsite manufacturing sector.

Attitudes toward safety in offsite are still in the embryonic stage, but are developing rapidly with increased attention from regulatory bodies such as the Health and Safety Executive. On the one hand, workers do not want to be injured themselves or be responsible for injuring others. On the other hand, accident studies (Gibb, Haslam, et al 2006) demonstrate that workers sometimes engage in unsafe acts. The reasons for this seem to be a combination of safety being overlooked as a result of heavy workloads and production pressure; taking shortcuts to save time; and an inadequate perception of risk. The underlying issue points to a lack of adequate training.

In context-specific training, the procedures and rules for dealing with particular tasks are delivered by trainers often with a good understanding of what they are doing. The factory inductions, operative awareness talks and tool box talks are examples of where this occurs. In the HASPREST study, however, there was little evidence of health and safety training for supervisory or managerial levels.

The observations indicate that front line supervisors in offsite undertake safety-related training. It was apparent from interviews that offsite supervisors frequently have a good safety awareness and understanding of accident causation and prevention. Nevertheless, there remains a perceived conflicting priority of meeting project deadlines and a lack of positive incentives for individuals in a supervisory role to give safety their attention.

With regard to occupational health, a key area that offsite manufacturers should embrace is that of pre-employment screening and health surveillance as this is the cornerstone of an effective comprehensive program of health for manufacturing employees. A number of offsite manufacturers have in operation extensive health screening and monitoring surveillance schemes. For example these may include monthly blood toxicology analysis where paint and substances hazardous to health are used.

Most offsite facilities enable good communication between operatives due to the reduction in physical distance. There still remains isolated cases of high levels of background noise which can be easily mitigated through designated sound controlled production units. The observed problem of undue reliance on informal communication was noted in some instances, when the safety risk is such that a more robust system of communication should be in place.

6.8.5 Onsite health and safety issues

This section of the tool provides advice and information for those supplying, installing and managing all aspects of on-site works for pre-assembled products. On-site works include transport and delivery of products to site as well as installation into their final position. Advice and information is provided for:

- The supply and installation of offsite products on site;
- The management of the installation of offsite products on site.

In this case the example chosen is suspended ceilings. The information is presented in tabular form under 3 main headings. The information is arranged in tabular form (Figure 6.11) with the associated sub-headings.

Figure 6.11 Supply and installation of offsite units on site; suspended ceilings

Internal - Suspended Ceilings FULL PDF VERSION CLICK HERE

ON-SITE Works		
Activities	**Hazards**	**What to look for**
Handle unit	Manual handling	Probably more mechanical handling – more thought as more expensive 'special' panels cf ubiquitous plasterboard, but panels may be heavier
Fix ceiling channels & hangers	MSDs (work overhead) Falls from height	Probably less ad hoc than drylining alternative fixing reduce power tool use Although the heights involved are relatively modest, this is still a considerable hazard, especially when combined with the restricted work area. Most projects now ban the use of stepladders on safety grounds and the use of stilts is not advisable. Purpose made access towers with appropriate fall protection are now available and should be used
Fix ceiling channels & hangers	Power tools (HAVS etc), cuts etc	Cuts from ceiling hangers are a major issue here, check that method statement addresses this risk
Fix panel	Manual handling, power tools (HAVS etc)	Should be better system – less ad hoc, consider alternative fixings reducing power tools
Decoration	Paint, COSHH	Less likely to have site applied decoration
Ancillary site risks	Slips, trips, falls	Ensure site housekeeping is excellent to maximise additional benefit from reduced workforce numbers

Activities - lists the main activities associated with the construction of the selected element.

Main Hazards - lists the main hazards associated with the activities above.

What to look for - provides good and poor practice, suggesting what should be expected while installing, managing or inspecting the on-site aspects of offsite products.

The relevant HASPREST database can be accessed for each individual element. It should be noted that the options offered within the HASPREST database are not exhaustive. The categories within the toolkit should however provide sufficiently similar elements to obtain an adequate indication of risks.

6.8.6 Whole life health and safety issues

The final stage of the HASPREST tool, provides advice and information on the whole life health and safety issues.

Whole-life performance is not the main focus of HASPREST. However, this section has been included to provide an outline of the main issues for operation, maintenance and eventual demolition that are involved in the 'construction' process.

The health and safety issues for the whole life of the facility or product can be significantly influenced by offsite. The key health and safety determinant for whole life is design.

Design should take into account the long-term maintenance of the building and the ultimate disposal or dismantling of a building or facility and offsite has a significant role to play in the health and safety issues over the life cycle of the building.

Prior to the advent of the original CDM regulations in 1994, the dismantling of a building was not considered fully at the design stage. This has caused some difficulties in the past, for example, the use of pre-stressed components created considerable health and safety issues during demolition. The inherent danger of rapid stress reduction could result in explosive failure of beams during the demolition phase, with serious consequences for the health and safety of the operatives. Even after these may have been considered, the relevant documentation and advice was not readily available to demolition contractors. There is now a legal obligation to produce a health and safety file that must include these issues.

The whole life performance of a building can be enhanced by a tight specification and good design. Offsite has a role to play in that if the products are well designed there will be less environmental impact. In addition the quality of the product improves the whole life of the building, which is a main benefit of offsite, and which can be more readily controlled provided the manufacturing design has been carefully considered. These factors in combination, lead to better products, which in turn will improve the whole life performance.

Offsite can enhance the long term maintenance health and safety issues by enabling ease of access through modular components that can be removed or replaced as complete units and repaired remotely from the building in a secure controlled environment. In terms of demolition, offsite can aide demolition through the design of units so that they may be removed easily and sequentially and may then be refurbished or recycled. However, these benefits will only be realised if they are specifically 'designed-in'. Furthermore, if whole-life issues are not considered then offsite can contribute to creating a worse environment for operational and maintenance staff. For example, components installed in optimum factory conditions, could be difficult to maintain or replace once in their final position if they have not been carefully designed for this eventuality.

6.9 Summary

This chapter has provided an overview of the HASPREST toolkit, outlining the six main stages and the advice and information provided. The main stages are; why consider health and safety issues early in the project; develop a health and safety strategy for offsite; develop a pre-construction health and safety assessment for offsite elements; offsite health and safety issues for offsite products, the focus of this thesis; on site health and safety issues for offsite products and health and safety issues for the whole life of the facility or product. Health and safety are issues that are problematical within the construction process. The use of offsite can assist in reducing health and safety risks. HASPREST is a tool that can assist in addressing some of the main problems. The tool is intended to be useful in the preparation of risk assessments, installation and management of offsite works on-site.

7 DISCUSSION

7.1 Introduction

This chapter discusses the results presented in chapter five in the context of the existing body of knowledge as presented in the literature review chapters 2 and 3. The chapter presents a discussion of the results which are organised into sections corresponding to the main themes in relation to the research aims and objectives (1.3.1). In each of the sections, the results from the three main phases (Chapter 5): phase I the group expert interviews, phase II the ergonomic audits and observations and phase III the semi-structured interviews are discussed in comparison with the existing knowledge. This reveals the relationship between the results and the existing knowledge which provides an identification of the contributions to knowledge of the research and the conclusions presented in Chapter 8.

7.1.1 Results discussed in connection with the research objectives

This section discusses the results in connection with the objectives, the section is arranged to discuss UK construction health and safety and offsite terminology, the health and safety benefits and disadvantages of offsite, changes in processes to further reduce residual offsite risks which provides knowledge and an insight into the nature and extent of the effect of offsite on occupational safety and health. A discussion of the risk management tool is presented. The discussion is organised in appropriate themes which reflect the main issues that were unveiled by the study.

Wolfe (2009), provides four questions which provide a framework for discussion, these questions provided guidance in the discussion:

- *'how results fit into the existing body of knowledge;*
- *do they give new insights;*
- *are they consistent with current theories; and,*
- *do they suggest new theories'.*

Comparison between the results and the existing knowledge provide a means of converting the results into contributions to knowledge. In the following themed sections if the comparison suggests and agreement between the results and the existing knowledge then further investigation is presented. If there is disagreement, then suggested reasons are provided. The study has gone further than previous research by examining by expert opinion the activities and risks for insitu and offsite solutions, exploring ergonomic risks and investigating the changes in process which remove and reduce risk in the offsite factory.

The results reveal the knowledge relating to the benefits of offsite manufacture and the residual risks in the factory. The following sections discuss the themes.

7.1.2 Health and safety performance of construction and offsite terms

The literature review suggests that health and safety in UK construction performs poorly in relation to the utility, service and manufacturing industry (2.2.1). In comparison to manufacturing, fatal injuries in construction is three and half times greater and six times greater for major injuries. This finding reflects the continuing need for health and safety performance improvement in UK construction and suggests that manufacturing may offer the opportunity for improvement. The literature revealed that a number of terms were in operation for offsite. Since the start of this research, it appears that the industry has moved on, in that the terms in use, including offsite manufacture and offsite construction appear to be generally termed offsite.

7.1.3 Health and safety benefits and disadvantages of offsite

This section covers two aspects: first in relation to the group interview participants' views on offsite and health safety risk in comparison with in situ construction. The second aspect relates to the ergonomic audits and observations carried out in the case study organisations.

Benefits of offsite

The results of the three phases: the expert group interviews, the ergonomic audits and observations and the semi-structured interviews have identified the benefits of offsite. The phases combine together to reveal that overall there are significant health and safety benefits in the usage of offsite (see e.g., 5.3.7.1, 5.3.8.1, 5.3.9.1, 5.4.5.1, 5.4.5.3, 5.5.5.5 and 5.5.2). The benefits relate to specific activities within the offsite categories and context studied. The benefits include the elimination of work at height, reduction in noise, reduction in work in confined space, reduction in congested work with trade overlap and greater control over the work in the factory. This finding is in agreement with the work of Gibb (2003), who surveyed drivers and constraints of 50 leading clients and discussed the benefits of offsite including less congestion on site and improved health and safety. The findings are also in agreement with Groak et al. (1997) in that offsite contributes to a healthier and safer work environment. Furthermore the findings corroborate POST (2003) in that the use of offsite, in a controlled factory environment can assist in the reduction of accidents. Many results suggest a range of benefits for the use of offsite, the in-depth ergonomic analysis, phase II, revealed detailed aspects of benefits in relation to operatives activities in the factory. These include: work at a suitable height (bench work) which allows acceptable arm extension and reach, little frequent muscle load on arms and shoulders, occasional turning and twisting, and neutral wrist positions. The offsite manufacturers claimed that these are long term health benefits of offsite which contribute to a reduction in MSDs and RSIs. However, while these benefits were identified during the review, they relate to specific activities and there was evidence in the results for other activities where risks remain present.

The results from each phase of investigation when grouped together suggest that there are significant benefits of offsite, in particular the elimination of work at height, work at a suitable height, control over specific work activities, a reduction in the possibility of MSDs and RSIs, less trade overlap, less congestion and reduction in noise. These findings are encouraging for the improvement of health and safety, however the results identified a number of disadvantages as discussed in the following section.

Disadvantages of offsite

The disadvantages of offsite are also identified in the results. The disadvantages include; transportation and delivery of units of large size and weight with associated high consequence craneage and handling risks (unit fall and hand injury), whole body vibration, cuts, MSDs, RSIs, fumes and slips trips and falls. There appears to be little in the literature to support identification of offsite health and safety risk issues.

The detailed ergonomic assessment results revealed a number of risks in relation to specific operatives activities in the factory. These include: prolonged standing and large trunk movements during mould construction (MSDs), manual tying of reinforcement (RSIs), and reaching and high overhead work in the storage of units. The results also revealed that where activities are similar to insitu construction, e.g., lifting and carrying material the risks remain. The results suggest that offsite manufacturers cannot assume that offsite will remove all occupational health and safety risks. Although, considerable improvements were noted in case study 1, (5.2.7) cleanliness and housekeeping issues with associated residual risks such as slips, trips and falls were evident. This particular aspect has little coverage in the literature, Gibb (1999: 44) states the environmental benefits of offsite, however this was found not necessarily to be the case, the findings suggest that care should be taken when drawing inferences of the health and safety benefits of offsite.

7.1.4 Changes in process to reduce offsite residual risks

This section relates to selected case study solutions to further reduce residual risks, explored in phase III the semi-structured interviews. These solutions are grouped into four approaches: process change, workplace environment designing out risks, automation and the use of tools. The offsite manufacturers strategies identified in the study for removing and reducing residual risks in the offsite factory are generally in agreement with the suggestions proposed in the literature reviewed, the following sections detail the learning from the study.

Process change

This section discusses the change in processes that reduce residual risks in offsite. The results from phase III indicated that changes to the workplace design resulted in the reduction of residual risks in the factory. Two of the case study respondents; Revolutionary Pod Modules and Caledonian Building systems had installed two dedicated production lines with delineated walkways, and had implemented a waste recycling scheme that involved designated material storage areas. This is in agreement with the work of Fawcett and Wood (1982), the use of delineated walkways, zoned areas indicating materials storage, production lines that are long, straight and "in-line" to provide access to both sides of a considerable portion of the production run are all highly recommended.

Caledonian Building Systems, adopted the use of continuous flow manufacturing including group work, cross training on the different tasks in a group and job rotation linked with the redesign of selected machines and workstations for the elimination of awkward postures. This is in agreement with (Health and Safety Commission (HSC) 1999). This, coupled with the adoption of a systems approach to safety in manufacturing the initiation of safety awareness programmes, and specialised training on ergonomics for machine operators were examples of good practice. These measures were in place to minimise the observed residual risks such as, trailing cables across production lines and walkways and protruding risks such as steel channel components and a general lack of good housekeeping.

The use of medical surveillance in the form of a pre-employment examination is one of the cornerstones of an effective comprehensive program of health for manufacturing employees (Fawcett and Wood, 1982). The study indicated that a number of health hazards exist in offsite manufacturing, e.g. fumes from welding and painting and there was evidence from the case studies that health monitoring has not been fully embraced. The offsite industry has been urged to increase health monitoring but further effort is required.

Case study 1, Trent Concrete Ltd introduced self compacting concrete as opposed to traditional concrete requiring vibration as described in section 5.5.2, this technique reduced the amount of concrete operatives from four to two, eliminated external vibration and reduced the risks of RSI and MSDs.

Case study 2, Revolutionary Pod Modules adopted the use of pre-cut gyproc board cut at bench height supplied for each pod (5.5.2). This reduces the amount of work inside the pod and the presence of trip hazards.

Workplace environment designing out risks

Offsite manufacturers' techniques to reduce risks by changing the workplace environment and designing out risks identified in the study include: work activities carried out at bench height e.g., cutting of gyproc and assembly of services. Case study 3, Caledonian Building systems re-designed the assembly of the floor and ceiling frames to enable assembly at bench height (see section 5.5.2) to reduce the risks of high overhead work and reaching. This finding supports the work of Dul 2001 (20-24) that the work height should avoid excessive reaches. Case study 2, Revolutionary Pod Modules changed the tiling sequence inside pods, this involved the use of alternating the work of tiling and grouting between two operatives, where before both tasks were completed by the same operative, again this is recommended by Dul (2001: 104).

Two of the case studies, Trent Concrete and Revolutionary Pod Modules suggest that there is a need for a change in the approach to personnel and composition of the workshop. The literature advises improvements to the workshop environment through project team members who are appointed within teams as a result of their experience and expertise. This has been stated by Court et al (2009: 89) *'this activity was conducted in a workshop environment, with project team members assigned to the team because of their individual expertise. The team members were represented with the following disciplines: project leader (one of the writers), offsite manufacturing engineer, construction manager, commissioning manager, maintenance engineer, mechanical and electrical engineer, mechanical design and electrical design engineer, architectural technician, structural engineer, procurement engineer, and component suppliers'*. This consideration favours the use of innovation in teamwork and team composition with an increase in the number and expertise of operatives (5.4.5.1 and 5.4.5.3). This is not surprising given the fact that it involves an increase in the range of disciplines and empowerment of the workforce.

Automation

The opportunity to increase control over work practices in offsite can reduce many of the risks associated with material handling. The use of mechanical handling to reduce manual handling can contribute to a reduction in repetitive strain injuries (RSIs) and musculoskeletal disorders (MSDs). The semi-structured interviews revealed that two of the case study organisations, Revolutionary Pod modules and Caledonian Building Systems have increased mechanical handling to minimise risks in specific processes e.g., installation of craneage for handling steel channel sections during welding and the use of cranes to manipulate floor and ceiling cassettes into orientation at bench height. Managers in offsite have paid attention to the manual handling requirements for some materials, through the introduction of smaller tile pallets for example and the use of concrete material manipulators. These findings are supported in the literature for example Taylor (2003) discusses the health and safety advantages of using material manipulators (see section 3.5.4.1). There were, however, instances where this approach did not seem to have been adopted, even with widely used generic items. There are situations where alternatives were available but not in use due to reasons of custom and practice, cost or availability. There are many situations where modest changes to materials or the method in which they are supplied could improve health and safety.

Tools used in offsite

Observation of the tools used in the three offsite case studies were generally of a high standard and in good condition compared to insitu. However, there were occasional instances case study 1, where shared equipment, having multiple users were subject to heavy wear and tear. In such circumstances the use of scheduled inspection and maintenance schedules easily administered in a factory environment are recommended. Similarly, the use of Personal Protective Equipment (PPE) as a control measure can be readily inspected and controlled in the factory environment. However, it was observed that some of the PPE found in use in two of the offsite organisations were uncomfortable and appeared to interfere with the wearer's ability to perform their work. As is the case in the whole of the construction sector, the appropriate use of PPE needs to be addressed. In isolated instances it was observed that the PPE itself lead to safety problems, for example a safety harness caught on a handrail on top of a module, causing a back injury. The problems of risk homeostasis as discussed by Cameron et al (2007), were observed in a limited number of instances, where the provision of PPE, such as a harness can make operatives feel safer, therefore leading them to take greater risk. This emphasizes the important message that, despite the current focus of risk management in the industry on PPE, it should only be a last resort. Elimination or reduction in the risk through design and planning tools e.g., hazard identification workshops should be considered (Cameron and Hare 2008).

7.1.5 The effect of offsite on health and safety in construction

The preceding sections have provided knowledge and an insight into the nature and extent of the effect of offsite on occupational health and safety. The results suggest that offsite improves health and safety in specific activities however, residual risks remain. The following sections discuss the effect.

Many construction processes are left to the discretion of site personnel. This is the fine detail beyond that specified in the design instructions. Haslam et al (2003), state that it is apparent that tension exists over precisely where the boundary should lie in the division of responsibility between the design and contractor teams. Offsite can eliminate these grey areas, allowing increased control over a tight specification and increased control over the problems of blurred responsibility and difficulties with communication between one contractor and another.

The deficiencies in project management and planning can lead to difficulties with the project schedule in traditional construction, which in turn result in time pressure on all involved within a project. These can be more easily controlled in offsite through the reduction in trade overlap and relaxation of crowded workspaces. The increased control in the context of project scheduling is a significant benefit of offsite.

A recent Loughborough/HSE study into accident causality Haslam et al. (2003) identified that many construction accidents occurred 'off-task', for example where operatives were moving around the site. The results suggest that in offsite, the control of activities 'off-task' is a major health and safety performance benefit. There is far greater scope for a fully inclusive risk assessment even for activities which are not directly related to the permanent works.

The phases revealed that activities and workplace familiarity of workers engaged in offsite was a significant contributory factor in reduced accidents and ill health. It even appears that, in some cases, this familiarity can mitigate the risks created by less than best practice in other areas (e.g. workplace tidiness). Although, this practice should not be relied upon. It was observed that, in one instance, the employment of skilled workers with a high level of experience and familiarity with the work, the environment and their co-workers coupled with a secure stable workforce appeared to allow a low accident and low ill-health incidence in an offsite environment that had yet to fully embrace the best practice techniques of offsite.

The problems of skilled labour supply create difficulties in appointing appropriately skilled workers, this in turn affects safety. While offsite is not immune to such problems the retention of the workforce and the ability to attract skilled workers can be facilitated with more control within a factory environment. Examples include a stable workforce in familiar surroundings, removal of an itinerant workforce and the elimination of associated travel stress.

The challenge to offsite manufacturers is to install systems to manage teams. It was observed from two of the offsite case studies that management control between vocational groups sometimes resulted in unclear lines of responsibility. Safety training and improved organisation can overcome these problems. These are far easier to deliver and control in the offsite environment.

7.2 Verify and disseminate the risk management tool

The preceding sections discussed the results in relation to the existing knowledge. This section presents the research outcome component which formed part of HASPREST; the risk management tool *"the offsite health and safety risk management tool for principal contractors inspecting offsite works, supplier/manufacturer of offsite works and managers of on-site works who are installing offsite products"*. The tool was published as a CD and guide and demonstrated and disseminated at three national industry exhibitions; *buildoffsite 2004, Interbuild 2004* and *Offsite 2004* in addition a number of workshops were organised at Loughborough University attended by industry and academics.

The results of the phases and the supplementary work of the HASPREST project combined to provide overall strategic and detailed risk management advice. The lack of research in offsite risk management is important given that there are over 100 offsite systems in the UK, which are supplied by over 300 manufacturers (Mtech Group 2004). Phase III, the semi-structured interviews examined the use of the tool within the three case study organisations selected for analysis. The results revealed that the tool was in active use in the offsite manufacturing organisations. In each case study organisation the tool was used for a series of workshops and training sessions with offsite health and safety managers and production personnel.

The study recommends that the tool could be used not only for risk management but also for learning in relation to risk awareness. During the study an important issue that emerged is that the industry is not aware of how offsite is safer or why offsite is safer, and do not have an appreciation of the residual risks, this hampers efforts for improvement. The tool addresses this problem by incorporating not only the results from the phase investigations but also contributions from a wide range of expert opinion from industry and the academic community, which provides important knowledge transfer input.

7.3 Summary

This chapter has discussed the results of the study in relation to the objectives within the existing body of knowledge. The discussion has included the themes of UK construction health and safety and offsite terminology, the health and safety benefits and disadvantages of offsite, changes in processes to further reduce residual offsite risks which provides knowledge and an insight into the nature and extent of the effect of offsite on occupational safety and health. A discussion of the risk management tool has been presented. The discussion has revealed the research results and the existing body of knowledge. This chapter leads to the presentation of the achievement of the research objectives, the contribution of knowledge made by the study and the conclusion of the thesis in the following chapter.

8 CONCLUSIONS

8.1 Introduction

The first chapter introduced the thesis. The second and third chapters provided a theoretical background to health and safety performance, accident causality, ergonomic programmes, offsite technology, its affect on occupational health and safety and innovative manufacturing techniques for improving offsite manufacture. Chapter 4 provided the methodological framework for the research, namely qualitative research methods. Chapter 5 presented the research results, by identifying offsite risks which assisted in producing a risk management framework for improved health and safety management of offsite works. Chapter 6 presented HASPREST and the risk management tool which the thesis informed. The preceding chapter discussed the results in relation to the existing body of knowledge and identified the thesis contribution to knowledge. This chapter concludes the thesis, summarising the findings and the main conclusions from the research. The limitations of the study are presented.

The following sections present the achievement of the objectives of the research. The contributions to knowledge, the limitations of the research and publications from the study are presented, and some future research considerations.

8.1.1 Achievement of the objectives

The objectives of the research, developed in chapter one are re-stated as:

1. Review the health and safety performance of UK construction, identify barriers and drivers to improvement and identify key theories of accident causation;
2. To identify and clarify the concept of offsite and associated terminologies and provide a definition for the thesis;
3. To identify the activities and risks for selected elements/units for both offsite and insitu solutions and to identify offsite residual risks and how such risks can be reduced;
4. The effect of offsite on occupational safety and health in the construction industry – both positive and negative;

5. To develop a structured and transparent offsite health and safety risk management tool for principal contractors inspecting offsite works, supplier/manufacturer of offsite works and managers of on-site works who are installing offsite products;
6. Verify and disseminate the research findings.

8.1.2 Objective one

The first objective was to *review the health and safety performance of UK construction.* In order to achieve this objective a literature review of the context of health and safety in construction, including the drivers and barriers to performance and the characteristics of accidents was conducted. The study has identified through the literature review that health and safety in UK construction performs poorly in relation to the utility, service and manufacturing industry (2.2.1). In comparison to manufacturing, fatal injuries in construction is three and half times greater and six times greater for major injuries. The type of accidents have changed little over the years with falls accounting for almost half of all fatalities (2.4.1).

The implications for industry are that the construction sector is not as safe as manufacturing, but also that construction manufacturing as a subset of manufacturing requires performance improvement. As a result, an increase in the need to maximise the use of offsite is indicated. The need to improve learning between the construction manufacturing sector and the rest of manufacturing is required and it is suggested that this could be achieved through industry forums, continuing professional development (CPD) and training.

8.1.3 Objective two

The second objective concerned *identify and clarify the concept of offsite and associated terminologies and provide a definition for the thesis.* The literature revealed that many terms relating to offsite are in operation (3.1). The historical development of offsite using healthcare as an example was reviewed (3.3) and a categorisation of offsite terminologies was presented (3.4). Over the course of this research, the terminology including offsite manufacture and offsite construction appear to be generally termed offsite. The drivers and barriers of offsite were reviewed (3.5). There is a paucity of knowledge relating to the effect of offsite on occupational safety and health in the factory. The safety and health benefits of offsite include, greater control over the environment, reduction in site labour and elimination of many hazardous tasks such as work at height. The health issues include greater control over operatives' tasks and work environment. The use of automation and tele-operation systems and integrated manufacture provide alternative means of reducing labour and reducing risks during installation of offsite units. Construction as a manufacturing process provides a number of advantages, economies of scale, the ability to deploy capital equipment and tighter safety management. Innovative manufacturing techniques provide enhanced safety and health benefits, through organisation, automation and respect for people.

8.1.4 Objective three

The third objective was *to identify the activities and risks for selected elements/units for both offsite and* insitu *solutions and to identify offsite residual risks and how such risks can be reduced.* Three research issues were investigated in relation to this objective and were examined in three discrete research components of the study; namely phase I, the group interviews, phase II, the ergonomic audits and phase III, the semi-structured interviews and observation. Firstly, the research identified and analysed the selected activities and risks for the manufacture of non-volumetric face finished precast concrete panels, volumetric washrooms and modular buildings. Secondly the study detailed the change in risks in moving from insitu to offsite. The third research issue was investigated by face-to face interviews with three offsite manufacturing organisations to identify offsite residual risks that remain and an indication of how these risks are managed.

The implications for industry are that having identified the activities and risks, it is suggested that a tool like HASPREST should be developed further to ensure that the risks are better understood so that mitigation action is taken.

8.1.5 Objective four

The fourth objective was *to identify the effect of offsite on occupational safety and health in the construction industry – both positive and negative.* The study has provided a picture of how offsite effects health and safety, in terms of the risks identified and how the risk changes from in situ to offsite solutions for the activities studied. For example, in the precast concrete case, the main risks associated with the offsite solution were craneage of moulds, manual handling and cuts from reinforcement assembly, dermatitis and (MSDs), hand arm vibration and whole body vibration. The main risk change identified from in situ to offsite was that working at height in the construction of brickwork for cladding was removed in the offsite solution using precast cladding panels. In transporting the precast units, the risks were claimed to be road traffic, mechanical handling and offloading risks. The risk change was that these risks were of a more serious consequence in the event of panel fall. An additional risk of crush injury was identified compared to in situ in the connection of the panels.

In the toilet pod case, the main factory risks associated with the offsite solution were manual handling and mechanical handling, (MSDs), cuts, overhead work, and crouching and working in confined spaces. In transporting the pods, the risks were road traffic, craneage and manual handling. The risks associated with installation and site works of the finished pod were slips, trips and temporary work collapse and cuts.

In the modular building case, the main factory risks associated with the offsite solution were manual handling, mechanical handling, (MSDs), cuts, fumes, overhead work and hand arm vibration. The risks associated with loading and transporting the modules included road traffic and craneage. The risks associated with installation and site works of the finished module were cuts, slips and falls and crush injury. The study concluded that in all three cases studied there was more control over risks in the factory than on site.

The study has shown that offsite has significant positive benefits for health and safety (7.1.3). The study identified a number of negative aspects and residual risks to health and safety when using offsite (7.1.4). The semi-structured interview phase investigated how three offsite manufacturers reduced residual risks. Strategies include those related to: process change, workplace environment designing out risks, automation and the use of tools (7.1.4). Overall, it was concluded that offsite improves health and safety, however, residual risks remain.

The industry should follow best practice and utilise the benefits of offsite such as the reduction of work at height. The major conclusions for industry are that manufacturers should not be complacent and best practice guides should be produced. This has the implication that more resource should be allocated to education of the benefits of offsite through continuing professional development (CPD) to assist in understanding the management of offsite residual risks.

8.1.6 Objective five

The fifth objective was *to develop a structured and transparent offsite health and safety risk management tool for principal contractors inspecting offsite works, supplier/manufacturer of offsite works and managers of on-site works who are installing offsite products.* The tool draws on the main study findings from phases I and II combining the data and presenting the results. To achieve this objective three research issues were investigated. First, the activities and risks for selected units elements were identified and analysed (phase I, see section 5.3). Secondly the results from this phase were taken to a series of in-depth ergonomic risk audits (phase II, see section 5.4). Thirdly the original risks identified in phases I and II were verified by face-to-face semi-structured interviews with three of the case study offsite organisations (phase III, see section 5.5). Though the data and the results are primarily based on the three phases, the author is aware that care should be taken for generalising the data in such a qualitative sample.

Since the dissemination of HASPREST and the initial interest in the tool, the challenge now is for industry to maximise the use of offsite and take offsite risk management more seriously.

8.1.7 Objective six

The sixth objective was *to verify and disseminate the research findings.* The results from phase I were verified by phase II. These findings combined to inform the risk management tool. The risks identified were then verified by three offsite manufacturers using semi-structured interviews. Phase III, the semi-structured interviews examined the use of the tool within the three case study organisations selected for analysis. The tool was used in the offsite manufacturing organisations for a series of workshops and training sessions with offsite health and safety managers and production personnel.

The findings from the study were published at a number of academic conferences (8.10) and the main output the risk management tool was published as a CD and guide. The tool was demonstrated and disseminated at three national industry exhibitions; *buildoffsite 2004, Interbuild 2004* and *Offsite 2004* in addition a number of workshops were organised at Loughborough University attended by industry and academics. The feedback provided useful verification of the tool content.

It can be concluded that the research objectives as detailed in section (1.3.1) have been achieved.

8.2 Contribution to knowledge

The preceding section has outlined the achievement of the objectives (8.1.1-8.1.6). The following sections summarises the thesis' contributions to knowledge.

8.2.1 An understanding of offsite risks and residual risks

The study has provided a contribution to the identification and understanding of the activities and risks in offsite. Previously little research has been carried out in risk identification of offsite. The expert group interviews and the ergonomic risk audit aimed to improve the knowledge of offsite risk. This knowledge informed the risk management tool.

8.2.2 An understanding of processes to reduce offsite residual risk

The research has contributed to the understanding of the strategies and practices that offsite manufacturers adopt to minimise offsite residual risk. The semi-structured interviews, phase III identified residual risk in three case study manufacturers. This improved knowledge and gained an important insight into the strategies and process changes that offsite manufacturers adopt to reduce offsite residual risk.

8.2.3 The development of an offsite risk management tool

The research has produced an offsite risk management tool which assists in the development of a strategy for delivering offsite solutions in a manner that maximises the benefits to the health and safety of all those involved in the process. This addresses the gap in knowledge available at present regarding offsite risk management. The tool provides access to a database which covers selected elements within building, civil engineering and engineering construction for the identification of risks associated with activities for the insitu solution and the equivalent offsite solution. This provides risk awareness which contribute to the development of risk assessments and strategies for minimising risk in offsite production processes.

8.2.4 Understanding the effect of offsite on health and safety

The study has provided a contribution to the effect offsite has on occupational health and safety. While there are clearly significant benefits of using offsite e.g., reduction in work at height, a number of disadvantages were uncovered in the research, in particular an understanding of offsite residual risks and the strategies used by offsite manufacturers to reduce residual risk, were significant knowledge gains.

Overall, the research has contributed to knowledge in relation to offsite and health and safety in relation to activities and risks, ergonomic risk, offsite residual risk and the strategies used to reduce residual risk.

8.3 Limitations of the study

This section presents the limitations of the research that occurred during the study. The author was aware of a number of limitations, these relate to the relatively small sample size and the qualititative nature of the research. Phase I involved eleven experts that formed the group interviews, the activities and risks of the selected units and elements were chosen based on the experts background and interest thus bias in the results were an acknowledged limitation of the study. Phase II used three offsite manufacturers, thus no claim as to a statistical representative sample of UK offsite manufacture was implied in the study.

The risk management tool, was developed from the existing body of knowledge and the phases of investigation results. The data used was relatively small, eleven experts and three case study organisations. These limitations were in part a result of practical considerations of resource in relation to the short time window, both of the author and the case study respondents during the project.

8.4 Publications from the study

There have been several publications from the study, these assist in the dissemination of the knowledge contributions of research to industry and the research community. Table 8.1 lists the publications.

Table 8.1 Publications from the study

1. McKay, L. J., Gibb, A.G.F., Blismas, N.G. & Pendlebury, M.C & Haslam, R.A.,(2005) HASPREST – Health and Safety implications from offsite production, European Construction Institute, Loughborough, 2004, 150pp. ISBN 0 947974 16 4 (CD)
2. McKay, L. J., Gibb, A.G.F., Pendlebury, M.C & Haslam, R.A. (2005) Health and safety management of offsite construction – how close are we to production manufacturing?, 4th Triennial International Conference – cib W99, rethinking and revitalizing Construction Safety, Health, Environment and Quality, Port Elizabeth, South Africa, Smallwood & Haupt (eds), pp. 432-441,
3. McKay, L. J., Gibb, A.G.F., Pendlebury, M.C & Haslam, R.A. (2005) The Development of an Accident causal Model For Offsite Production in Construction. In:, Proceedings of the ARCOM 2003 Conference, Brighton, Vol. 2, pp. 358-72
4. Gibb, A.G.F, Pavitt, T.C. & McKay, L.J. (2004) Designing for health and safety in cladding installation - implications from pre-assembly, ICBEST, Sydney Australia.
5. McKay, L. J., Gibb, A.G.F., Pendlebury, M.C & Haslam, R.A. (2002) Implications for the effect of standardisation and pre-assembly on health, safety and accident causality: preliminary results. *In:*, *Proceedings of the ARCOM 2002 Conference*, Northumbria, Vol. 1, pp. 257-64
6. McKay, L. J., Gibb, A.G.F., Pendlebury, M.C & Haslam, R.A. (2001) The effect of Standardisation and Pre-Assembly on Health, Safety and Accident causality in Construction. ARCOM Workshop, Edinburgh.

8.5 Future research

Further research into offsite risk and residual risk are advised in this section.

An increase in the number of case studies to investigate the activities and risks in offsite manufacture would provide a larger database and provide further verification of the results of this study.

The risk management tool could be used as a learning and teaching tool in industry and could also provide a validation study. The software could be updated to provide a user-friendly interactive database. The existing data could be increased and built upon using a larger number of case study material. The inclusion of more case study would further enhance the tool.

The research could be extended to cover the international context. The offsite risk situation across Europe and the United States would provide a compliment to this study. The data would enhance the risk management tool and provide a useful additional database as the globalisation of offsite manufacture increases.

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Appendix A HASPREST CD ROM

CD ROM version of HASPREST

A CD ROM version of the risk management tool HASPREST is attached with this thesis. The focus of this thesis is centred on section four of the tool ***'offsite health and safety issues for OSP products'.***

The CD when installed will load automatically. There are six main parts of the tool these are;

1. why consider health and safety issues early in a project;
2. develop a project health and safety strategy for OSP;
3. develop a pre-construction health and safety assessment for OSP elements;
4. ***offsite health and safety issues for OSP products;***
5. on-site health and safety issues for OSP products;
6. health and safety issues for the whole life of the facility or product.

To understand how to operate and use HASPREST effectively, please read the HASPREST user guide first, this is supplied as a PDF file on the CD ROM.

Appendix B Steering Group Agendas

AGENDA

Steering Group Meeting 1

Loughborough University, Brockington Building, Conference Room, Loughborough

15th March 2002

Part 1: Business

1. Welcome and introduction
2. Apologies for absence
3. HASPREST
4. Introduction overview of HASPREST set in context of IMMPREST and CIRIA
5. Progress: WP1 and workplace audits
   - Overview of the research;
   - Objectives.
6. Causes of accidents in construction
7. Terms of reference
8. Clarify heads of agreement
9. Optimum structure for information transmission
10. Role of steering group
11. any other business

Part 2: workshop

12. work place audit tool
13. Identify three case study organisations and dates for ergonomic analysis
14. Project characteristics (5 minute presentation by each steering group collaborator)
15. Programme of work
16. Date of next meeting
17. Close

AGENDA

Steering Group Meeting 2

Loughborough University, Brockington Building, Conference Room, Loughborough

30th August 2002 1:00pm – 4:00pm

Part 1: Business

18. Welcome and apologies for absence
19. Minutes of the last meeting held on 15 March 2002
20. Matters arising from the minutes
21. Progress report
    - Key stages of the research and outline current stage;
    - Feedback on data gathered to date ‘first 30 report’

Part 2: workshop

22. Brainstorm the ‘first 30 report’
23. Interview programme
24. Next steps
25. Any other business
26. Date of next meeting
27. Close

DTI/EPSRC Ref: M\6\03

AGENDA

Steering Group Meeting 3

Loughborough University, Brockington Building, Conference Room, Loughborough

7th March 2003 1:00pm – 4:00pm

28. Welcome and apologies for absence
29. Minutes of the last meeting held on 30 August 2002
30. Matters arising from the minutes
31. Progress report
    - Focus of CD tool and nature of advice;
    - Feedback on data gathered to date 'first 30 report'
32. Causality review and health and safety risk model (tool behind future presentation)
33. Next steps
34. Any other business
35. Date of next meeting
36. Close

DTI/EPSRC Ref: M\6\03

AGENDA

Steering Group Meeting 4

Loughborough University, Brockington Building, Conference Room, Loughborough

23rd June 2003 2:00pm – 4:00pm

37. Welcome and apologies for absence
38. Minutes of the last meeting held on 7 March 2003
39. Matters arising from the minutes
40. Progress report
41. CD tool: demonstration of HASPREST;
    - Research associate industrial placement RAIS:
        - current proposal
        - run training workshops for HASPREST
        - use the HASPREST tool to develop and refine risk assessment for insitu and offsite
        - undertake health and safety audits for offsite and in situ installation complete with confidential report
        - use the HASPREST tool to develop promotional literature

Collaborator commitment:

- in-kind support
- support for the development and application work

Part 2 workshop

42. Data validation activities and risks
43. Next steps
44. Any other business
45. Close

DTI/EPSRC Ref: M\6\03

Appendix C 1st Group interview schedule

Expert Group Interview Schedule

AGENDA

Expert Group Interview One – Main building elements

Loughborough University, Brockington Building, Conference Room, Loughborough

19th April 2002, 12:00pm – 4:00pm

1. Welcome and apologies for absence
2. Introductions
   - participant introduction, background and interest in the research
   - particular area of construction and or offsite manufacture
3. Introduction to project
4. Aim of the research
   - Overview of the research;
   - Objectives.
5. Areas to be covered;
   - identify the main building elements for analysis;
   - list of activities associated with the methods of each insitu construction phase;
   - list of risks associated with each insitu construction phase;
   - list of activities associated with the methods of each offsite manufacture phase;
   - list of risks associated with each offsite manufacture phase;
   - opinion/evidence for each risk;
   - information on how the risk changes from insitu to offsite, e.g. more likely or less likely risk.
6. Tea break
7. Discussion
8. Final remarks
9. Next steps
10. Date of next meeting
11. Close

DTI/EPSRC Ref: M\6\03

Appendix D 2nd Group interview schedule

Expert Group Interview Schedule

AGENDA

Expert Group Interview Two – Offsite Risk Change

Loughborough University, Brockington Building, Conference Room, Loughborough

12th September 2002, 12:00pm – 4:00pm

1. Welcome and apologies for absence
2. Introductions
   - participant introduction, background and interest in the research
   - particular area of construction and or offsite manufacture
3. Introduction to project: aim of the research
   - Overview of the research;
   - Objectives.
4. Areas to be covered;
   - verify activities associated with the methods of each insitu construction phase;
   - verify risks associated with each insitu construction phase;
   - verify activities associated with the methods of each offsite manufacture phase;
   - verify risks associated with each offsite manufacture phase;
   - discussion on evidence for each risk;
   - provide key comments on risk change;
   - information on how the risk changes from insitu to offsite;
   - codify how the risk changes from insitu to offsite, e.g. more likely or less likely risk.
5. Tea break
6. Discussion –spilt into three groups

Using the following code, discuss how the risks change from insitu to offsite;

- The risk change from insitu to offsite was coded as follows; S (no change), R (risk removed), A (additional risk), LL (less likely), ML (more likely), LC (less serious consequence), MC (more serious consequence), C (more controllable).
- What activities are different or the same for insitu and offsite
- What risks are avoided
- What risks are easier to control in the offsite environment

7. Close

Appendix E steps in the identification of building elements

Expert Panel Research Notes

Loughborough University, Brockington Building, Conference Room, Loughborough

19th April 2002, 12:00pm – 4:00pm

Phase I

Expert Group Interview one – issues

Objective: To determine those building elements for detailed study, insitu verses the offsite equivalent.

Question: What building elements will be considered.

Points to consider:

Restrict the number of building elements to a practical and manageable size given the project time and resource constraints.

Some elements may not have an offsite equivalent e.g. excavation is common for both insitu and offsite solutions.

Key steps

Step 1.2:

Identification of building elements for study using a consensus decision making approach;

The Flow of the Consensus Process

- Raise a building element for inclusion e.g. cladding
- Clarify the building element for insitu and offsite e.g. insitu brick/blockwork and precast concrete face finished panels.
- Discuss the building element, bring out possible other cladding elements (restricting number of options to a manageable size).
- Note agreements and disagreements and the underlying reasons for them — discuss those underlying reasons.
- Evaluate the different cladding elements for the group
- Check that everyone truly **consents** to the chosen building element.

Using this consensus process a list of building elements were selected for the study. The headings were restricted to major building, civil engineering and engineering construction. Each of the eleven experts was asked to vote for an element. The results are presented below indicating those who voted for and against the element under consideration. The majority in favour of an element allowed for further discussion until consensus was reached among the experts and that element was then selected.

Major Building category

Options substructure:

(same for insitu and offsite)

Element	Yes	No	Comments	Element selected
Excavations	11	0	Same for both insitu and offsite	✓
Inspection chambers	8	3	3 (A, G, I) experts stated that this is not relevant.	✓
Piling	9	2	2 (G, I) experts stated that this is not relevant.	✓
Foundations (Pad)	9	2	2 (G, I) experts stated that this is not relevant.	✓

Buildings – structure

(Insitu verses offsite equivalent)

Element	Yes	No	Comments	Element selected
Insitu concrete vs. steel & pre-cast	9	2	2 (G, I) experts stated that this is not relevant.	✓
Brick/bockwork walls vs. concrete panels	8	3	3 (G, I, J) experts stated that this is not relevant.	✓
Brick/bockwork walls vs. timber panels	8	3	3 (G,I, J) experts stated that this is not relevant.	✓

Buildings – cladding

Element	Yes	No	Comments	Element selected
Insitu brick/bockwork walls vs. precast concrete (unfinished)	9	2	2 (G, I) experts stated that this is not relevant.	✓
Insitu brick/bockwork walls vs. precast concrete (finished)	9	2	2 (G, I) experts stated that this is not relevant.	✓
Stick vs. unitised curtain wall	9	2	2 (G, I) experts stated that this is not relevant.	✓
Stick vs. panellised curtain wall	9	2	2 (G, I) experts stated that this is not relevant.	✓
Built-up sheets vs. composite panels	8	3	3 (A, G, I)experts stated that this is not relevant.	✓

Buildings - roofing

Element	Yes	No	Comments	Element selected
Asphalt/bitumen vs. composite panels	7	4	4 (A, B, G, I,) experts stated that this is not relevant.	✓
Asphalt/bitumen vs. composite panels	7	4	4 (A, B, G, I) experts stated that this is not relevant.	✓

Buildings - internals

Element	Yes	No	Comments	Element selected
Drylining vs. demountable partitions	7	4	4 (A, B, G, I) experts stated that this is not relevant.	✓
Suspended ceilings	8	3	3 (A, G, I) experts stated that this is not relevant.	✓
Washrooms/kitchens	9	2	2 (G, I) experts stated that this is not relevant.	✓

Buildings – services/modules

Element	Yes	No	Comments	Element selected
Mechanical and electrical source units	7	4	4 (A, E, G, I) experts stated that this is not relevant.	✓
Mechanical and electrical vertical distribution	7	4	4 (A, E, G, I) experts stated that this is not relevant	✓
Mechanical and electrical horizontal distribution	7	4	4 (A, E, G, I) experts stated that this is not relevant	✓

Civil engineering

Element	Yes	No	Comments	Element selected
Excavations	11	0	Same for both insitu and offsite	✓
Inspection chambers	8	3	3 (A, G, I) experts stated that this is not relevant	✓
Piling	9	2	2 (G, I) experts stated that this is not relevant.	✓
Bridges A precast concrete	8	3	4 (A, G, I) experts stated that this is not relevant	✓
Bridges B steel	7	4	4 (A, E, G, I) experts stated that this is not relevant	✓
Bridges C hybrid	8	3	4 (A, G, I) experts stated that this is not relevant	✓
Culverts	8	3	4 (A, G, I) experts stated that this is not relevant	✓
Tunnels	8	3	4 (A, G, I) experts stated that this is not relevant	✓

Engineering construction

Element	Yes	No	Comments	Element selected
Excavations	11	0	Same for both insitu and offsite	✓
Inspection chambers	8	3	3 (A, G, I) experts stated that this is not relevant	✓
Piling	9	2	2 (G, I) experts stated that this is not relevant	✓
Foundations (Pad)	9	2	2 (G, I) experts stated that this is not relevant.	✓
Insitu concrete vs. steel and precast frame	7	4	4 (A, E, G, I) experts stated that this is not relevant.	✓
Built up sheets vs. composite panel cladding	8	3	3 (A, G, I) experts stated that this is not relevant.	✓
Process plant source	7	4	4 (A, E, G, I) experts stated that this is not relevant.	✓
Process plant distribution	7	4	4 (A, E, G, I) experts stated that this is not relevant.	✓

Appendix F Steps in the identification of activities and risks

Expert Panel Research Notes

Loughborough University, Brockington Building, Conference Room, Loughborough

19th April 2002, 12:00pm – 4:00pm

Phase I

Expert Group Interview one – issues

Activities and Risks Meeting Outputs

Using a consensus decision process approach a list of activities and risks were built up for insitu and offsite for each building element selected for study (step 1.3). The discussion regarding the activities and risks continued until saturation was reached, that is when no further useful data was revealed. The example shown below is for cladding brick/blockwork versus precast concrete panels. The results are presented below indicating those who voted for and against the activities and risks under consideration. The majority in favour allowed for further discussion until consensus was reached among the experts and that activity and risks was then selected.

Objective: List the activities and risks for both insitu and offsite solutions for each element

Question: List activities and risk for insitu brick blockwork cladding:

Step 1.3 Building element: **Buildings – cladding**

Activities and risk for insitu brick blockwork cladding, activities conducted "offsite";

Main activities conducted "off site"	Risks	Yes	No	Comments	Selected
Delivery of base materials to brick ready mix suppliers	Various but same as OSP factory	11	0	Same insitu and offsite	✓
Mix clay place in moulds and fire bricks at works	Various but same as OSP factory	11	0	Same insitu and offsite	✓
Transport & deliver bricks and mortar to site	Road traffic, site access, site conditions, mechanical handling, offloading.	9	2	1 (A, I) expert stated that these were not relevant	✓

Activities and risk for insitu brick blockwork cladding, activities conducted "on - site";

Main activities conducted "on site"	Risks	Yes	No	Comments	Selected
Ground beam concrete	Concrete burns	10	1	1 (I) expert stated that these were not relevant	✓
Prepare site for bricklaying	Various but same as OSP factory	9	2	2 (A, I) expert stated that these were not relevant	✓
Set out corners, Transport bricks	Repetitive tasks, manual handling (MH), cuts, dermatitis, MSDs falling material, unstable ground, exposure to UV.	9	2	2 (A, I) expert stated that these were not relevant	✓
Moving bricks/blocks to workface	(MH), falling material, unstable ground.	10	1	1 (I) expert stated that these were not relevant	✓
Erecting work platforms	(MH), MSDs, working at height, overhead work, walking into objects or projections	10	1	1 (I) expert stated that these were not relevant	✓
Mix mortar	Dermatitis, breathing dust fumes, mortar splashes in eyes, rash allergies, exposure to	10	1	1 (I) expert stated that these were not relevant	✓

(Continued)

Brick cutting	Struck by brick from saw, electric cutting equipment shock, dust, grot or brick splinters, noise, exposure to UV. MH	10	1	1 (I) expert stated that these were not relevant	✓
Laying mortar	Dermatitis, repetitive tasks, MSD, MH, working at height.	10	1	1 (I) expert stated that these were not relevant	✓
Bricklaying	Working at height, exposure to UV, MH, confined space work, dermatitis, clearing away mortar, overspill, cleaning mortar from	10	1	1 (I) expert stated that these were not relevant	✓
Fix wall ties, mesh reinforcement place lintels & DPC	Repetitive tasks, cuts splinters	10	1	1 (I) expert stated that these were not relevant	✓
Pointing/finishing	Working at height, confined space, repetitive tasks, dermatitis	9	2	2 (A, I) experts stated that this activity is not relevant	✓
Ancillary site risks	Slips, trips, falls	9	2	2 (A, I) expert stated that these were not relevant	✓

Similarly the activities and risks conducted "offsite" for precast concrete face finished panels (step 1.4) were recorded as follows:

Step 1.4

Main activities conducted "off site"	Risks	Yes	No	Comments	Selected
Delivery of base materials to factory	Various but same as OSP factory	11	0	Same insitu and offsite	✓
Place slips or architectural finish.	Cuts, dermatitis, MH	9	2	2 (A, I) expert stated that these were not	✓
Reinforce fix inserts	Mechanical handling, craneage	10	1	1 (I) expert stated that these were not relevant	✓
Mix concrete, place concrete, vibrate.	Various but same as ready mix. Craneage, dermatitis, MH,	10	1	1 (I) expert stated that these were not relevant	✓
Form box-outs	MSDs, dermatitis	10	1	1 (I) expert stated that these were not relevant	✓
Remove/store	Mechanical handling, craneage	9	2	2 (A, I) expert stated that these were not	✓
• Transport and deliver panels to site.	Road traffic, mechanical handling, offloading etc.	10	1	1 (I) expert stated that these were not relevant	✓
• Transport and deliver plant to site	Road traffic, mechanical handling, offloading etc	9	2	2 (A, I) expert stated that these were not relevant	✓

The activities and risks conducted "on-site" for precast concrete face finished panels were recorded as follows:

Main activities conducted "on site"	Risks	Yes	No	Comments	Selected
Prepare site for panels	Various but same as insitu	11	0	Same insitu and offsite	✓
Move panels to required position	Mobile plant risks, hand injuries, large loads	10	1	1 (I) expert stated that these were not relevant	✓
Connect panel to frame	Plant hand injuries	10	1	1 (I) expert stated that these were not relevant	✓
Jointing in mastics		10	1	1 (I) expert stated that these were not relevant	✓
Finishing		9	2	2 (A, I) expert stated that these were not	✓
Ancillary site risks	Slips, trips, falls	9	2	2 (A, I) expert stated that these were not	✓

Appendix G Identification of risk change from insitu to offsite

Expert Panel Research Notes

Loughborough University, Brockington Building, Conference Room, Loughborough

12th September 2002, 12:00pm – 4:00pm

<u>Phase I</u>

Expert Group Interview Two – issues

Objective: To verify the activities and risks from group interview one. Discuss how the risk changes from insitu to offsite.

Question: What risks are additional, the same, less likely or more controllable.

Points to consider:

Some risks will be the same for both insitu and offsite e.g. delivery of base materials to factory.

Key steps

Building element: **Buildings – cladding**

<u>Step 1.5</u>

The expert group were asked to verify the activities and risks from expert group interview one. The panel verified the activities and risks from expert group interview one.

<u>Step 1.6</u>

Discuss the risk change for each activity

Step 1.7

The risk change from insitu to offsite for brickwork and blocklaying were recorded as follows:

Main activities conducted “off site”

Main activities conducted “off site”	Risks	Risk change compared to offsite
Delivery of base materials to brick ready mix suppliers	Various but same as OSP factory	Same
Mix clay place in moulds and fire bricks at works	Various but same as OSP factory	Same
Transport & deliver bricks and mortar to site	Road traffic, site access, site conditions, mechanical handling, offloading etc	Additional risk (A), same.

Main activities conducted “on site”

Main activities conducted “on site”	Risks	Risk change compared to offsite
Ground beam concrete	Concrete burns	Same
Prepare site for bricklaying	Various but same as OSP factory	Same
Set out corners, Transport bricks	Repetitive tasks, manual handling (MH), cuts, dermatitis, MSDs falling material, unstable ground, exposure to UV.	Additional risk (A)
Moving bricks/blocks to workface	(MH), falling material, unstable ground.	More controllable in offsite.
Erecting work platforms	(MH), MSDs, working at height, overhead work, walking into objects or projections	More controllable in offsite
Mix mortar	Dermatitis, breathing dust fumes, mortar splashes in eyes, rash allergies, exposure to UV, (MH).	Additional risk

(Continued);

Brick cutting	Struck by brick from saw, electric cutting equipment shock, dust, grot or brick splinters, noise, exposure to UV. MH	Additional risk
Laying mortar	Dermatitis, repetitive tasks, MSD, MH, working at height.	Additional risk
Bricklaying	Working at height, exposure to UV, MH, confined space work, dermatitis, clearing away mortar, overspill, cleaning mortar from tools.	Additional risks
Fix wall ties, mesh reinforcement place lintels & DPC	Repetitive tasks, cuts splinters	Additional risks
Pointing/finishing	Working at height, confined space, repetitive tasks, dermatitis	More control in offsite
Ancillary site risks	Slips, trips, falls	More likely

Step 1.8

The risk change from offsite to insitu for precast concrete face finished panels were recorded as follows:

Main activities conducted "off site

Main activities conducted "off site"	Risks	Risk change compared to offsite
Delivery of base materials to factory	Various but same as OSP factory	Same
Place slips or architectural finish.	Cuts, dermatitis, MH	Less likely (LL) Controllable (C)
Reinforce fix inserts	Mechanical handling, craneage	Additional risk (A).
Mix concrete, place concrete, vibrate.	Various but same as ready mix. Craneage, dermatitis, MH, MSDs HAVS, dermatitis, whole body vibration, MSDs, dermatitis.	Less likely, controllable.
Form box-outs	MSDs, dermatitis	Less likely (LL), controllable.
Remove/store	Mechanical handling, craneage	Additional (A), more controllable (MC)
Transport and deliver panels to site.	Road traffic, mechanical handling, offloading etc.	Additional (A), more controllable (MC)
Transport and deliver plant to site	Road traffic, mechanical handling, offloading etc	Additional (A), more controllable (MC).

Main activities conducted "on site

Main activities conducted "on site"	Risks	Risk change compared to offsite
Prepare site for panels	Various but same as insitu	Same
Move panels to required position	Mobile plant risks, hand injuries, large loads	Additional more Controllable (MC)
Connect panel to frame	Plant hand injuries	Additional risk (A).
Jointing in mastics		
Finishing		Less likely (LL), controllable.
Ancillary site risks	Slips, trips, falls	Less likely (LL)

Appendix H Ergonomic Audit

Ergonomic Audit

Phase II

The data from phase two, the ergonomic risks, revealed the risks from the activities during offsite manufacture from the three case studies. These activities and risks were compared with those from phase I and any additional activities and risks added for the element under consideration. The activities and risks identified during the audit for precast concrete face finished panels were recorded as follows:

Ergonomic audit: Precast concrete face finished panels

Issues: activities and risks examined for each activity in phase II

Activity	Phase II
Mould construction	Trunk movement (MSDs), constrained standing (MSDs), slips and trips
Reinforcement assembly	Wrist injury (RSI), constrained standing (MSDs), slips and trips
Place concrete	Wrist injury (RSI), lifting (MSDs), constrained standing (MSDs), vibration (RSI), slips and trips, wet work (dermatitis)
Transportation/storage	Extension of arms (RSI), wrist injury (RSI), overhead work (RSI), lifting (MSDs), wet work (dermatitis)
Installation	

Ergonomic audit: Toilet Pods

Issues: activities and risks examined for each activity in phase II

Activity	Phase II
Steel channel frame erection	Overhead work (MSDs), lifting (MSDs), slips and trips
Gyproc panel installation	Lifting (MSDs), slips and trips
Tiling	Wrist injury (RSI), overhead work (MSDs), lifting (MSDs), wet work (dermatitis)
Service installation	Overhead work (RSI), lifting (MSDs), slips and trips
Transport	
Installation	

Ergonomic audit: Modular buildings

Issues: activities and risks examined for each activity in phase II

Activity	Phase II
Steel channel frame	Wrist (RSI), overhead work (MSDs), lifting (MSDs), constrained standing (MSDs), slips and trips
Insulation to walls	Slips and trips
Steel sheeting to walls	Load on arms (RSI), wrist injury (RSI), overhead work (MSDs), lifting (MSDs), constrained standing (MSDs), slips and trips
MDF to walls ceiling	Extension of arms (RSI), load on arms (RSI), wrist (RSI), overhead work (RSI), lifting (MSDs), constrained standing (MSDs), slips and trips
Gyproc to walls ceiling	Extension of arms (RSI), load on arms (RSI), wrist (RSI), overhead work (RSI), lifting (MSDs), constrained standing (MSDs), slips and trips
Services	Overhead work (RSI), slips and trips
Transport	
Module installation	

Appendix I Development of HASPREST tool phase I and II

This appendix presents the data analysis and results of the study phases I and II. The work included the analysis of the data for the 1st and 2nd Expert Group Interviews and the ergonomic audits.

The data came from the research notes taken during the fieldwork, the research diary, telephone conversation notes and survey responses recorded during the expert group interviews. The data were qualititative in nature.

The data from phase I and II were combined. The tables for each case were recorded and sent to the collaborators for comment. The comments from the returned sheets were noted and were added to the final database tables.

Examples of the tables sent to collaborators for the three case studies are presented below:

<u>Phases I and II</u>

Precast concrete face finished panels

Activity	**Phase I**	**Phase II**	**Combined risks (HASPREST)**
Mould construction	Mechanical handling	Trunk movement (MSDs), constrained standing (MSDs), slips and trips	Mechanical handling, Trunk movement, constrained standing (MSDs), slips and trips
Reinforcement assembly	Manual handling and cuts	Wrist injury (RSI), constrained standing (MSDs), slips and trips	Manual handling, cuts, wrist injury (RSI), constrained standing (MSDs), slips and trips.
Place concrete	Dermatitis, (MSDs), hand arm vibration, whole body vibration	Wrist injury (RSI), lifting (MSDs), constrained standing (MSDs), vibration (RSI), slips and trips, wet work (dermatitis)	Dermatitis, wrist injury (RSI),lifting, (MSDs), constrained standing, hand arm vibration, whole body vibration.
Transportation/storage	Road traffic, mechanical handling and offloading risks	Extension of arms (RSI), wrist injury (RSI), overhead work (RSI), lifting (MSDs), wet work (dermatitis)	Road traffic, mechanical handling and offloading, extension of arms (RSI), wrist injury (RSI), lifting, (MSDs), wet work.
Installation	Panel fall, mobile plant, crush injury		Panel fall, mobile plant, crush injury.

Toilet Pods

Activity	Phase I	Phase II	Combined risks (HASPREST)
Steel channel frame erection	Manual handling (MSDs), cuts. overhead work (MSDs)	Overhead work (MSDs), lifting (MSDs), slips and trips	Manual handling, (MSDs), overhead work, lifting, slips and trips
Gyproc panel installation	Manual handling (MSDs), cuts	Lifting (MSDs), slips and trips	Manual handling, lifting, (MSDs), cuts, slips and trips
Tiling	Restricted work area, (MSDs)	Wrist injury (RSI), overhead work (MSDs), lifting (MSDs), wet work (dermatitis)	Restricted work area, overhead work, lifting (MSDs)
Service installation	Restricted work area, (MSDs	Overhead work (RSI), lifting (MSDs), slips and trips	Restricted work area, overhead work,(RSI) lifting, (MSDs), slips and trips.
Transport	Road traffic, manual handling, craneage		Road traffic, manual handling, craneage
Installation	Cuts, craneage, MSDs, slips and trips		Cuts, craneage, (MSDs), slips and trips

Precast concrete face finished panels

Activity	Phase I	Phase II	Combined risks (HASPREST)
Steel channel frame	Manual handling (MSDs), mechanical handling, cuts, fumes, overhead work (MSDs)	Wrist (RSI), overhead work (MSDs), lifting (MSDs), constrained standing (MSDs), slips and trips	Wrist injury (RSI), Manual handling, lifting, constrained standing, mechanical handling, overhead work, (MSDs), cuts, fumes, slips and trips
Insulation to walls	Manual handling (MSDs), overhead work	Slips and trips	Manual handling, overhead work, (MSDs), slips and trips.
Steel sheeting to walls	Manual handling (MSDs), overhead work	Load on arms (RSI), wrist injury (RSI), overhead work (MSDs), lifting (MSDs), constrained standing (MSDs), slips and trips	Manual handling (MSDs), overhead work, lifting, constrained standing (MSDs), load on arms, wrist injury (RSI), slips and trips.
MDF to walls ceiling	Manual handling (MSDs), overhead work	Extension of arms (RSI), load on arms (RSI), wrist (RSI), overhead work (RSI), lifting (MSDs), constrained standing (MSDs), slips and trips	Manual handling, lifting, constrained standing, overhead work (MSDs), extension of arms, load on arms, wrist injury, (RSI), slips and trips.
Gyproc to walls ceiling	Manual handling (MSDs), overhead work	Extension of arms (RSI), load on arms (RSI), wrist (RSI), overhead work (RSI), lifting (MSDs), constrained standing (MSDs), slips and trips	Manual handling, overhead work, lifting, constrained standing, (MSDs),wrist injury, extension of arms, load on arms (RSI), slips and trips.
Services	Manual handling (MSDs), cuts, hand arm vibration (HAVS),	Overhead work (RSI), slips and trips	Manual handling, (MSDs), overhead work, hand arm vibration (RSI), cuts, slips and trips.
Transport	Road traffic, (MSDs), craneage		Road traffic, (MSDs), craneage
Module installation	Cuts, craneage, MSDs, slips and trips		Cuts, craneage, MSDs, slips and trips.

Appendix J HASPREST Sheets

Full Report hasprest.pdf

Appendix K ABA tool

Analysis conducted by:

LJM

Date:_15/08/2002

Work Place Data: **No: 1**

Site: Colwick, Notts

Building: Workshop 1

Work place: Factory workshop

Remarks: Construction of timber moulds for precast concrete face finished cladding panels

Number of workers involved: 2

Note: *the definitions used in the checklist are as follows:*
occasional*: less than 5% of shift time*
frequent*: between 5% and 30% of shift time*
very frequent*: over 30% of shift time*

1 Required height

Activity suitable for workers between 5' and 6'5'' in height	g	✓	
Activity more suitable for workers taller than 5' 5''	g		
Activity more suitable for workers shorter than 6'	g		
Activity more suitable only for workers with a height between 5' 5'' and 6'	**a**		

Notes:

2 Extension of arms (including shoulder joint)

Movements required for a reach up to 30cm (1')	g	✓	
Movements required for a reach up to 56cm (1'10")	g		
Reaching required beyond 56cm (1'10")	**a**		

Notes:

3* Frequent muscle load on arms and shoulders during activities when <u>sitting</u> *(nb lifting/carrying is a separate category)*

Little or no effort required (forces exerted under 10 N*)	g	✓	
Medium effort required (forces exerted under 50N)	g		
Large effort required (forces under 80 N)	**a**		
Excessive effort required (forces over 80N)	**r**		

** Example: To open a door with automatic closer takes approx. 50 N*

Notes:

4* Frequent muscle load on arms and shoulders during activities when <u>standing / walking</u> (NB not lifting/carrying)

little or no effort required (forces exerted under 25 N)	g	✓	
Medium effort required (forces exerted under 120N)	g		
Large effort required (forces exerted under 180 N)	**a**		
Excessive effort required (forces exerted over 180N)	**r**		

** Effort: Ex. To push a Rover Mini takes approx. 150*

Notes:

5 Risk to wrist / lower arms (turning, twisting, wrist deviation, forceful movements)

occasional	g	✓	
frequent	**a**		
very frequent	**r**		

6 High / overhead work (122cm or 4')

No handling above 122cm (4')	g	✓	
occasional overhead handling with little effort (forces exerted under 10 N)	g		
frequent overhead handling with little effort (forces exerted under 10 N)	**a**		
occasional overhead handling with effort (forces exerted over 10 N)	**a**		
frequent overhead handling with effort (over 10N) or prolonged holding work	**r**		

Notes:

7 Grip

power grip only (with neutral wrist position) or occasional pinch grip	g	✓	
frequent / very frequent pinch grip	a		
difficult / awkward gripping required	**a**		

Notes:

8 Trunk movement

slight twisting and bending movements	g		
twisting under 15°, bending under 30°	g		
large movements (twist under 35°,bend under 90°)	**a**	✓	
prolonged / difficult large movements <u>or</u> full movement (twist over 35°,bend over 90°)	**r**		

9 Movement of the hip *Distinct from trunk movement*

slight movement , e.g. walking	g	✓	
moderate movement (bending angle under 90°	g		
full movement (bending angle over 90°)	**a**		
frequent or prolonged movement (bending over 90°)	**r**		

Notes:

10 Movement of the knee

slight movement, e.g. walking	g	✓	
moderate movement (bending angle under 90°), e.g. sitting	g		
full movement (bending angle over 90°)	**a**		
frequent or prolonged bending (over 90°) and/or twisting	**r**		

Notes:

11 Movement of the ankles

slight movement, e.g. walking	g	✓	
infrequent full movement of ankles e.g. reaching	g		
very frequent ankle movement or frequent / prolonged twisting	**a**		

Notes:

11 Lifting and carrying

no lifting or lifting of weights under 1 kg	g		
frequent lifting under 5 kg occasionally under 10 kg	g	✓	
frequent lifting under 10 kg occasionally under 18 kg	**a**		
frequent lifting under 18 kg occasionally under 25 kg	**a**		
frequent lifting over 18 kg occasionally over 25 kg	**r**		
very frequent lifting over 10 kg	**r**		

Notes:

13 Lifting and carrying (ergonomic conditions)

ergonomically favourable conditions	g	✓	
unfavourable conditions: occasional lifting and carrying	**a**		
unfavourable conditions: frequent lifting and carrying	**r**		

Notes:

14 Standing

standing with freedom to move or alternate with sitting/walking	g		
frequent constrained standing	**a**	✓	
frequent static (over half hour) standing	**a**		
continuous (over 90% of shift) static or constrained standing	**r**		

Notes:

15 Walking

walking with freedom to alternate with sitting/standing	g	✓	
constant walking	g		
walking not possible or only occasional	**a**		
constant walking in unfavourable conditions	**r**		

Notes:

16 Sitting

sitting with freedom to alternate with walking/standing	g	✓	
continuous sitting (over 90% of shift)	**a**		
sitting preferable but not possible	**a**		
continuous sitting (over 90% of shift) in ergonomically unfavourable conditions	**r**		

Notes:

17 Noise

Assessment level under ceiling value*	g	✓	
Assessment level under 90 dB(A) but over ceiling value	**a**		
Assessment level over 90 dB(A) or 85 dB(A) incl. pulsed noise	**r**		

*Ceiling value:- 55 dB(A) for mental activity
70 dB(A) for some mental/ some physical activities
85 dB(A) for mainly physical activities

Notes:

18 Climate

Climatic conditions in comfort range	g	✓	
climatic conditions outside comfort range, depending on season	**a**		
climatic conditions continuously(over 90% of shift) outside the comfort range	**r**		

Notes:

Measured values:
illumination:
_________ *Lux*
noise :
_________ *dB(A)*
max. weights:
_________ *kg*

19 Lighting - *see reference values

Lighting at least at reference value for task at all times of day	g	✓	
Lighting below reference value for task but over 50% of level	**a**		
Lighting under 50% of reference value	**r**		

*reference values simple visual tasks over **250 Lux**
higher visual tasks over **500 Lux**
fine visual tasks over **750 Lux**

Notes:

20 Vibration

no particular discomfort caused by vibration	g	✓	
discomfort caused by vibration	**a**		

Notes:

21 Hazardous materials in the working area (E.g., corrosive, flammable, toxic substances etc.)

not present	g		
present and assessed as under 50% of **O**ccupational **E**xposure **S**tandard (OES)	g		
50% - 100% of OES or causing discomfort	**a**	✓	
over Occupational Exposure Standard	**r**		
present and not tested	**r**		

Notes:

22 Wet

not exposed	g	✓	
exposed	**a**		

Notes:

23 Driving and steering activity

no driving and steering activity	g	✓	
driving and steering activity	g		

Notes:

24 Production Incentive

time to stop (for quick break) without affecting others	g	✓	
can stop but affects others	**a**		
no time to stop	**r**		

Notes:

25 Shift work

no shift work or permanent day shift	g	✓	
2 shift work-rotated (e.g. 6am-2pm, 2pm-10pm)	g		
permanent night shift	**a**		
3 shift work	**a**		

Notes:

26 Risk (safety risks present)

no special risk in the execution of the job	g		
possible risk in execution of job, but adequate control measures taken	g	✓	
possible risk in execution of job, precautions not taken	**r**		

Notes:

KEY: the abbreviations used in the second column mean:
g = no action required (green)
a = action required (amber)
r = high priority action required (red)

NB ALL REDS SHOULD BE INVESTIGATED	
No. of ambers:3 No. of reds: 0	**Total Ergonomic Score (TES)**
no red items	**GREEN** **23**
max. 2 red items and under 5 amber	**AMBER** **3**
2 red items and over 5 amber **or** 3 or more red items	**RED** **0**

Appendix L ABA Guidelines

PURPOSE OF THE ABA ASSESSMENT

The ABA is used as the first stage in the total ergonomic assessment process. It is designed to be quick to use (by a trained assessor) and the outcome is an overall ergonomic assessment which highlights areas which need attention. It is completed in sections (each covering a different aspect of ergonomics) and during the assessment each section is rated either:

GREEN No action required

At the end of the ABA, the results of all the sections are integrated to give an overall score. This is provided to indicate priorities for action between several jobs which have been assessed. Regardless of the total score, it is still important that any reds are investigated after the assessment (and all ambers considered).

Once any areas of concern (reds and ambers) have been identified, the facilitator can continue with the ergonomic process. This will probably involve completion of a more detailed checklist to properly define any problems and the formulation of a project team to help generate and implement solutions. It is highly recommended that the more detailed ergonomic toolset is used as a further assessment since it gives much more thorough coverage than the ABA.

The ABA and all ergonomic checklists should only be used by people with some ergonomic training since they rely on a base knowledge of the subject. It is also important to remember that checklists can only act as reminders of the areas that should be considered - if you think that there is an ergonomic problem in the area you are assessing then it should be noted and addressed regardless of whether there is a category for it in the checklist.

BEFORE YOU START

First fill in the sections at the top of the sheet concerning the details of the job etc. This section may be useful for future reference, possibly by other associates. It is important that the job can be identified easily from what you write in this top section - don't worry if you do not have quite all the information asked for in the form, but do make sure that the job can be easily identified.

Second remember to check the box that gives the definitions of "occasional, frequent, very frequent"-. these terms are used throughout the document.

HOW TO PERFORM AN ASSESSMENT

1. Make sure that you have spent some time observing the job before you start. it is best to complete the assessment actually next to the operation so that you are not relying on memory and that you can check an details with the associate doing the job.
2. Always explain what you are doing before starting and stress that the assessment is of the job, not the associate.
3. It is advisable to ask for the associate's opinion of the job (if possible) and whether he/she experiences any problems with it (or has any changes to suggest).
4. Tick one box only per section (e.g. one tick for the whole section "010 required height")
5. Write any relevant comments/observations in the 'notes" space at the end of each section
6. At the end. count up the ambers and reds and score the assessment (see instructions later)

EXPLANATORY NOTES - SECTION BY SECTION

The categories in each section go from green (top category) through amber and usually to red (last category). If numerical limits are specified (i.e. degrees of twist, Newtons of force) then only the upper limit is given in that section. For instance if the first category is “forces exerted under 10N And the second forces exerted under 50N then this second category should be ticked for forces between 10 and 50 Newtons. This means that it is important to read all the options before choosing the appropriate category.

010 required height

Tick the box which best describes the suitable height range for the job. Some jobs may be impossible/impractical for people of certain heights because of physical restrictions of the workstation. However, also consider whether a job is really s2Iitable only for people of a particular stature. Team leaders / associates may be able to advise on this, or it may he a matter for personal judgment.

020 Extension of arms (including shoulder joint)

How far do operators need to reach (i.e. extend their arms) to do the job? The numbers given in the categories assume an upright trunk so remember also to consider trunk angle when looking at the reach, If the associate has to bend forward to reach something, include the distance covered by the bending action as well as the arm reach.

030 / 040 Frequent muscle load on arms and shoulders during activities when *sitting.!* standing / walking

If the operation is performed sitting, complete section 030. If it performed standing, then complete section 040.
This is concerned with the exertion of force as part of the job - note that it does not include lifting or carrying (which is dealt with in a later section). Examples of force exertion might be:

the manipulation of a weld gun
pushing or pulling a trolley or pallet
pushing panels along pipe rails
manipulation of a grinder at a distance from the body
etc.
The categories are classified by the amount of force exerted, this is given in Newtons (N). If you hold a 1Kg weight steady in your hand, the downward force from the weight (and the upward force from your arm) is 10 Newtons. Some other examples are given on the ABA sheet itself.

Sometimes it is possible to measure force using a strain gauge (if this measures in Kg you can multiply by 10 to give the value in Newtons): there is a strain gauge in the medical centre. If you cannot measure the force. then you may have to estimate it - do not be afraid to do this. Remember also to note whether associates feel that the effort required to do any aspect of the job is giving them problems: if it is, changes may be needed whether or not the force is sufficient to “qualify” for an amber rating.

Note that the section refers to “frequent” loading but if an activity is only occasional it may still be worth recording in the “notes” section (for instance, an occasional but very heavy job such as pushing a conveyor belt).

050 Risk to wrist lower arms (turning, wrist deviation. Forceful movements)

Is there any risk to the wrists or lower arms from the actions performed in the job? If so, tick the appropriate category according to the frequency of risky operations.

Thee are a range of conditions that place the wrist at risk; these include the following

deviated positions
forceful movements (especially in deviated positions)
repetitive art/wrist movements (especially in deviated positions)
twisting and turning movements of the arm/wrist
static muscle loading in the lower arm

You need to judge whether the job you are considering constitutes a risk - if in doubt it may help to ask the operators and team leader whether anyone experiences hand/arm pain from this job. Generally a problem will be quite clear simply from observation.

060 High / Overhead work
This section deals with work conducted above shoulder height - i.e. with the hands/arms elevated above the shoulders. Work does not need literally to be "over head" to be a problem.
The alternative categories reflect both the frequency of such work: and the forces exerted when working above shoulder height.

070 Grip
The categories here are concerned with the type (and frequency) of grip used in the job. The grip is "green" if it is in the "power" position (see Joyce Institute Folder) or is only occasionally of the pinch type. The two amber categories distinguish between frequent/very frequent pinch grips and other forms of difficult/awkward gripping.

080 Trunk movement
This section deals with bending and twisting movements of the trunk - for instance bending over to pick things up, bending across to load a press, twisting to reach something etc. The categories refer to different amounts of bending and twisting. Remember to read all the options before choosing.

090 Movement of the hip
This is similar to trunk movement so try to avoid recording the same body movement in both sections. There may be occasions however when a movement is definitely of the hip rather than of the trunk - for instance when crouching down - and these are the occasions when this section can be used. Again the categories refer to the amount of movement and its frequency/duration.

100 Movement of the Knee
Any knee movement should fall into one of these categories - if the movement is no greater than in normal walking/standing then choose the first green - otherwise choose according to the degree of movement and whether twisting occurs.

110 Movement of the ankles
Once again any ankle movement can be classified into one of these categories. Infrequent full ankle movement is considered green simply because it is infrequent. Frequent or prolonged fulfill movement (or twisting') can be a problem.

120 Lifting and Carrying
This section only gives brief consideration to the whole area of manual handling and should not be used as the only assessment if lifting and carrying forms a significant part of the job. If you suspect there is any risk to the associate from lifting/carrying then you should arrange to have a manual handling assessment carried out for the job (or you may be trained to do this yourself - contact Karen Towers in the medical centre for further information on manual handling).
The ABA categories refer to the weight of the load which is lifted and the frequency of the lift - the load should be weighed whenever possible (or the weigh: may be given on the process sheet)

130 Lifting and carrying (ergonomic conditions)
This section refers only to the ergonomic conditions for lifting and carrying (not for other types of work). There are a variety of conditions which are considered unfavourable for instance:
if the load is bulky or unstable
if the load is difficult or awkward to grip (or greasy, wet)
if there is insufficient space to manipulate the load or position the body to lift correctly
if the area in which the lifting/carrying occurs is cluttered or obstructed
if the lift occurs at a distance from the body. or with the body at an angle to the load
if the job involves lifting to/from lower than the knee
if the job involves lifting to/from higher than the shoulder

140 / 150 / 160- Standing /Walking /Sitting
It may be easier to consider all these sections together since they are all related. The following information may help you to choose the appropriate category:

<u>Standing</u>
"constrained standing" means that there is little freedom to move the feet or choose a comfortable position
"static standing" means that a single position is held for some time (i.e. that the muscle are statically loaded) and that there is little possibility of changing posture. (the operator-will be able to tell you this).

<u>Walking</u>
"unfavourable conditions" might refer to a poor, hazardous or oily floor surface, or other aspects of the job which make walking difficult or dangerous.

<u>Sitting</u>
This section may need to be completed even if there is no sitting on the job (because it asks if sitting is preferable but not possible). Ergonomically unfavourable conditions for continuous sitting include
having a poor chair
no back rest
no adjustability of the seat
seat too high or low (feet should rest flat on the floor or on a foot platform)
no lumber support

170 Noise
Several different ceiling values arc given depending on the type of activity. It should be readily apparent if the noise level is above 9OdB(A) since hearing protection is mandatory at this level. If the noise exceeds 85 dB(A) hearing protection should be available to associates but is not compulsory. If you consider that noise might be a problem in the area, you should have it assessed with a sound level meter. If this is done. make sure that the sound is measured at the position where operators normally stand.

180 Climate
This section refers to temperature and humidity and it is important to ask how the conditions vary in the summer and winter. Other factors may also be important here such as draughts and radiant heat (e.g. heat from the sun shining through glass).
Do not be influenced here by whether or not you think that anything can he done about the climate the work area - if it is uncomfortable it should he recorded.

190 Lighting
As with noise, several values are given for lighting depending on the type of activity. Clearly better lighting is required for finer tasks or tasks where good vision is important (such as inspection). If possible it is best to measure the lighting in the area of work – this should certainly be done if the associates (or yourself) feel that there is a problem with the light.

200 Vibration
Vibration is not an easy thing to measure so we must rely on the reports of vibration by people in the work area. The two categories in this section are clear enough - but remember that vibration can affect individual parts of the body as well as the whole body. In particular hand/arm vibration that associates experience (from power tools for instance) can be damaging in the long term (if regularly experienced) even if not uncomfortable in the short term. If you think that hand/arm vibration exposure may be a risk, record it in the notes section and consult a member of the medical team (in Health and Safety) for advice.

210 Hazardous materials in the working area
This section is concerned mainly with the type of materials that are covered by COSHH regulations for instance, acids, flammable materials, toxic or corrosive substances. If present these substances should have been assessed versus the "occupational exposure standard" and the results of the assessment known. Choose a category as appropriate.

220 Wet
Are the associates typically exposed to liquids (e.g. water, oil) in their work?

2.30 Driving and steering activity
This section is used purely as a record of whether driving or steering activity is undertaken by associates on the job. (Both categories are green)

2.40 Production Incentive
Record here the degree to which associates are constrained by the production levels. Can they stop for a few minutes break without affecting other people, or are other people affected by this? If there is no time to stop, the job is classified as red.

250 Shift Work
Record in this section what the shift pattern is for the job. Remember that the ABA assesses the job not the associate, so if a job is done on a night shift (even if you are assessing it on days) you should tick the third or fourth category (amber). It is only when a job is on/v done on days that it should t recorded in the first green category.

280 Risk (safety risks present)
This section gives an opportunity to note any risk that has been identified which you have not recorded elsewhere on the ABA form. For instance, any safety risks that are present in carrying out the job can be included here. However do not repeat information that has already been covered in another section.

SCORING
At the end of the assessment add up the number of reds and ambers you have and record them in the scoring section. Following the instructions tick the appropriate category (green, amber or red) for the whole sheet, this gives an indication of how severe any problems are and can be used to prioritize action if you are assessing several jobs at once. Remember that even if the overall score is OK, all reds should be followed up and all ambers at least reviewed.

Appendix M Case study example completed audit sheets

Analysis conducted by:

LJM

Date:_15/08/2002

Work Place Data: **No: 1**

Site: Colwick, Notts

Building: Workshop 1

Work place: Factory workshop

Remarks: Construction of timber moulds for precast concrete face finished cladding panels

Number of workers involved: 2

Note: *the definitions used in the checklist are as follows:*
occasional*: less than 5% of shift time*
frequent*: between 5% and 30% of shift time*
very frequent*: over 30% of shift time*

1 Required height

Activity suitable for workers between 5' and 6'5'' in height	g	✓	
Activity more suitable for workers taller than 5' 5''	g		
Activity more suitable for workers shorter than 6'	g		
Activity more suitable only for workers with a height between 5' 5'' and 6'	**a**		

Notes:

2 Extension of arms (including shoulder joint)

Movements required for a reach up to 30cm (1')	g	✓	
Movements required for a reach up to 56cm (1'10'')	g		
Reaching required beyond 56cm (1'10'')	**a**		

Notes:

3* Frequent muscle load on arms and shoulders during activities when sitting *(nb lifting/carrying is a separate category)*

Little or no effort required (forces exerted under 10 N*)	g	✓	
Medium effort required (forces exerted under 50N)	g		
Large effort required (forces under 80 N)	**a**		
Excessive effort required (forces over 80N)	**r**		

** Example: To open a door with automatic closer takes approx. 50 N*

Notes:

4* Frequent muscle load on arms and shoulders during activities when standing / walking (NB not lifting/carrying)

little or no effort required (forces exerted under 25 N)	g	✓	
Medium effort required (forces exerted under 120N)	g		
Large effort required (forces exerted under 180 N)	**a**		
Excessive effort required (forces exerted over 180N)	**r**		

** Effort: Ex. To push a Rover Mini takes approx. 150*

Notes:

5 Risk to wrist / lower arms (turning, twisting, wrist deviation, forceful movements)

occasional	g	✓	
frequent	**a**		
very frequent	**r**		

6 High / overhead work (122cm or 4')

No handling above 122cm (4')	g	✓	
occasional overhead handling with little effort (forces exerted under 10 N)	g		
frequent overhead handling with little effort (forces exerted under 10 N)	**a**		
occasional overhead handling with effort (forces exerted over 10 N)	**a**		
frequent overhead handling with effort (over 10N) or prolonged holding work	**r**		

Notes:

7 Grip

power grip only (with neutral wrist position) or occasional pinch grip	g	✓	
frequent / very frequent pinch grip	a		
difficult / awkward gripping required	**a**		

Notes:

8 Trunk movement

slight twisting and bending movements	g		
twisting under 15°, bending under 30°	g		
large movements (twist under 35°,bend under 90°)	**a**	✓	
prolonged / difficult large movements or full movement (twist over 35°,bend over 90°)	**r**		

9 Movement of the hip *Distinct from trunk movement*

slight movement , e.g. walking	g	✓	
moderate movement (bending angle under 90°	g		
full movement (bending angle over 90°)	**a**		
frequent or prolonged movement (bending over 90°)	**r**		

Notes:

12 Movement of the knee

slight movement, e.g. walking	g	✓	
moderate movement (bending angle under 90°), e.g. sitting	g		
full movement (bending angle over 90°)	**a**		
frequent or prolonged bending (over 90°) and/or twisting	**r**		

Notes:

11 Movement of the ankles

slight movement, e.g. walking	g	✓	
infrequent full movement of ankles e.g. reaching	g		
very frequent ankle movement or frequent / prolonged twisting	**a**		

Notes:

13 Lifting and carrying

no lifting or lifting of weights under 1 kg	g		
frequent lifting under 5 kg occasionally under 10 kg	g	✓	
frequent lifting under 10 kg occasionally under 18 kg	**a**		
frequent lifting under 18 kg occasionally under 25 kg	**a**		
frequent lifting over 18 kg occasionally over 25 kg	**r**		
very frequent lifting over 10 kg	**r**		

Notes:

13 Lifting and carrying (ergonomic conditions)

ergonomically favourable conditions	g	✓	
unfavourable conditions: occasional lifting and carrying	**a**		
unfavourable conditions: frequent lifting and carrying	**r**		

Notes:

14 Standing

standing with freedom to move or alternate with sitting/walking	g		
frequent constrained standing	**a**	✓	
frequent static (over half hour) standing	**a**		
continuous (over 90% of shift) static or constrained standing	**r**		

Notes:

15 Walking

walking with freedom to alternate with sitting/standing	g	✓	
constant walking	g		
walking not possible or only occasional	**a**		
constant walking in unfavourable conditions	**r**		

Notes:

16 Sitting

sitting with freedom to alternate with walking/standing	g	✓	
continuous sitting (over 90% of shift)	**a**		
sitting preferable but not possible	**a**		
continuous sitting (over 90% of shift) in ergonomically unfavourable conditions	**r**		

Notes:

17 Noise

Assessment level under ceiling value*	g	✓	
Assessment level under 90 dB(A) but over ceiling value	**a**		
Assessment level over 90 dB(A) or 85 dB(A) incl. pulsed noise	**r**		

*Ceiling value:- 55 dB(A) for mental activity
70 dB(A) for some mental/ some physical activities
85 dB(A) for mainly physical activities

Notes:

18 Climate

Climatic conditions in comfort range	g	✓	
climatic conditions outside comfort range, depending on season	**a**		
climatic conditions continuously(over 90% of shift) outside the comfort range	**r**		

Notes:

Measured values:
illumination:
_________ *Lux*
noise :
_________ *dB(A)*
max. weights:
_________ *kg*

19 Lighting - *see reference values

Lighting at least at reference value for task at all times of day	g	✓	
Lighting below reference value for task but over 50% of level	**a**		
Lighting under 50% of reference value	**r**		

*reference values simple visual tasks over **250 Lux**
higher visual tasks over **500 Lux**
fine visual tasks over **750 Lux**

Notes:

20 Vibration

no particular discomfort caused by vibration	g	✓	
discomfort caused by vibration	**a**		

Notes:

21 Hazardous materials in the working area (E.g., corrosive, flammable, toxic substances etc.)

not present	g		
present and assessed as under 50% of **O**ccupational **E**xposure **S**tandard (OES)	g		
50% - 100% of OES or causing discomfort	**a**	✓	
over Occupational Exposure Standard	**r**		
present and not tested	**r**		

Notes:

22 Wet

not exposed	g	✓	
exposed	**a**		

Notes:

23 Driving and steering activity

no driving and steering activity	g	✓	
driving and steering activity	g		

Notes:

24 Production Incentive

time to stop (for quick break) without affecting others	g	✓	
can stop but affects others	**a**		
no time to stop	**r**		

Notes:

25 Shift work

no shift work or permanent day shift	g	✓	
2 shift work-rotated (e.g. 6am-2pm, 2pm-10pm)	g		
permanent night shift	**a**		
3 shift work	**a**		

Notes:

26 Risk (safety risks present)

no special risk in the execution of the job	g		
possible risk in execution of job, but adequate control measures taken	g	✓	
possible risk in execution of job, precautions not taken	**r**		

Notes:

KEY: the abbreviations used in the second column mean:
g = no action required (green)
a = action required (amber)
r = high priority action required (red)

NB ALL REDS SHOULD BE INVESTIGATED	
No. of ambers:3 No. of reds: 0	**Total Ergonomic Score (TES)**
no red items	**GREEN** **23**
max. 2 red items and under 5 amber	**AMBER** **3**
2 red items and over 5 amber **or** 3 or more red items	**RED** **0**

Analysis conducted by:

LJM

Date:_21/05/2002

Work Place Data: No: 1

Site: Beverley

Building: Workshop 1

Work place: Factory workshop

Remarks: Washroom manufacture; steel channel frame erection

Number of workers involved: 2

Note: *the definitions used in the checklist are as follows:*
occasional*: less than 5% of shift time*
frequent*: between 5% and 30% of shift time*
very frequent*: over 30% of shift time*

1 Required height

Activity suitable for workers between 5' and 6'5'' in height	g	✓	
Activity more suitable for workers taller than 5' 5''	g		
Activity more suitable for workers shorter than 6'	g		
Activity more suitable only for workers with a height between 5' 5'' and 6'	**a**		

Notes:

2 Extension of arms (including shoulder joint)

Movements required for a reach up to 30cm (1')	g	✓	
Movements required for a reach up to 56cm (1'10'')	g		
Reaching required beyond 56cm (1'10'')	**a**		

Notes:

3* Frequent muscle load on arms and shoulders during activities when <u>sitting</u> *(nb lifting/carrying is a separate category)*

Little or no effort required (forces exerted under 10 N*)	g	✓	
Medium effort required (forces exerted under 50N)	g		
Large effort required (forces under 80 N)	**a**		
Excessive effort required (forces over 80N)	**r**		

** Example: To open a door with automatic closer takes approx. 50 N*

Notes:

4* Frequent muscle load on arms and shoulders during activities when <u>standing / walking</u> (NB not lifting/carrying)

little or no effort required (forces exerted under 25 N)	g		
Medium effort required (forces exerted under 120N)	g	✓	
Large effort required (forces exerted under 180 N)	**a**		
Excessive effort required (forces exerted over 180N)	**r**		

** Effort: Ex. To push a Rover Mini takes approx. 150*

Notes:

5 Risk to wrist / lower arms (turning, twisting, wrist deviation, forceful movements)

occasional	g	✓	
frequent	**a**		
very frequent	**r**		

6 High / overhead work (122cm or 4')

No handling above 122cm (4')	g		
occasional overhead handling with little effort (forces exerted under 10 N)	g		
frequent overhead handling with little effort (forces exerted under 10 N)	**a**		
occasional overhead handling with effort (forces exerted over 10 N)	**a**	✓	
frequent overhead handling with effort (over 10N) or prolonged holding work	**r**		

Notes:

7 Grip

power grip only (with neutral wrist position) or occasional pinch grip	g	✓	
frequent / very frequent pinch grip	a		
difficult / awkward gripping required	**a**		

Notes:

8 Trunk movement

slight twisting and bending movements	g		
twisting under 15°, bending under 30°	g	✓	
large movements (twist under 35°,bend under 90°)	**a**		
prolonged / difficult large movements <u>or</u> full movement (twist over 35°,bend over 90°)	**r**		

9 Movement of the hip *Distinct from trunk movement*

slight movement , e.g. walking	g		
moderate movement (bending angle under 90°	g	✓	
full movement (bending angle over 90°)	**a**		
frequent or prolonged movement (bending over 90°)	**r**		

Notes:

14 Movement of the knee

slight movement, e.g. walking	g		
moderate movement (bending angle under 90°), e.g. sitting	g	✓	
full movement (bending angle over 90°)	**a**		
frequent or prolonged bending (over 90°) and/or twisting	**r**		

Notes:

11 Movement of the ankles

slight movement, e.g. walking	g	✓	
infrequent full movement of ankles e.g. reaching	g		
very frequent ankle movement or frequent / prolonged twisting	**a**		

Notes:

15 Lifting and carrying

no lifting or lifting of weights under 1 kg	g		
frequent lifting under 5 kg occasionally under 10 kg	g		
frequent lifting under 10 kg occasionally under 18 kg	**a**		
frequent lifting under 18 kg occasionally under 25 kg	**a**	✓	
frequent lifting over 18 kg occasionally over 25 kg	**r**		
very frequent lifting over 10 kg	**r**		

Notes:

13 Lifting and carrying (ergonomic conditions)

ergonomically favourable conditions	g	✓	
unfavourable conditions: occasional lifting and carrying	**a**		
unfavourable conditions: frequent lifting and carrying	**r**		

Notes:

14 Standing

standing with freedom to move or alternate with sitting/walking	g	✓	
frequent constrained standing	**a**		
frequent static (over half hour) standing	**a**		
continuous (over 90% of shift) static or constrained standing	**r**		

Notes:

15 Walking

walking with freedom to alternate with sitting/standing	g	✓	
constant walking	g		
walking not possible or only occasional	**a**		
constant walking in unfavourable conditions	**r**		

Notes:

16 Sitting

sitting with freedom to alternate with walking/standing	g	✓	
continuous sitting (over 90% of shift)	**a**		
sitting preferable but not possible	**a**		
continuous sitting (over 90% of shift) in ergonomically unfavourable conditions	**r**		

Notes:

17 Noise

Assessment level under ceiling value*	g	✓	
Assessment level under 90 dB(A) but over ceiling value	**a**		
Assessment level over 90 dB(A) or 85 dB(A) incl. pulsed noise	**r**		

*Ceiling value:- 55 dB(A) for mental activity
70 dB(A) for some mental/ some physical activities
85 dB(A) for mainly physical activities

Notes:

18 Climate

Climatic conditions in comfort range	g	✓	
climatic conditions outside comfort range, depending on season	**a**		
climatic conditions continuously(over 90% of shift) outside the comfort range	**r**		

Notes:

Measured values:
illumination:
_________ *Lux*
noise :
_________ *dB(A)*
max. weights:
_________ *kg*

19 Lighting - *see reference values

Lighting at least at reference value for task at all times of day	g	✓	
Lighting below reference value for task but over 50% of level	**a**		
Lighting under 50% of reference value	**r**		

*reference values simple visual tasks over **250 Lux**
higher visual tasks over **500 Lux**
fine visual tasks over **750 Lux**

Notes:

20 Vibration

no particular discomfort caused by vibration	g	✓	
discomfort caused by vibration	**a**		

Notes:

21 Hazardous materials in the working area (E.g., corrosive, flammable, toxic substances etc.)

not present	g		
present and assessed as under 50% of **O**ccupational **E**xposure **S**tandard (OES)	g		
50% - 100% of OES or causing discomfort	**a**	✓	
over Occupational Exposure Standard	**r**		
present and not tested	**r**		

Notes:

22 Wet

not exposed	g	✓	
exposed	**a**		

Notes:

23 Driving and steering activity

no driving and steering activity	g	✓	
driving and steering activity	g		

Notes:

24 Production Incentive

time to stop (for quick break) without affecting others	g	✓	
can stop but affects others	**a**		
no time to stop	**r**		

Notes:

25 Shift work

no shift work or permanent day shift	g	✓	
2 shift work-rotated (e.g. 6am-2pm, 2pm-10pm)	g		
permanent night shift	**a**		
3 shift work	**a**		

Notes:

26 Risk (safety risks present)

no special risk in the execution of the job	g		
possible risk in execution of job, but adequate control measures taken	g	✓	
possible risk in execution of job, precautions not taken	**r**		

Notes:

KEY: the abbreviations used in the second column mean:
g = no action required (green)
a = action required (amber)
r = high priority action required (red)

NB ALL REDS SHOULD BE INVESTIGATED	
No. of ambers:3 No. of reds: 0	**Total Ergonomic Score (TES)**
no red items	**GREEN** **23**
max. 2 red items and under 5 amber	**AMBER** **3**
2 red items and over 5 amber **or** 3 or more red items	**RED** **0**

Analysis conducted by:

LJM

Date:_24/05/2002

Work Place Data: **No: 1**

Site: Carlton Newark

Building: Workshop 1

Work place: Factory workshop

Remarks: Modular building; steel channel structural frame erection

Number of workers involved: 4

Note: *the definitions used in the checklist are as follows:*
occasional: *less than 5% of shift time*
frequent: *between 5% and 30% of shift time*
very frequent: *over 30% of shift time*

1 Required height

Activity suitable for workers between 5' and 6'5'' in height	g	✓	
Activity more suitable for workers taller than 5' 5''	g		
Activity more suitable for workers shorter than 6'	g		
Activity more suitable only for workers with a height between 5' 5'' and 6'	**a**		

Notes:

2 Extension of arms (including shoulder joint)

Movements required for a reach up to 30cm (1')	g		
Movements required for a reach up to 56cm (1'10'')	g	✓	
Reaching required beyond 56cm (1'10'')	**a**		

Notes:

3* Frequent muscle load on arms and shoulders during activities when <u>sitting</u> *(nb lifting/carrying is a separate category)*

Little or no effort required (forces exerted under 10 N*)	g	✓	
Medium effort required (forces exerted under 50N)	g		
Large effort required (forces under 80 N)	**a**		
Excessive effort required (forces over 80N)	**r**		

** Example: To open a door with automatic closer takes approx. 50 N*

Notes:

4* Frequent muscle load on arms and shoulders during activities when standing / walking (NB not lifting/carrying)

little or no effort required (forces exerted under 25 N)	g		
Medium effort required (forces exerted under 120N)	g	✓	
Large effort required (forces exerted under 180 N)	**a**		
Excessive effort required (forces exerted over 180N)	**r**		

** Effort: Ex. To push a Rover Mini takes approx. 150*

Notes:

5 Risk to wrist / lower arms (turning, twisting, wrist deviation, forceful movements)

occasional	g		
frequent	**a**	✓	
very frequent	**r**		

6 High / overhead work (122cm or 4')

No handling above 122cm (4')	g		
occasional overhead handling with little effort (forces exerted under 10 N)	g		
frequent overhead handling with little effort (forces exerted under 10 N)	**a**	✓	
occasional overhead handling with effort (forces exerted over 10 N)	**a**		
frequent overhead handling with effort (over 10N) or prolonged holding work	**r**		

Notes:

7 Grip

power grip only (with neutral wrist position) or occasional pinch grip	g	✓	
frequent / very frequent pinch grip	a		
difficult / awkward gripping required	**a**		

Notes:

8 Trunk movement

slight twisting and bending movements	g		
twisting under 15°, bending under 30°	g	✓	
large movements (twist under 35°,bend under 90°)	**a**		
prolonged / difficult large movements <u>or</u> full movement (twist over 35°,bend over 90°)	**r**		

9 Movement of the hip *Distinct from trunk movement*

slight movement , e.g. walking	g		
moderate movement (bending angle under 90°	g	✓	
full movement (bending angle over 90°)	**a**		
frequent or prolonged movement (bending over 90°)	**r**		

Notes:

16 Movement of the knee

slight movement, e.g. walking	g	✓	
moderate movement (bending angle under 90°), e.g. sitting	g		
full movement (bending angle over 90°)	**a**		
frequent or prolonged bending (over 90°) and/or twisting	**r**		

Notes:

11 Movement of the ankles

slight movement, e.g. walking	g	✓	
infrequent full movement of ankles e.g. reaching	g		
very frequent ankle movement or frequent / prolonged twisting	**a**		

Notes:

17 Lifting and carrying

no lifting or lifting of weights under 1 kg	g		
frequent lifting under 5 kg occasionally under 10 kg	g		
frequent lifting under 10 kg occasionally under 18 kg	**a**	✓	
frequent lifting under 18 kg occasionally under 25 kg	**a**		
frequent lifting over 18 kg occasionally over 25 kg	**r**		
very frequent lifting over 10 kg	**r**		

Notes:

13 Lifting and carrying (ergonomic conditions)

ergonomically favourable conditions	g	✓	
unfavourable conditions: occasional lifting and carrying	a		
unfavourable conditions: frequent lifting and carrying	r		

Notes:

14 Standing

standing with freedom to move or alternate with sitting/walking	g		
frequent constrained standing	a	✓	
frequent static (over half hour) standing	a		
continuous (over 90% of shift) static or constrained standing	r		

Notes:

15 Walking

walking with freedom to alternate with sitting/standing	g	✓	
constant walking	g		
walking not possible or only occasional	a		
constant walking in unfavourable conditions	r		

Notes:

16 Sitting

sitting with freedom to alternate with walking/standing	g	✓	
continuous sitting (over 90% of shift)	a		
sitting preferable but not possible	a		
continuous sitting (over 90% of shift) in ergonomically unfavourable conditions	r		

Notes:

17 Noise

Assessment level under ceiling value*	g	✓	
Assessment level under 90 dB(A) but over ceiling value	a		
Assessment level over 90 dB(A) or 85 dB(A) incl. pulsed noise	r		

*Ceiling value:- 55 dB(A) for mental activity
70 dB(A) for some mental/ some physical activities
85 dB(A) for mainly physical activities

Notes:

18 Climate

Climatic conditions in comfort range	g	✓	
climatic conditions outside comfort range, depending on season	a		
climatic conditions continuously(over 90% of shift) outside the comfort range	r		

Notes:

Measured values:
illumination:
_________ *Lux*
noise :
_________ *dB(A)*
max. weights:
_________ *kg*

19 Lighting - *see reference values

Lighting at least at reference value for task at all times of day	g	✓	
Lighting below reference value for task but over 50% of level	a		
Lighting under 50% of reference value	r		

*reference values: simple visual tasks over **250 Lux**
higher visual tasks over **500 Lux**
fine visual tasks over **750 Lux**

Notes:

20 Vibration

no particular discomfort caused by vibration	g	✓	
discomfort caused by vibration	a		

Notes:

21 Hazardous materials in the working area (E.g., corrosive, flammable, toxic substances etc.)

not present	g		
present and assessed as under 50% of **O**ccupational **E**xposure **S**tandard (OES)	g		
50% - 100% of OES or causing discomfort	a	✓	
over Occupational Exposure Standard	r		
present and not tested	r		

Notes:

22 Wet

not exposed	g	✓	
exposed	a		

Notes:

23 Driving and steering activity

no driving and steering activity	g	✓	
driving and steering activity	g		

Notes:

24 Production Incentive

time to stop (for quick break) without affecting others	g	✓	
can stop but affects others	a		
no time to stop	r		

Notes:

25 Shift work

no shift work or permanent day shift	g	✓	
2 shift work-rotated (e.g. 6am-2pm, 2pm-10pm)	g		
permanent night shift	a		
3 shift work	a		

Notes:

26 Risk (safety risks present)

no special risk in the execution of the job	g		
possible risk in execution of job, but adequate control measures taken	g	✓	
possible risk in execution of job, precautions not taken	r		

Notes:

KEY: the abbreviations used in the second column mean:
g = no action required (green)
a = action required (amber)
r = high priority action required (red)

NB ALL REDS SHOULD BE INVESTIGATED	
No. of ambers:3 No. of reds: 0	**Total Ergonomic Score (TES)**
no red items	**GREEN** 21
max. 2 red items and under 5 amber	**AMBER** 5
2 red items and over 5 amber **or** 3 or more red items	**RED** 0

Appendix N Phase III semi-structured interview schedule

Semi-structured Interview

SCHEDULE

Phase III: semi-structured interview

Location:

Date:

Areas to discuss:

Risk from phases I and II.

The main risks based on the group interviews and ergonomic audits that were identified following the HASPREST work:

Please comment on the following:

1. Comment on the original risks encountered during the manufacturing process in 2003?
2. What areas of risk have been addressed by significant changes in the processes used in the last five years, please provide examples where appropriate?
3. What areas of risk cannot be addressed and have to be managed, how are they managed?
4. Have you used HASPREST

Observation:

The observation phase allows the observer to identify two or three areas where there are significant changes to the processes in order to reduce or eliminate risk:

Process change 1

Risk reduced and/or eliminated

Process change 2

Risk reduced and/or eliminated

Process change 3

Risk reduced and/or eliminated

Appendix O Case study selected transcripts

Phase III: semi-structured interview selected transcripts

Case study 1: Trent Concrete Ltd, non-volumetric, cladding- heavy commercial face finished

Trent Concrete Ltd, Head Office, Colwick Nottingham

16th July 2009

In the following transcript, the following code is adopted: LM (the author) and F, the Managing Director of Trent Concrete Ltd.

Comment on the original risks encountered during the manufacturing process?

LM	10:19	*'the risks identified in placing the concrete in the mould were, wrist injury (RSI) manual handling, lifting, constrained standing (MSDs), vibration and wet work (dermatitis) were these correct?*
F	10:20	*'those risks were correct at that time, but have changed with a change in process'*

What areas of risk have been addressed by significant changes in the processes used in the last five years, please provide examples where appropriate?

LM	10:22	*'what processes have changed and what risks have changed?'*
F	10:25	*'in general our processes have not changed over the last twenty years. The only process that has changed is in the type of concrete we use. We are using self compacting concrete as opposed to traditional grey concrete'*
LM	10:28	*'please explain how this process has reduced or eliminated risks?'*

F	10:29	*'we use self compacting concrete from about early 2004, it took 2 years to develop self compacting concrete for our products to get the colour etc, this has a major health and safety aspect, for starters its self compacting, it's discharged straight into the mould, so the chances of fatigue, tired, being worn out has gone completely. We have gone from four operatives around a mould to just two, there is no external vibration required, no poker vibration or hand held vibrators required, no vibration white finger, the noise from vibrating tables is eliminated. The self compacting concrete achieves higher strength and increased consistency'*

What areas of risk cannot be addressed and have to be managed, how are they managed?

LM	10:54	*'what risks cannot be addressed and have to be managed and how are they managed?'*
F	10:55	*'all other processes are exactly the same, everything is done by hand there is no other way of doing it'*
LM	10:59	*'what about pre-assembled reinforcement cages?'*
F	11:02	*'we tried that, but we could not achieve the tolerances and quality we require, even then somebody has to fabricate that'.*
LM	11:09	*'what about using steel moulds as opposed to timber'*
F	11:10	*'steel is more expensive and less adaptable, steel moulds are used when there is considerable repetition, our average repetition is about six, a timber mould can be used and adapted to suit the quality requirements our clients demand at a suitable cost'*

HASPREST

THE EFFECT OF PRE-ASSEMBLY AND STANDARDISATION ON HEALTH, SAFETY AND ACCIDENT CAUSALITY IN CONSTRUCTION

FULL SET OF TOOLKIT DATASHEETS

Loughborough University

Substructure- Excavation – Trenches or small shafts for drainage, services, utilities- max dimensions single pipe 1000mm x depth varies (All Sectors)
Main H& S Issues: Elimination of exposed trench wall, reduced manual handling,
These activities are based on insitu trench excavation and timbering, verses pre assembled shoring systems

Insitu trench supports				Pre assembled shoring			
Opinions/Evidence	**cf OSP**	**Main Hazards**	**Off-Site Activities**	**Off-Site Activities**	**Main Hazards**	**cf insitu**	**Opinions/Evidence**
Same for OSP factory		Transport, handling etc	Deliveries of base materials	Deliveries to factory	Transport, handling etc	LL	More organised as single delivery location
Ad hoc so likely to be harder to control	ML	Road traffic, plant	Transportation & delivery	Manufacture shoring system			Industrialised process – should be well managed – outside HASPREST scope
	ML	Manual handling	------ " -------	Transportation & delivery	Plant, craneage	C	More organised as fewer, larger deliveries
					Manual handling	LL	More likely to be mechanically handled
Opinions/Evidence	**cf OSP**	**Main Hazards**	**On-Site**	**On-Site & Transportation**	**Main Hazards**	**cf insitu**	**Opinions/Evidence**
	S	Plant, Working below ground level, vibration, Open holes, Manual handling etc.	Excavate trench	Excavate trench	Plant, Working below ground level, vibration, Open holes, Manual handling etc.	S	
Very heavy, difficult work	ML	confined spaces below ground, trench collapse, cuts, manual handling, frequent bending,	Install steel trench sheets, timbering, whaling & shoring	Position in trench	Mechanical handling	A	Most likely to be mechanically lifted into position
					Manual handling	LL	Less MH than insitu
Ad hoc shoring more hazardous	ML	Collapse of trench	Working in trench				
	S	Confined spaces	"	Working in trench	Collapse of trench	LL	trench collapse less likely with tried and tested shoring system
	S	MSDs, MH etc depending on operation	"	"	Confined spaces	S	
				"	MSDs, MH etc depending on operation	S	
More site labour required	ML	Various (See ConCA)	Ancillary site risks				
				Ancillary site risks	Various (See ConCA)	LL	Less site labour required

Risk change code (insitu>>pre-assembled):S = same (no change) R = Risk removed N = New risk LL = Less likely ML = More likely LC = less serious consequence MC = more serious consequence C = more controllable

Substructure- Inspection chambers for drainage or services (Commercial)
Activities based on in situ brick chambers verses pre-cast or UPVC chambers
Main H&S issues: Working below ground level, wet concrete, brickwork related MSDs, Dermatitis, Weils disease

Insitu chambers

Opinions/Evidence	cf OSP	Main Hazards	Off-Site Activities
Same for OSP factory		Transport, handling etc	Deliveries of base materials
Out of HASPREST scope			Manufacture of materials
More, ad hoc	LL	Road traffic	Transport to site

Opinions/Evidence	cf OSP	Hazards	On-Site Activities
More, ad hoc		MSDs, Manual handling	Deliveries to site
	S	Eg confined spaces, Plant, Vibration, Open holes, Manual handling etc	Excavation
	ML	confined spaces, Cuts, Manual handling, frequent bending	Install steel trench sheets Timbering, whaling or shoring
	ML	Dermatitis, Weils disease	Concrete base
	A	Confined spaces, Manual handling, MSDs, dermatitis	Brickwork to walls
Often not required with OSP solutions (eg not for UPVC)	A, ML	Dernatitis, weils disease	Haunching/benching
Not usually required with OSP solutions	A	Concrete burns, dermatitis	Insitu concrete to chamber top
	S	MSDs, manual handling	Install chamber access cover
	S	MSDs, manual handling	Backfill etc
More site labour	ML	Trips, falls, plant	Ancillary site risks

Pre-assembled chambers

Off-Site Activities	Main Hazards	cf insitu	Opinions/Evidence
Deliveries to factory	Transport	LL	More organised as single delivery location
Deliver materials and out-sourced sub-assemblies	Manual and mechanical handling	LL, C	More controllable as fixed factory location. Likely to be more mechanical handling
	Manufacturing process	LL, C	
chamber			
Prepare units for transportation	Craneage, mechanical handling	C	More controllable risks as in factory environment
Transportation	Road traffic	C	Fewer, larger loads
Delivery to site	Site access, craneage etc	C	Fewer, larger loads

On-Site Activities	Hazards	cf insitu	Opinions/Evidence
Excavation	confined spaces, Plant, Vibration, Open holes, Manual handling etc	S	
Concrete base	Dernatitis, weils disease	LL	Usually only blinding concrete needed – ie less work
Position chamber (UPVC)	Manual Handling	LC	Much lighter loads to manoeuvre
OR……… Position chamber rings (PC) in excavation	Craneage and MH (if large), crushing against excavation sides	A	
Haunching/benching (for PC only)	Confined spaces, dermatitis	S	Not needed for UPVC
Install PC chamber lid	Craneage and MH (if large), MH (if small)	A	
Install UPVC chamber lid	Various minor	A	Very light loads etc
Install chamber access cover	MSDs, manual handling	S	
	MSDs, manual handling	S	
	Trips falls etc	LL	Less site labour

Risk change code (insitu>>pre-assembled):S = same (no change) R = Risk removed N = New risk LL = Less likely ML = More likely LC = less serious consequence MC = more serious consequence C = more controllable

Substructure – Piling (Commercial)

These activities are based on insitu augured piles and insitu concrete pile caps/beams vs vibrated or driven pre-cast concrete piles and precast concrete pile caps/beams
Main H& S Issues: Elimination of pile top breakdown, elimination of wet concrete, reduction in manual handling (eg rebar)

Augured Piles

Comments	cf OSP	Main Hazards	Main Off-Site Activities
	S	Various but same as OSP factory	Delivery of base materials to ready-mix and rebar suppliers
	S	Various but same as OSP factory	Mix concrete at works
	A	Road traffic, site access, site conditions	Transport & deliver ready-mix concrete and rebar to site
	S	Road traffic, mechanical handling, offloading etc	Transport & deliver plant to site
Comments	**cf OSP**	**Main Hazards**	**Main On-Site Activities**
	S	Various but same as OSP	Prepare site for piling
	A	Contaminated spoil	Augur Hole
	S	Plant, vibration, plant maintenance on site	-----"------
	A	Dermatitis, concrete burns, concrete pumps & pipelines on uneven ground etc, clearing away concrete overspill, cleaning concrete from plant/pipelines	Place Concrete *(typically pumped to rig and placed into shaft via hollow augur)*
	A	Manual Handling, cuts etc	Place cage into concreted hole
	S	Plant, manual handling, contaminated ground etc.	Reduce ground level around pile (to suit pile cap level)
Major problem	A	HAVS, whole body vibration, slips, trips etc	Break down pile top (contaminated section*) Blinding concrete to pile cap
	A	*Dermatitis, concrete burns*	Formwork, rebar, concrete to pile cap/beam
	A	MSDs etc	Bend pile rebar into pile cap
	A	*Dermatitis, concrete burns*	Strike formwork to pile cap/beam
	S	Plant, manual handling, HAVS	Fill around pile cap to required level
Less site labour required	LL	Slips, trips falls, plant	Ancillary site risks

Pre-cast driven/vibrated piles

Main Off-Site Activities	Main Hazards	cf insitu	Comments
Delivery of base materials to factory	Various but same as for insitu	S	
Set up Moulds	Mechanical handling, craneage	A	
-----"------	Manual handling	A	
Reinforce, fix inserts etc	Mechanical handling, craneage	C	
-----"------	Manual handling	LL, C	
Mix concrete	Various but same as ready mix	S	
Place concrete	Craneage, dermatitis, MH, MSDs	LL, C	
Vibrate	HAVS, dermatitis	LL,C	
Form box-outs	MSDs, dermatitis	LL, C	
Finish top surface	MSDs, dermatitis	LL, C	
Remove/store	Mechanical handling, craneage	A, C	
Transport and deliver piles to site	Road traffic, mechanical handling, offloading etc	A	
Transport & deliver plant to site	Road traffic, mechanical handling, offloading etc	S	
Main On-Site Activities	**Main Hazards**	**cf insitu**	**Comments**
Prepare site for piling	Various but same as insitu	S	
Move piles to required position	Mechanical handling, manual handling, hand injuries, large loads	A	
Drive or vibrate pile to required depth	Plant, Vibration, hand injuries		
-----"------	Noise (especially for driven piles)		
Reduce ground level around pile (to suit pile cap level)	Plant, manual handling, contaminated ground etc.	S	
Place PC caps/beams	Craneage, manual handling, hand injuries	A	
Formwork around connections & install linking rebar	Dermatitis, concrete burns Dermatitis, concrete burns	LL	Much less than for insitu pile caps – should be straight forward
Concrete connection	Dermatitis, concrete burns	LL	Much less than for insitu pile caps – should be straight forward
	Dermatitis, concrete burns	LL	Much less than for insitu pile caps – should be straight forward
Fill around pile cap to required level	Plant, manual handling, HAVS	S	
Ancillary site risks	Slips, trips falls, plant)	LL	Less site labour

Note – OSP factory craneage usually overhead gantry crane vs insitu mobile (crawler) crane
Note – Choice between augured and driven may be dependant upon geotechnical considerations

Risk change code (insitu>>pre-assembled): S = same (no change) R = Risk removed A = Additional (new) risk LL = Less likely ML = More likely LC = less serious consequence MC = more serious consequence C = more controllable

Substructure – Pads (Commercial)

These activities are based on insitu concrete pad foundations vs Pre-Cast concrete pads

Main H& S Issues: Elimination of wet concrete, reduction in manual handling (eg rebar) less trade overlap

Insitu Pads

Comments	cf OSP	Main Hazards	Main Off-Site Activities
	S	Various but same as OSP factory	Delivery of base materials to ready-mix and rebar suppliers
	S	Various but same as OSP factory	Mix concrete at works
	A	Road traffic, site access, site conditions	Transport & deliver ready-mix concrete and rebar to site
	S	Road traffic, mechanical handling, offloading etc	Transport & deliver plant to site
Comments	**cf OSP**	**Main Hazards**	**Main On-Site Activities**
	S	Various but same as OSP	Prepare site for excavation
	A	Contaminated spoil	Excavate to formation
	S	Plant, see excavation	-----"------
		Concrete burns etc see Concrete	Blinding Concrete 50~75mm
		Cuts, MSDs, MH, RSI tying bars.	Place main reinforcement (both directions), place starter bar rebar for column or box outs for holding down bolts (Steel Column)
		Cuts, MH, HAVS (power tools), working below ground level, power tools.	Pad formwork, assume site made timber shutters)
	A	Craneage, skip or pump, dermatitis, concrete burns,	Place Concrete *(typically pumped to rig and placed into formwork)*
		HAVS, MSDs, MH	Vibrate pad concrete
	A	Manual Handling, cuts from nails, rough edges on ply etc, hand injuries etc.	Strike pad formwork/falsework
		MH, HAVS, MSDs, (eg float) COSHH (curing agent), MSD & slips Polythene to cure.	Finish pad
	S	MH, MSDs, COSHH (release agent),.	Refurbish all formwork
Less site labour required	LL	Slips, trips, falls	Ancillary site risks

Pre-cast pads

Main Off-Site Activities	Main Hazards	cf insitu	Comments
Delivery of base materials to factory	Various but same as for insitu	S	
Set up Moulds	Mechanical handling, craneage	A	Should be well organised with risks minimised.
-----"------	Manual handling	A	
Reinforce, fix inserts etc	Mechanical handling, craneage	C	Should be well organised with risks minimised.
	Manual handling	LL, C	Should be well organised with risks minimised.
Mix concrete	Various but same as ready mix	S	
Place concrete	Craneage, dermatitis, MH, MSDs	LL, C	Should be well organised with risks minimised.
Vibrate	HAVS, dermatitis	LL,C	Should be well organised with risks minimised.
Form box-outs	MSDs, dermatitis	LL, C	Should be well organised with risks minimised.
Finish top surface	MSDs, dermatitis	LL, C	Should be well organised with risks minimised.
	Mechanical handling, craneage	A, C	Should be well organised with risks minimised.
Transport and deliver pads to site	Road traffic, mechanical handling, offloading etc	A	
Transport & deliver plant to site	Road traffic, mechanical handling, offloading etc	S	
Main On-Site Activities	**Main Hazards**	**cf insitu**	**Comments**
Prepare site for pads	Various but same as insitu	S	
Move pads to required position	Craneage, Mechanical handling, manual handling, hand injuries, large loads	A.MC	Movement of PC Pads more serious consequence if load falls.
	Plant, hand injuries	LL, C	Controlled
	Plant, manual handling, contaminated ground etc.	S	
Prepare pads for column		S	
Rebar to starter bars for columns	Craneage, manual handling, hand injuries,	S,	
		LL	Much less than for insitu pile caps – should be straight forward
	Plant, manual handling, HAVS	S	
Ancillary site risks	Slips trips, falls	LL	Less site labour

Note – OSP factory craneage usually overhead gantry crane vs insitu mobile (crawler) crane

Note – Choice between augured and driven may be dependant upon geotechnical considerations

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Superstructure – Frame – insitu concrete V Steel columns/metal deck/conc..slab/PC slab (Commercial)

Main H&S issues, working at height, craneage, insitu concrete risks

Activities based on insitu columns, beams and slabs vs steel columns & beams with profiled metal deck/insitu concrete topped slabs *(additional option with precast concrete floor units*

Insitu Concrete

Opinions/Evidence	cf OSP	Main Hazards	Off-Site Activities
Industrialised process should be well organised with risks minimised		Various – but outside scope of HASPREST	Manufacture of base materials
Same for OSP factory		Transport, handling etc	Deliveries of base materials to ready-mix plant
Should be well organised with risks minimised		Various – but outside scope of HASPREST	Ready-mix concrete manufacture
More ad hoc deliveries	ML	Road traffic	Transport materials to site
More ad hoc deliveries	ML	Craneage, plant, access etc	Deliveries

Opinions/Evidence	cf OSP	Main Hazards	On-Site Activities
	S	Concrete burns, dermatitis	Ground floor concrete
	A	MH, MSDs, cuts, RSI tying bars	Place column rebar
Details depend on formwork design –crane-handled pre-formed systems reduce many of these risks	A	MH, MSDs, cuts, hand injuries, power tools, falls from height	Column formwork (assume site-made timber shutters)
	A	Craneage, skip (maybe pump), falls from height, dermatitis,	Place column concrete
	A	HAVS, MSDs, MH	Vibrate column concrete
	A	Material falling, cuts from nails etc, MSDs, MH	Strike column formwork
Details depend on falsework design –crane-handled pre-formed systems reduce many of these risks	A	MH, MSDs, hand injuries, material falling, falls from height	Slab/beam falsework
Details depend on formwork design –crane-handled pre-formed systems reduce many of these risks	A	MH, MSDs, cuts, hand injuries, falls from height, power tools	Slab/beam formwork
Access across slab rebar is particularly hazardous for all workers	A	MH, MSDs, cuts, RSI tying bars, trips, falls from height	Install slab/beam reinforcement
More slab concrete required cf steel frame/metal decking	ML	Pump – Plant, MH pipes, falls (knocked by pipe), dermatitis, blow-out (maybe crane/skip), clean out pipes	Place slab/beam concrete
More slab concrete required cf steel frame/metal decking	ML	Concrete – dermatitis, concrete burns, trips (on rebar), falls from height	“
More slab concrete required cf steel frame/metal decking	ML	HAVS, MSDs, MH, trips, falls from height	Vibrate slab/beam concrete
Same surface area as decking option, or PC slab topping	S	MH, MSDs, HAVS (if powerfloat), COSHH (curing agent), MSDs & slips (polythene to cure)	Finish slab concrete
No formwork required for metal decking option	A	Material falling, cuts from nails etc, MSDs, MH, falls from height	Strike slab/beam formwork
No formwork required for metal decking option	ML	MSDs, MH, COSHH (Release agent), cuts (scrapers)	Refurbish ALL formwork
Details depend on falsework design –crane-handled pre-formed systems reduce many of these risks		Material falling, MSDs, MH, falls from height	Move slab/beam formwork
More site labour required	ML	Slips, trips, falls.	Ancillary site risks

Steel

Off-Site Activities	Main Hazards	cf insitu	Opinions/Evidence
Deliveries of base materials	Transport, handling etc	S	Same for insitu
Rolling of structural steel beams , columns	Various – but outside scope of HASPREST	A	Industrialised process should be well organised with risks minimised
Manufacture of steel decking	Various – but outside scope of HASPREST	A	Industrialised process should be well organised with risks minimised
Ready-mix concrete manufacture	Various – but outside scope of HASPREST	LL	Should be well organised with risks minimised – less concrete required cf insitu
Manufacture PC slabs (OPTION)			
Transport steel (or PC) to site	Road traffic	LL	More organised deliveries
Transport ready-mix concrete to site	Road traffic	LL	Less concrete required cf insitu
Deliveries	Craneage, plant, access etc	LL	More organised deliveries

On-Site Activities	Main Hazards	cf insitu	Opinions/Evidence
Ground floor concrete	Concrete burns, dermatitis	S	
Cast-in ‘holding down’ / location bolts	Hand injuries, dermatitis	A	
Install columns	Craneage, MH, ‘struck-by’, trapped hand, power tools/HAVS (bolts), falls from height (upper floors only)	A	
Install beams	Craneage, MH, ‘struck-by’, trapped hand, power tools/HAVS (bolts), falls from height	A	Design to aid connections can significantly reduce many of these risks
Make connections	HAVS & noise (bolt power tools), falls from height, bolts dropped, MH/MSDs (adjust beam position), hand trap	A	Design to aid connections can significantly reduce many of these risks
PROFILED DECKING OPTION Place profiled metal deck	Craneage, MH, cuts, falls from height	A	Safe method for placing essential to prevent falls from height
Cut decking to size or around openings	Cuts, HAVS (power tools), fire (from sparks), falls from height	A	Risks can be removed if decking is pre-cut off-site, or reduced if done at ground level
‘shot-fire’ rivets to secure decking and edge trim etc	Power tools, noise, impact injury from ‘rivets’	A	
‘explosive’ weld shear studs to beams	Power tools, burns, fire from weld spatter	A	
Place concrete on decking	Pump – Plant, MH pipes, falls (knocked by pipe), dermatitis, blow-out (maybe crane/skip), clean out pipes	LL	Less concrete that insitu concrete option
PRECAST SLAB OPTION Place precast slabs	Craneage, ‘struck-by’, falls from height	A	
Formwork to connections, edges etc (fix and strike)	MH, MSDs, cuts, hand injuries, falls from height, power tools	LL	Much less formwork than insitu option
Concrete to connections	Craneage, skip, ‘struck-by’, falls from height, dermatitis	LL	Much less than insitu or metal deck options
Ancillary site risks	Slips, trips, falls.	LL	Less site labour than insitu

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Superstructure – Frame – Load Bearing Walls brick/block vs concrete panels (Residential)
Main H&S issues, working at height, craneage,
Activities based on insitu brickwork vs PC concrete load bearing panels

Brick/blocklayings				Pre-cast concrete panel			
Comments	**cf OSP**	**Main Hazards**	**Main Off-Site Activities**	**Main Off-Site Activities**	**Main Hazards**	**cf insitu**	**Comments**
	S	Various but same as OSP factory	Delivery of base materials to brick ready mix suppliers	Delivery of base materials to factory	Various but same as for insitu	S	
	S	Various but same as OSP factory	Mix clay place in moulds and fire bricks at works	Set up Moulds	Mechanical handling, craneage	S	
	A	Road traffic, site access, site conditions	Transport & deliver bricks and mortar to site				
	S	Road traffic, mechanical handling, offloading etc		Reinforce, fix inserts etc	Mechanical handling, craneage	A	
Comments	**cf OSP**	**Main Hazards**	**Main On-Site Activities**	Mix concrete	Various, same as ready mix	S	
	S	Concrete burns, dermatitis	Ground beam concrete	Place concrete	Craneage, dermatitis, MH, MSDs	C	
	S	Various but same as OSP	Prepare site for bricklaying	Vibrate	HAVS, dermatitis, whole body vibration	C, A	Large panels often result in whole body vibration during compaction.
			Set out corners	Form box-outs	MSDs, dermatitis	LL, C	
.	A	Repetitive tasks, MH, Cuts, Dermatitis, MSD, falling material, unstable ground, exposure to UV.	Transport bricks				
The use of a heightened level of set out pile of bricks and mortar decreases the workload for high brick rows	C in OSP	MH, falling material, unstable ground	Moving bricks/blocks to workface	Remove/store	Mechanical handling, craneage	A, MC	Consequence of panel fall or sling failure more series consequence.
	C in OSP	MH, MSD, working at height, overhead work, walking into objects or projections.	Erecting work platforms	Transport and deliver panels to site	Road traffic, mechanical handling, offloading etc	A, MC	Consequence of panel fall or sling failure more series consequence.)
	A	Dermatitis, breathing dust fumes, mortar splashes in eyes, rash allergies, exposure to UV .MH	Mix mortar	Transport & deliver plant to site	Road traffic, mechanical handling, offloading etc	A, MC	Mobile crane risks
					Main Hazards	**cf insitu**	**Comments**
	A	Struck by cut brick from saw, electric cutting equipment-electric shock, dust grit or brick splinters, noise, exposure to UV. MH	Brick cutting	Installation of foundations, ground floor slab	Concrete burns, dermatitis		
				Prepare site for panels	Various but same as insitu	S	
	A	Dermatitis, repetitive tasks, MSD, MH working at height	Laying mortar	Attach galvanised steel channel sections	Cuts, HAVS, (power tools), noise, impact injury		
				Move panels to required position	Mobile plant risks, hand injuries, large loads, craneage	A, MC	Hand injuries more serious
	A	Working at height, exposure to UV, MH, confined space work, Dermatitis, clearing away mortar overspill, cleaning mortar from tools.	Bricklaying	Prop and fix panels with base fixings, corner channels and T channels panel to panel	Plant, hand injuries, HAVS, (power tools), cuts.	A,	Hand injuries more serious
	A	Repetitive tasks, cuts splinters	Fix wall ties, mesh reinforcement place lintels & DPC	Erect work platform	Working at height, falls of materials	S, MC	Falling material: Insitu facings more serious consequence.
		Working at height, confined space, repetitive tasks, dermatitis	Pointing/finishing		MH, MSD, craneage, hand injuries	S, MC	Falling material: Insitu facings more serious consequence.
Less site labour required	LL	Slips, trips, falls	Ancillary site risks	Finishing		LL	Less finishing work required
				Ancillary site risks	Slips, trips, falls	LL	Less site labour

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Superstructure – Frame – Load Bearing Walls brick/block vs timber panels (Residential)
Main H&S issues, working at height, craneage,
Activities based on insitu brickwork vs timber load bearing panels

Brick/blocklayings				Timber panel			
Comments	**cf OSP**	**Main Hazards**	**Main Off-Site Activities**	**Main Off-Site Activities**	**Main Hazards**	**cf insitu**	**Comments**
	S	Various but same as OSP factory	Delivery of base materials to brick ready mix suppliers	Delivery of base materials to factory	Various but same as for insitu	S	
	S	Various but same as OSP factory	Mix clay place in moulds and fire bricks at works	Set out frames		S	
	A	Road traffic, site access, site conditions	Transport & deliver bricks and mortar to site	Fix frames	HAVS,(power tools), cuts, skin abrasion.	S	
	S	Road traffic, mechanical handling, offloading etc		Cut and fix ply sheets	Cuts, HAVS, (power tools)	S	
Comments	**cf OSP**	**Main Hazards**	**Main On-Site Activities**	Finish sheets	Various, same as ready mix	S	
	S	Concrete burns, dermatitis	Ground beam concrete				
	S	Various but same as OSP	Prepare site for bricklaying				
			Set out corners				
.	A	Repetitive tasks, MH, Cuts, Dermatitis, MSD, falling material, unstable ground, exposure to UV.	Transport bricks				
The use of a heightened level of set out pile of bricks and mortar decreases the workload for high brick rows	C in OSP	MH, falling material, unstable ground	Moving bricks/blocks to workface	Remove/store	Mechanical handling, craneage	A, MC	Consequence of panel fall or sling failure more series consequence.
	C in OSP	MH, MSD, working at height, overhead work, walking into objects or projections.	Erecting work platforms	Transport and deliver panels to site	Road traffic, mechanical handling, offloading etc	A, MC	Consequence of panel fall or sling failure more series consequence.)
	A	Dermatitis, breathing dust fumes, mortar splashes in eyes, rash allergies, exposure to UV .MH	Mix mortar	Transport & deliver plant to site	Road traffic, mechanical handling, offloading etc	A, MC	Mobile crane risks
					Main Hazards	**cf insitu**	**Comments**
					Concrete burns, dermatitis		
				ground floor slab			
	A	Struck by cut brick from saw, electric cutting equipment-electric shock, dust grit or brick splinters, noise, exposure to UV. MH	Brick cutting	Prepare site for panels	Various but same as insitu	S	
				Attach galvanised steel channel sections	Cuts, HAVS, (power tools), noise, impact injury		
	A	Dermatitis, repetitive tasks, MSD, MH working at height	Laying mortar	Move panels to required position	Mobile plant risks, hand injuries, large loads, craneage	A, MC	Hand injuries more serious
				Prop and fix panels with base fixings.	Plant, hand injuries, HAVS, (power tools), cuts.	A,	Hand injuries more serious
	A	Working at height, exposure to UV, MH, confined space work, Dermatitis, clearing away mortar overspill, cleaning mortar from tools	Bricklaying	Erect work platform	Working at height, falls of materials	S, MC	Falling material: Insitu facings more serious consequence.
	A	Repetitive tasks, cuts splinters	Fix wall ties, mesh reinforcement place lintels & DPC		MH, MSD, craneage, hand injuries	S, MC	Falling material: Insitu facings more serious consequence.
	C in OSP	Working at height, confined space, repetitive tasks, dermatitis	Pointing/finishing	Finishing		LL	Less finishing work required i.e. remedials
Less site labour required	LL	Slips, trips, falls	Ancillary site risks	Ancillary site risks	Slips, trips, falls	LL	Less site labour

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Superstructure – Frame – Insitu sloping roof frame vs timber trusses (Residential)
Main H&S issues, working at height, craneage,
Activities based on insitu sloping roof frame vs timber trusses

Insitu roof				Timber trusses			
Comments	**cf OSP**	**Main Hazards**	**Main Off-Site Activities**	**Main Off-Site Activities**	**Main Hazards**	**cf insitu**	**Comments**
	S	Various but same as for insitu	Delivery of base materials to factory	Delivery of base materials to factory	Various but same as for insitu	S	
						S	
					HAVS,(power tools), cuts, skin abrasion.	LL,C	
					Cuts, HAVS, (power tools), MH, MSDs,	LL,C	
				jack rafters and common rafters. Cut ceiling joists, wall plates			
Comments	**cf OSP**	**Main Hazards**	**Main On-Site Activities**	Machine and plane all members on both sides	Various but same as insitu	LL,C	
	S,	Cuts, HAVS, (power tools), MH, MSDs,	Cut rafters, ridge pieces, jack rafters and common rafters. Cut ceiling joists, wall plates	Arrange components in frame.	MH, MSDs, RSI (accurately positioning members)	A, C	
	S		Position wall plate	Position assembly in press			
		Mh, MSDs, RSI, working at height etc.	Erect access framework, scaffold etc	Position nail plates to all joints (both faces)			
		MH, MSDs, cuts, RSI, use of hand tools, or HAVS use of nail guns. Working at height, falling materials	Attach joists to wall plates, nail, members together	Press components together	MSDs, RSI (accurate position of nail plates)	A C	
	C in OSP	MH, falling material.	Moving rafters, purlins, ties etc	Remove/store	Mechanical handling, craneage	A, MC	Consequence of truss fall or sling failure more series consequence.
	C in OSP	MH, MSD, working at height, overhead work, walking into objects or projections.	Position and fix rafters ties and purlins etc	Transport and deliver trusses to site	Road traffic, mechanical handling, offloading etc	A, MC	Consequence of truss fall or sling failure more series consequence.)
				Transport & deliver plant to site	Road traffic, mechanical handling, offloading etc	A, MC	Mobile crane risks
					Main Hazards	**cf insitu**	**Comments**
Less site labour required	LL	Slips, trips, falls)	Ancillary site risks				
				Position wall plates	Various but same as insitu	S	
					Cuts, HAVS, (power tools), noise, impact injury	A	
				& Prop			
					Hand injuries, large loads, craneage	A, MC	Hand injuries more serious
					Plant, hand injuries, HAVS, (power tools), cuts.	A,	Hand injuries more serious
					Working at height, falls of materials	S, MC	Falling material.
					MH, MSD, craneage, hand injuries	S, MC	Falling material.
						LL	Less finishing work required
					Slips, trips, falls)	LL	Less site labour

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Superstructure – Frame – Insitu sloping roof frame vs steel trusses (Residential)
Main H&S issues, working at height, craneage,
Activities based on insitu sloping roof frame vs steel trusses

Insitu roof				Steel trusses			
Comments	**cf OSP**	**Main Hazards**	**Main Off-Site Activities**	**Main Off-Site Activities**	**Main Hazards**	**cf insitu**	**Comments**
	S	Various but same as for insitu	Delivery of base materials to factory	Delivery of base materials to factory	Various but same as for insitu	S	
						S	
					HAVS,(power tools), cuts, skin abrasion.	LL,C	
					Cuts, heavy cutting tools (press), MH, MSDs,	LL,C	
				gussets, capping pieces etc.			
Comments	**cf OSP**	**Main Hazards**	**Main On-Site Activities**	Machine and finish all cut edges.	Cuts, MH MSDs,	LL,C	
	S,	Cuts, HAVS, (power tools), MH, MSDs,	Cut rafters, ridge pieces, jack rafters and common rafters. Cut ceiling joists, wall plates	Arrange components in frame.	MH, MSDs, RSI (accurately positioning members)	A, C	
	S		Position wall plate	Weld components together	Burns, fumes, cuts, etc	LL, C	
		MH, MSDs, RSI, working at height etc.	Erect access framework, scaffold etc				
		MH, MSDs, cuts, RSI, use of hand tools, or HAVS use of nail guns. Working at height, falling materials	Attach joists to wall plates, nail, members together				
	C in OSP	MH, falling material.	Moving rafters, purlins, ties etc	Remove/store	Mechanical handling, craneage	A, MC	Consequence of truss fall or sling failure more series consequence.
	C in OSP	MH, MSDs, working at height, overhead work, walking into objects or projections.	Position and fix rafters ties and purlins etc	Transport and deliver trusses to site	Road traffic, mechanical handling, offloading etc	A, MC	Consequence of truss fall or sling failure more series consequence.)
				Transport & deliver plant to site	Road traffic, mechanical handling, offloading etc	A, MC	Mobile crane risks
					Main Hazards	**cf insitu**	**Comments**
Less site labour required	LL	Slips, trips, falls	Ancillary site risks	Erect work platform	Working at height, falls of materials	S, MC	Falling material: more serious consequence.
					Craneage etc	A	
				columns.	Cuts, HAVS, (power tools), noise, impact injury	A	
					Hand injuries, large loads.	A, MC	Hand injuries more serious
					Plant, hand injuries, HAVS, (power tools), cuts.	A,	Hand injuries more serious
						LL	Less finishing work required
					Slips, trips, falls	LL	Less site labour

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Cladding –heavy commercial (Commercial)
These activities are based on insitu brick/blockwork vs PC concrete backing panels and insitu facing
Main H& S Issues: working at height, craneage, reduction in manual handling (eg bricklaying)

Brick/blocklaying

Comments	cf OSP	Main Hazards	Main Off-Site Activities
	S	Various but same as OSP factory	Delivery of base materials to brick ready mix suppliers
	S	Various but same as OSP factory	Mix clay place in moulds and fire bricks at works
	A	Road traffic, site access, site conditions	Transport & deliver bricks and mortar to site
	S	Road traffic, mechanical handling, offloading etc	

Comments	cf OSP	Main Hazards	Main On-Site Activities
	S	Concrete burns, dermatitis	Ground beam concrete
	S	Various but same as OSP	Prepare site for bricklaying
.	A	Repetitive tasks, MH, Cuts, Dermatitis, MSD, falling material, unstable ground, exposure to UV.	Set out corners Transport bricks
The use of a heightened level of set out pile of bricks and mortar decreases the workload for high brick rows	C in OSP	MH, falling material, unstable ground	Moving bricks/blocks to workface
	C in OSP	MH, MSD, working at height, overhead work, walking into objects or projections.	Erecting work platforms
	A	Dermatitis, breathing dust fumes, mortar splashes in eyes, rash allergies, exposure to UV .MH	Mix mortar
	A	Struck by cut brick from saw, electric cutting equipment- electric shock, dust grit or brick splinters, noise, exposure to UV. MH	Brick cutting
	A	Dermatitis, repetitive tasks, MSD, MH working at height	Laying mortar
	A	Exposure to UV, MH, confined space work, Dermatitis, clearing away mortar overspill, cleaning mortar from tools	Bricklaying
	A	Repetitive tasks, cuts splinters	Fix wall ties, mesh reinforcement place lintels & DPC
	C in OSP	Working at height, confined space, repetitive tasks, dermatitis	Pointing/finishing
Less site labour required	LL	Slips, trips, falls	Ancillary site risks

Pre-cast concrete cladding panel

Main Off-Site Activities	Main Hazards	cf insitu	Comments
Delivery of base materials to factory	Various but same as for insitu	S	
Set up Moulds	Mechanical handling, craneage Joinery hazards, noise, machinery, wood dust	S	
Reinforce, fix inserts etc	Mechanical handling, craneage	A	
Mix concrete	Various but same as ready mix	S	
Place concrete	Craneage, dermatitis, MH, MSDs	C	Introduction of self compacting concrete reducing vibration requirement
Vibrate	HAVS, dermatitis, whole body vibration	C, A	Large panels often result in whole body vibration during compaction.
Form box-outs	MSDs, dermatitis	LL, C	
Remove/store	Mechanical handling, craneage	A, MC	Consequence of panel fall or sling failure more series consequence
Transport and deliver panels to site	Road traffic, mechanical handling, offloading craneage, working on lories at height	A, MC	Consequence of panel fall or sling failure more series consequence
Transport & deliver plant to site	fflooding site access for lorries	A, MC	Mobile crane risks

Main On-Site Activities	Main Hazards	cf insitu	Comments
Prepare site for panels	Various but same as insitu	S	Panels delivered on lorry and craned direct from lorry to in-situ position.
Erect work platform	Working at height, falls of materials	S, MC	Falling material: Insitu facings more serious consequence. Often working off completed floor slabs with good harness points, and edge protection.
position	Mobile plant risks, hand injuries, large loads	A, MC	Hand injuries more serious
Transport facings to workface	MH, MSD, craneage, hand injuries	S, MC	Falling material: Insitu facings more serious consequence.
Connect panel to frame	Plant, hand injuries	A,	Hand injuries more serious
Finishing		LL	Less finishing work required

Note – Pre cast cladding backing panels with insitu facings (facings can be manually handled)

Risk change code (insitu>>pre-assembled): S = same (no change) R = Risk removed A = Additional (new) risk LL = Less likely ML = More likely LC = less serious consequence MC = more serious consequence C = more controllable

Cladding –heavy commercial face Finished (Commercial)

These activities are based on insitu brick/blockwork vs PC concrete face finished panels

Main H& S Issues: working at height, craneage, reduction in manual handling (eg bricklaying)

Brick/blocklayings

Comments	cf OSP	Main Hazards	Main Off-Site Activities
	S	Various but same as OSP factory	Delivery of base materials to brick ready mix suppliers
	S	Various but same as OSP factory	Mix clay place in moulds and fire bricks at works
	A	Road traffic, site access, site conditions	Transport & deliver bricks and mortar to site
	S	Road traffic, mechanical handling, offloading etc	
Comments	**cf OSP**	**Main Hazards**	**Main On-Site Activities**
	S	Concrete burns, dermatitis	Ground beam concrete
	S	Various but same as OSP	Prepare site for bricklaying
			Set out corners
.	A	Repetitive tasks, MH, Cuts, Dermatitis, MSD, falling material, unstable ground, exposure to UV.	Transport bricks
The use of a heightened level of set out pile of bricks and mortar decreases the workload for high brick rows	C in OSP	MH, falling material, unstable ground	Moving bricks/blocks to workface
	C in OSP	MH, MSD, working at height, overhead work, walking into objects or projections.	Erecting work platforms
	A	Dermatitis, breathing dust fumes, mortar splashes in eyes, rash allergies, exposure to UV .MH	Mix mortar
	A	Struck by cut brick from saw, electric cutting equipment- electric shock, dust grit or brick splinters, noise, exposure to UV. MH	Brick cutting
	A	Dermatitis, repetitive tasks, MSD, MH working at height	Laying mortar
	A	Working at height, exposure to UV, MH, confined space work, Dermatitis, clearing away mortar overspill, cleaning mortar from tools	Bricklaying
	A	Repetitive tasks, cuts splinters	Fix wall ties, mesh reinforcement place lintels & DPC
	C in OSP	Working at height, confined space, repetitive tasks, dermatitis	Pointing/finishing
More site labour required	ML	Slips, trips, falls	Ancillary site risks

Pre-cast concrete cladding panel Face Finished

Main Off-Site Activities	Main Hazards	cf insitu	Comments
Delivery of base materials to factory	Various but same as for insitu	S	
Set up Moulds	Mechanical handling, craneage	S	
Place slips or Architectural finish	Cuts, dermatitis, MH	LL, C	
Reinforce, fix inserts etc	Mechanical handling, craneage	A	
Mix concrete	Various but same as ready mix	S	
Place concrete	Craneage, dermatitis, MH, MSDs	C	
Vibrate	HAVS, dermatitis, whole body vibration	C, A	Large panels often result in whole body vibration during compaction. (See Trent)
Form box-outs	MSDs, dermatitis	LL, C	
Remove/store	Mechanical handling, craneage	A, MC	Consequence of panel fall or sling failure more series consequence (ref Trent)
Transport and deliver panels to site	Road traffic, mechanical handling, offloading etc	A, MC	Consequence of panel fall or sling failure more series consequence (ref Trent)
Transport & deliver plant to site	Road traffic, mechanical handling, offloading etc	A, MC	Mobile crane risks
Main On-Site Activities	**Main Hazards**	**cf insitu**	**Comments**
Prepare site for panels	Various but same as insitu	S	Design could allow for internal working. Therefore no external access required.
Move panels to required position	Mobile plant risks, hand injuries, large loads	A, MC	Hand injuries more serious (Ref. Trent)
Connect panel to frame	Plant, hand injuries	A,	Hand injuries more serious (Ref. Trent)
Jointing in Mastics			
Finishing		LL	Less finishing work required
Ancillary site risks	Slips, trips, falls	LL	Less site labour

Note – Pre cast cladding finished panels

Risk change code (insitu>>pre-assembled): S = same (no change) R = Risk removed A = Additional (new) risk LL = Less likely ML = More likely LC = less serious consequence MC = more serious consequence C = more controllable

Cladding – Light commercial A (Commercial)

These activities are based on insitu stick curtain wall vs Unitised curtain wall

Main H& S Issues: Reduction in working at height, craneage, reduction in manual handling reduced need to work in exposed areas, avoid site handling of glass, avoids use of scaffolding

Stick system				Unitised panel system			
Comments	**cf OSP**	**Main Hazards**	**Main Off-Site Activities**	**Main Off-Site Activities**	**Main Hazards**	**cf insitu**	**Comments**
	S	Various but same as OSP factory	Delivery of base materials (aluminium) to suppliers	Delivery of base materials (aluminium) to suppliers	Various but same as for insitu	S	
	S	Various but same as OSP factory	Extrusion of aluminium framing channels and sections	Extrusion of aluminium framing channels and sections	Mechanical handling, craneage	S	
	S	Dust, fumes, hazardous substances	Anodising or powder coating of sections	Anodising or powder coating of sections	Dust, fumes, hazardous substances	S	
	S	Cuts, MH, MSD	Manufacture of panel or glazing elements	Manufacture of panel and /or glazing elements	Cuts, MH, MSD	S	
				welding, mechanical fixing channel framed unit.		A, C	
	S	Road traffic, mechanical handling, offloading etc	Finish & store sections/elements.	Transport & deliver panels to site	Mechanical handling, craneage Site access, road traffic, site conditions.	A	
Comments	**cf OSP**	**Main Hazards**	**Main On-Site Activities**	**Main On-Site Activities**	**Main Hazards**	**cf insitu**	**Comments**
	S	Road traffic mechanical handling site access site condition off loading	Transport & deliver sections/elements and infill panels to site	Transport & delivery of units to site	Craneage, MH and mobile plant	S	
	R	Working at height, MH, MSD.	Erection of work platform	Transport and delivery of plant (mechanical handling) device to site	Road traffic , mechanical handling, offloading	A	
	LL	Fall of materials. MH MSD, cuts	Transfer of components to the workface, mullions transoms and panel, glazing elements.	Prepare floor surface and set up plant on site.	MH	A	Avoids the need for working at height when installing the panels as all the installation work is carried out internally, from behind the edge protection handrail and not off the scaffold.
	R	MH, HAVS, cuts Working at height	Fix brackets to floor slab.	Fix brackets to floor slab	MH, HAVS	A	Reduces the likelihood of accidents resulting from falling objects dropped by site installers as the panels have been assembled using OSP and are not reliant on site assembly.
	R	MH HAVS cuts Working at height	Fix Mullions to brackets	Position Unitised panel on mechanical handling device	MH, plant etc	A	
	R	MH, HAVS cuts Working at height	Fix transoms to mullions	Manoeuvre unitised panel on to the dowels/brackets, and fix panel to brackets	Mobile plant, MH,	A	Reduces the hazard of site operatives working under or gaining site access from cladding installers working overhead, on scaffolding or associated mechanical access equipment.
	R	MH, HAVS, cuts Working at height	Fix panels/glazing to Mullions/transoms. Apply mastic sealant.	Apply gasket seal to unitised panel	cuts	A	
Less site labour	LL	Slips, trips, falls.	Ancillary site risks	Ancillary site risks	Slips, trips, falls	LL	Less site labour

Risk change code (insitu>>pre-assembled): S = same (no change) R = Risk removed A = Additional (new) risk LL = Less likely ML = More likely LC = less serious consequence MC = more serious consequence C = more controllable

Cladding – Light commercial B (Commercial)

These activities are based on insitu stick curtain wall vs Panellised curtain wall

Main H& S Issues: Reduction in working at height, craneage, reduction in manual handling reduced need to work in exposed areas, avoid site handling of glass, avoids use of scaffolding

Stick system				Panellised system			
Comments	**cf OSP**	**Main Hazards**	**Main Off-Site Activities**	**Main Off-Site Activities**	**Main Hazards**	**cf insitu**	**Comments**
	S	Various but same as OSP factory	Delivery of base materials (aluminium) to suppliers	Delivery of base materials (aluminium) to suppliers	Various but same as for insitu	S	
	S	Various but same as OSP factory	Extrusion of aluminium framing channels and sections	Extrusion of aluminium framing channels and sections	Mechanical handling, craneage	S	
	S	Dust, fumes, hazardous substances	Anodising or powder coating of sections	Anodising or powder coating of sections	Dust, fumes, hazardous substances	S	
	S	Cuts, MH, MSD	Manufacture of panel or glazing elements	Manufacture of panel and /or glazing elements	Cuts, MH, MSD	S	
						A, C	
				welding, mechanical fixing			
				channel			
				framed unit.			
	S	Road traffic, mechanical handling, offloading etc	Finish & store sections/elements.	Transport & deliver panels to site	Mechanical handling, craneage Site access, road traffic, site conditions.	A	
Comments	**cf OSP**	**Main Hazards**	**Main On-Site Activities**	**Main On-Site Activities**	**Main Hazards**	**cf insitu**	**Comments**
	S	Road traffic mechanical handling site access site condition off loading	Transport & deliver sections/elements and infill panels to site	Transport & delivery of units to site	Craneage, MH and mobile plant	S	
	R	Working at height, MH, MSD.	Erection of work platform	Transport and delivery of plant (mechanical handling) device to site	Road traffic , mechanical handling, offloading	A	
	LL	Fall of materials. MH MSD, cuts	Transfer of components to the workface, mullions transoms and panel, glazing elements.	Prepare floor surface and set up plant on site.	MH	A	Avoids the need for working at height when installing the panels as all the installation work is carried out internally, from behind the edge protection handrail and not off the scaffold.
	R	MH, HAVS, cuts Working at height	Fix brackets to floor slab.	Fix brackets to floor slab	MH, HAVS	A	Reduces the likelihood of accidents resulting from falling objects dropped by site installers as the panels have been assembled using OSP and are not reliant on site assembly.
	R	MH HAVS cuts Working at height	Fix Mullions to brackets	Position Unitised panel on mechanical handling device	MH, plant etc	A	
	R	MH, HAVS cuts Working at height	Fix transoms to mullions	Manoeuvre unitised panel on to the dowels/brackets, and fix panel to brackets	Mobile plant, MH,	A	Reduces the hazard of site operatives working under or gaining site access from cladding installers working overhead, on scaffolding or associated mechanical access equipment.
	R	MH, HAVS, cuts Working at height	Fix panels/glazing to Mullions/transoms. Apply mastic sealant.	Apply gasket seal to unitised panel	cuts	A	
Less site labour	LL	Slips, trips, falls	Ancillary site risks	Ancillary site risks	Slips, trips, falls	LL	Less site labour

Risk change code (insitu>>pre-assembled): S = same (no change) R = Risk removed A = Additional (new) risk LL = Less likely ML = More likely LC = less serious consequence MC = more serious consequence C = more controllable

Cladding – Light Industrial (Commercial)
These activities are based on built up sheets vs composite panels cladding
Main H& S Issues: craneage, reduction in risk of falling through “liner” during installation

Built up sheets				Composite Panels			
Comments	**cf OSP**	**Main Hazards**	**Main Off-Site Activities**	**Main Off-Site Activities**	**Main Hazards**	**cf insitu**	**Comments**
	S	Various but same as OSP factory	Delivery of base materials (aluminium) to suppliers	Delivery of base materials (aluminium) to suppliers	Various but same as for insitu	S	
	S	Various but same as OSP factory	Mould/press liner	Mould/press liner	Mechanical handling, craneage	S	
	S	Dust, fumes, hazardous substances	Mould/press insulation	Mould/press insulation	Dust, fumes, hazardous substances	S	
	S	Cuts, MH, MSD	Stamp Z purlins	Press top sheet	Cuts, MH, MSD	S	
	S	Cuts, MH, MSD	Press top sheet	Bond sheets together	Fumes, allergies etc	A, C	
	S	MH, HAVS	Finish & store separate sheets	Finishing	MH, HAVS	S	
	S	MH,	Transport & store	Transport and store	MH	S	
	S	Road traffic, mechanical handling, offloading etc	Transport individual sheets to site	Transport panels to site	Mechanical handling, craneage Site access , road traffic, site conditions.	S	
Comments	**cf OSP**	**Main Hazards**	**Main On-Site Activities**	**Main On-Site Activities**	**Main Hazards**	**cf insitu**	**Comments**
	S	Road traffic mechanical handling site access site condition off loading	Deliver individual sheets to site	Delivery of composite panels to site	Craneage, MH and mobile plant site access site condition off loading	S	
	S	Road traffic , mechanical handling, offloading.	Transport and delivery of plant (mechanical handling & Access) device to site	Transport and delivery of plant (mechanical handling & Access) device to site	Road traffic , mechanical handling, offloading	S	
	LL	Fall of materials. MH MSD, cuts	Transfer of components to the workface, liners, insulation spacer bars and top sheets and purlins.	Position composite panel on frame	MH	A	
Risk of fall through liner sheets during installation.	R	MH, HAVS, cuts Working at height	Fix liner sheets to frame.	Attach composite panel to framework	MH, HAVS	A	
	R	MH HAVS cuts Working at height	Fix “Mini Z” purlins to frame	Apply gasket sealant	MH		
	R	MH, HAVS cuts Working at height	Fix insulation and fasten top sheets to “mini Z” purlins	Position adjacent panel, butt and attach to panel/frame	MH, HAVS	A	
Less labour required	LL		Ancillary site risks	Ancillary site risks		LL	Less labour required

Note – Built up sheets Liner Insulation spacer bars and top sheets with “mini Z” purlin system.

Risk change code (insitu>>pre-assembled): S = same (no change) R = Risk removed A = Additional (new) risk LL = Less likely ML = More likely LC = less serious consequence MC = more serious consequence C = more controllable

Roofing (Industrial)

These activities are based on asphalt / bitumen vs composite panels for roofing
Main H& S Issues: craneage, reduction in risk of falling through "liner" during installation

Asphalt / bitumen				Composite Panels			
Comments	**cf OSP**	**Main Hazards**	**Main Off-Site Activities**	**Main Off-Site Activities**	**Main Hazards**	**cf insitu**	**Comments**
	S	Various but same as OSP factory	Delivery of base materials to suppliers	Delivery of base materials (aluminium) to suppliers	Various but same as for insitu	S	
	S	Various but same as OSP factory		Mould/press liner	Mechanical handling, craneage	S	
	S	Dust, fumes, hazardous substances	Addition of polymers to asphalt	Mould/press insulation	Dust, fumes, hazardous substances	S	
				Press top sheet	Cuts, MH, MSD	S	
					Fumes, allergies etc	A, C	
					MH, HAVS	S	
	S	MH,	Transport & store	Transport and store	MH	S	
	S	Road traffic, mechanical handling, offloading etc	Transport individual sheets to site	Transport panels to site	Mechanical handling, craneage	S	
					Site access , road traffic, site conditions.		
Comments	**cf OSP**	**Main Hazards**	**Main On-Site Activities**	**Main On-Site Activities**	**Main Hazards**	**cf insitu**	**Comments**
	S	Road traffic mechanical handling site access site condition off loading	Deliver solid blocks of mastic asphalt to site	Delivery of composite panels to site	Craneage, MH and mobile plant site access site condition off loading	S	
	S	Road traffic , mechanical handling, offloading.	Transport and delivery of plant (mechanical handling & Access) device to site	Transport and delivery of plant (mechanical handling & Access) device to site	Road traffic , mechanical handling, offloading	S	
	LL	Fall of materials. MH MSD, cuts	Transfer of components to the workface, bulk asphalt, insulation spacer bars.	Position composite panel on frame	MH	A	
Risk of fall through liner sheets during installation.	R	MH, HAVS, cuts Working at height	Fix sheathing felt to roof.	Attach composite panel to framework	MH, HAVS	A	
	R	MH HAVS cuts Working at height, burns , heat falls of hot asphalt, fire fumes etc.RSI,	Heat mastic asphalt, apply two coats at 20mm	Apply gasket sealant	MH		
	R	MH, HAVS cuts Working at height	Apply reflective mineral chippings.	Position adjacent panel, butt and attach to panel/frame	MH, HAVS	A	
Less labour required	LL		Ancillary site risks	Ancillary site risks		LL	Less labour required

Risk change code (insitu>>pre-assembled): S = same (no change) R = Risk removed A = Additional (new) risk LL = Less likely ML = More likely LC = less serious consequence MC = more serious consequence C = more controllable

Roofing (Industrial)

These activities are based on built up sheets vs composite panels for roofing
Main H& S Issues: craneage, reduction in risk of falling through “liner” during installation

Built up sheets				Composite Panels			
Comments	**cf OSP**	**Main Hazards**	**Main Off-Site Activities**	**Main Off-Site Activities**	**Main Hazards**	**cf insitu**	**Comments**
	S	Various but same as OSP factory	Delivery of base materials (aluminium) to suppliers	Delivery of base materials (aluminium) to suppliers	Various but same as for insitu	S	
	S	Various but same as OSP factory	Mould/press liner	Mould/press liner	Mechanical handling, craneage	S	
	S	Dust, fumes, hazardous substances	Mould/press insulation	Mould/press insulation	Dust, fumes, hazardous substances	S	
	S	Cuts, MH, MSD	Stamp Z purlins	Press top sheet	Cuts, MH, MSD	S	
	S	Cuts, MH, MSD	Press top sheet	Bond sheets together	Fumes, allergies etc	A, C	
	S	MH, HAVS	Finish & store separate sheets	Finishing	MH, HAVS	S	
	S	MH,	Transport & store	Transport and store	MH	S	
	S	Road traffic, mechanical handling, offloading etc	Transport individual sheets to site	Transport panels to site	Mechanical handling, craneage Site access , road traffic, site conditions.	S	
Comments	**cf OSP**	**Main Hazards**	**Main On-Site Activities**	**Main On-Site Activities**	**Main Hazards**	**cf insitu**	**Comments**
	S	Road traffic mechanical handling site access site condition off loading	Deliver individual sheets to site	Delivery of composite panels to site	Craneage, MH and mobile plant site access site condition off loading	S	
	S	Road traffic , mechanical handling, offloading.	Transport and delivery of plant (mechanical handling & Access) device to site	Transport and delivery of plant (mechanical handling & Access) device to site	Road traffic , mechanical handling, offloading	S	
	LL	Fall of materials. MH MSD, cuts	Transfer of components to the workface, liners, insulation spacer bars and top sheets and purlins.	Position composite panel on frame	MH	A	
Risk of fall through liner sheets during installation.	R	MH, HAVS, cuts Working at height	Fix liner sheets to frame.	Attach composite panel to framework	MH, HAVS	A	
	R	MH HAVS cuts Working at height	Fix “Mini Z” purlins to frame	Apply gasket sealant	MH		
	R	MH, HAVS cuts Working at height	Fix insulation and fasten top sheets to “mini Z” purlins	Position adjacent panel, butt and attach to panel/frame	MH, HAVS	A	
Less labour required	LL		Ancillary site risks	Ancillary site risks		LL	Less labour required

Note – Built up sheets Liner Insulation spacer bars and top sheets with “mini Z” purlin system.

Risk change code (insitu>>pre-assembled): S = same (no change) R = Risk removed A = Additional (new) risk LL = Less likely ML = More likely LC = less serious consequence MC = more serious consequence C = more controllable

Roofing (Industrial)

These activities are based on a tiles or, slate roof vs a pre assembled roof.
Main H& S Issues: craneage, working at height, MSD, MH

Tiles and Slates				Pre Assembled roofs			
Comments	**cf OSP**	**Main Hazards**	**Main Off-Site Activities**	**Main Off-Site Activities**	**Main Hazards**	**cf insitu**	**Comments**
	S	Various but same as OSP factory	Delivery of base materials (natural stone / fibre cement / crushed slate with resin binder) to suppliers	Delivery of base materials to suppliers	Various but same as for insitu	S	
	LL	MH, cuts	Mould/press tiles	Construct laths, insulation, lining and laminated soffit	MH, MSD	A, C	
	S	Dust, splinters	Split/Cut stone along planes of cleavage	Form vents, roof lights and primer for guttering	MH, MSD HAVS	A, C	
		MH, MSD, HAVS, cuts	Construction of timber truss frames				
	S	MH, HAVS	Finish & store slates/tiles	Finishing	MH, HAVS	S	
	S	MH,	Transport & store	Transport and store	MH	S	
	S	Road traffic, mechanical handling, offloading etc	Transport slates/tiles to site	Transport roof frames to site	Mechanical handling, craneage Site access , road traffic, site conditions.	S	
Comments	**cf OSP**	**Main Hazards**	**Main On-Site Activities**	**Main On-Site Activities**	**Main Hazards**	**cf insitu**	**Comments**
	S	Road traffic mechanical handling site access site condition off loading	Deliver slates to site	Delivery of roofing frames to site	Craneage, MH and mobile plant site access site condition off loading	S	
	S	Road traffic , mechanical handling, offloading.	Erection of work platform	Transport and delivery of plant (mechanical handling) device to site	Road traffic , mechanical handling, offloading	S	
	S	MH, Craneage	Installation of Truss frame	Position roof frame to eaves wall plate	MH, Craneage	S	
	LL, C	Breathing fibres, skin allergies	Lay Underlay/insulation	Fix roof frame to eaves	MH, MSD, cuts HAVS		
	LL, C	MH, MSD cuts, splinters working at height	Attach tiling battens to truss/rafter				
	S	Fall of materials. MH MSD, cuts, working at height	Transfer of slates, tiles to the workface, slates.	Transfer of slates/tiles to workface	MH	S	
	R	MH, HAVS, cuts Working at height	Position fix tiles, slates	Position fix tiles to frame	MH, HAVS, working at height	S	
						A	
Less labour required	LL		Ancillary site risks	Ancillary site risks		LL	Less labour required

Note – Traditional slate/tile construction.
Note – Prefabricated timber hinged roof elements

Risk change code (insitu>>pre-assembled): S = same (no change) R = Risk removed A = Additional (new) risk LL = Less likely ML = More likely LC = less serious consequence MC = more serious consequence C = more controllable

Internals – Partitions (Commercial)

Activities based on insitu drylining partitions verses demountable partition systems

Main H&S issues: manual handling, cuts, work in congested space

Insitu drylining partitions

Opinions/Evidence	cf OSP	Hazards	Off-Site Activities
Same for OSP factory		Transport, handling etc	Deliveries of base materials
Industrialised process – should be well managed		COSHH	Manufacture of plasterboard sheets
Industrialised process – should be well managed		Cuts	Manufacture of steel studs
Ad hoc so likely to be harder to control	ML	Road traffic, plant	Transportation & delivery
	ML	Manual handling	Transportation & delivery

Opinions/Evidence	cf OSP	Hazards	On-Site Activities
Site cutting/bending of studs	ML	Cuts	Install framework
Connecting studs (Power tools)	ML	Vibration (HAVS)	Install framework
Working near openings	ML	Open holes in building	Install framework
	ML	Manual handling etc	Install framework
	ML	Pulling cables though sharp holes in studs	1^{st} fix electrical etc
	ML	Manual handling	Install plasterboard
	ML	Cuts	Install plasterboard
Operation not needed in pre-ass systems	A	Cuts	Cut openings for sockets etc
Operation not needed in pre-ass systems	A	COSHH	Tape and joint
	ML	Cuts	2^{nd} fix electrical
Sharp edges etc	A	Cuts	Remove rubbish
	A	Manual handling	Remove rubbish
More people on site	ML	Slips, trips, falls	Ancillary site risks

Demountable Partitions

Off-Site Activities	Hazards	cf insitu	Opinions/Evidence
Deliveries to factory	Transport	LL	More organised as single delivery location
Deliveries to factory	Manual Handling	LL, C	
	Manual Handling	LL, C	Factory environment – more mechanical handling
	Cuts etc	C	Potential for improved practice / better training etc
Construct panels	COSHH hazards	C	Depends on materials used – easier to control
Finish panels	COSHH hazards		
Fabricate support framework	Cuts etc	C	Potential for improved practice / better training etc
Fabricate support framework	Machinery	C	Potential for improved practice / better training etc
Remove/store	Manual handling	LL, C	Probably using forklift etc
Transportation & delivery	Plant, craneage	C	More organised as fewer, larger deliveries
Transportation & delivery	Manual handling	LL	More likely to be mechanically handled

On-Site Activities	Hazards	cf insitu	Opinions/Evidence
Handle unit	Manual Handling	LL ML	Probably more mechanical handling – more thought as more expensive 'special' panels cf ubiquitous plasterboard But panels may be heavier
Fix wall / ceiling channels & posts	Manual handling	LL	Probably less ad hoc than drylining
Fix wall / ceiling channels & posts	Power tools (HAVS etc)	S	Little difference
Fix panel	Manual handling	LL	Should be better system – less ad hoc Insitu patching/make-ups
Fix panel	Power tools (HAVS etc)	LL, S	MAY be alternative fixings reducing power tools
	Cuts, MH, MSD's	LL, C	Likely to be less ad hoc as have to be 'designed-in'
		R	Socket holes pre-formed- risk removed: But pre-planned service holes invariably in wrong positions have to be cut anyway.
	Skin allergies	S	No significant change from insitu
	Slips, trips, falls	RL	Less people on site, fewer ad hoc activities

Risk change code (insitu>>pre-assembled): S = same (no change) R = Risk removed LL = Less likely ML = More likely LC = less serious consequence MC = more serious consequence C = more controllable

Internals - Suspended Ceilings (Commercial)

Activities based on insitu plasterboard suspended ceilings verses suspended ceiling systems
Main H&S issues: manual handling, cuts, work in congested space overhead work

Insitu plasterboard suspended ceiling

Opinions/Evidence	cf OSP	Hazards	Off-Site Activities
Same for OSP factory		Transport, handling etc	Deliveries of base materials
Industrialised process – should be well managed		COSHH	Manufacture of plasterboard sheets
Industrialised process – should be well managed		Cuts etc	Manufacture of mild steel fast hangers
Ad hoc so likely to be harder to control	ML	Road traffic, plant	Transportation & delivery
	ML	Manual handling	Transportation & delivery

Opinions/Evidence	cf OSP	Hazards	On-Site Activities
Site cutting/bending of studs	ML	Cuts	Install framework
Connecting studs (Power tools)	ML	Vibration (HAVS)	Install framework
			Install framework
	ML	Manual handling etc	Install framework
	ML	Pulling cables though sharp holes in studs	1st fix electrical etc
Inhaling dust from cut plasterboard	ML	Manual handling	Install plasterboard
	ML	Cuts	Install plasterboard
Operation not needed in pre-ass systems	A	Cuts	Cut openings for sockets etc
Operation not needed in pre-ass systems	A	COSHH	Tape and joint
	ML	Cuts etc	2nd fix electrical
Sharp edges etc	A	Cuts	Remove rubbish
	A	Manual handling	Remove rubbish
More people on site	ML	Slips, trips, falls	Ancillary site risks

Suspended Ceiling System

Off-Site Activities	Hazards	cf insitu	Opinions/Evidence
Deliveries to factory	Transport	LL	More organised as single delivery location
Deliveries to factory	Manual Handling	LL, C	
	Manual Handling	LL, C	Factory environment – more mechanical handling
	Cuts etc	C	Potential for improved practice / better training etc
Mould and press ceiling tiles	COSHH hazards	C	Depends on materials used – easier to control
Finish panels Trim excess "fins" etc	Cuts, COSHH		
Fabricate support framework	Cuts etc	C	Potential for improved practice / better training etc
Fabricate support framework	Machinery	C	Potential for improved practice / better training etc
Remove/store	Manual handling	LL, C	Probably using forklift etc
Transportation & delivery	Plant, craneage	C	More organised as fewer, larger deliveries
Transportation & delivery	Manual handling	LL	More likely to be mechanically handled

On-Site Activities	Hazards	cf insitu	Opinions/Evidence
Handle unit	Manual Handling	LL ML	Probably more mechanical handling – more thought as more expensive 'special' panels cf ubiquitous plasterboard But panels may be heavier
Fix ceiling channels & hangers	Manual handling	S	Probably less ad hoc than drylining
Fix ceiling channels & hangers	Power tools (HAVS etc)	S	Little difference
Fix panel	Manual handling	LL	Should be better system – less ad hoc
Fix panel	Power tools (HAVS etc)	LL, S	MAY be alternative fixings reducing power tools
	Cuts, power tools	LL, C	Likely to be less ad hoc as have to be 'designed-in'
		R	Socket holes pre-formed - risk removed
	Paint, COSHH	S	No significant change from insitu
	Slips, trips, falls	RL	Less people on site, fewer ad hoc activities

Risk change code (insitu>>pre-assembled): S = same (no change) R = Risk removed LL = Less likely ML = More likely LC = less serious consequence MC = more serious consequence C = more controllable

Mechanical Services Source (Commercial)

Activities based on site installation of mechanical services verses a mechanical source module / packaged plant room
Main H&S issues: crouching, congested/restricted space work, wet work, interaction of trades, material handling, hot work

Site Installation of Mechanical Services

Opinions/Evidence		Main Hazards	Off Site Activities
Industrialised processes – outside HASPREST scope		Industrialised processes – outside the scope of this project	Manufacture of materials and fittings etc
Ad hoc		Road traffic etc	Transport
Ad hoc – often poorly controlled	ML	Manual handling etc	Delivery
Opinions/Evidence		**Main Hazards**	**On Site Activities**
	A	Manual handling materials, MSDs, bending, cleaning area	Prepare site for plant and services.
Plinths may be insitu concrete, or steel truss/frames	A	Manual handling materials, MSDs, crouching, bending, dermatitis	Plinths / up-stands for pumps, pressure vessels, brackets for pipe-work, control panels and switchgear.
	ML	MSDs, work overhead, step ladders, dermatitis	Fix cable trays, services conduits
	ML	Power tools, cuts, crouching, bending, congested work areas, craneage/mechanical handling (depending on size of plant)	Install pumps, pipe-work, pressure vessels and control panels to plinths, align and secure
	ML	Manual handling materials, MSDs, crouching, bending, restricted work areas.	Install
Removing overlapping trades is the main benefit of packaged plant rooms modules	ML	MSD's, HAVS, cuts etc	Final fix services
	ML	Work overhead, cuts step ladders	
	ML	MSDs, crouching, bending	Miscellaneous items
	ML/A	Cuts, crouching, bending, congested work areas, overlapping interfacing trades	
	ML	Congested, restricted work areas, electrocution	Commissioning
More site labour	ML	Slips, trips, falls	Ancillary site risks
Major benefit of OSP	A	Especially overlapping trades issues	

Mechanical services module / packaged plant room

Off Site Activities	Main Hazards	Cf insitu	Opinions/Evidence
Manufacture of materials and fittings etc	Industrialised processes outside HASPREST scope		Industrialised processes – outside the scope of this project
Deliver materials etc to factory	Various	LL, C	More controlled as fixed location
Assemble frame structure	Manual / mechanical handling	LL, C	More chance to mechanise
Weld channels / box sections	MSDs, cuts etc burns, fumes	LL, C	Should be easier to control in factory
Paint frame	Overhead work, COSHH		
Install plinths/box sections/brackets for plant pressure vessels etc	MH, mechanical handling	MC, C	More control, clean environment less risk of contamination, electrical shorts.
Install cable trays	MSDs, cuts etc	C	Should be easier to control in factory
Install pipe-work and valves, control panels	Manual handling	C	Should be easier to control in factory
Install control panels	Crouching, restricted work area.		
		LL	More control over installation and possible site test of High voltage supply
	Manual handling	C	Should be easier to control in factory
		LL	Materials can be mechanically handled right to workface
Miscellaneous fittings, light fittings, storage bays etc	MSDs, HAVS, crouching, restricted work area etc	S, C	Should be easier to control in factory
Final fix services	MSDs, HAVS, cuts etc	S, C	Should be easier to control in factory
Commissioning	Congested / restricted work areas	C	Should be easier to control in factory
Commissioning	Electrocution	LL	Better control of 'power-on' etc
Doors etc	MSDs, cuts etc	C	Should be easier to control in factory
Trade overlap, interfaces etc	Various, slips, trips, falls	LL, C	Less overlap, multi-skilling
Prepare for transportation	MSDs, cuts etc	C	Should be easier to control in factory
Load onto transport	MSDs, cuts etc	C	Should be easier to control in factory
	Craneage	MC, C	Heavier loads – however, more controllable and usually mechanically handled
Transport	Road traffic etc	S, C	Same as insitu but fewer, larger loads. Overhead craneage etc – but controllable
Delivery	Craneage	MC, C	Heavier loads, more craneage but less ad-hoc
Delivery	Manual handling	LL	Craneage not man handling
On Site Activities	**Main Hazards**	**Cf insitu**	**Opinions/Evidence**
Installation of packaged plant room module to floor level	Craneage	N, MC, LL, C	Onto loading platform or launched onto slab – heavier / more complex but very much fewer / more controllable
	Temporary works collapse	MC	Loading platform
Movement of packaged plant room module across floor	MSDs, slips & trips	N	New risk as pulling/pushing heavy load across floor – but not ad hoc and should be controllable
	MSDs	N	New risk as pulling/pushing heavy load into place – but not ad hoc and should be controllable
	Cuts, MSDs, Electrocution	LL	More straight forward with modules
	Cuts, MSDs, Electrocution, congested work areas	LL	Less on-site commissioning needed
	Slips, trips, falls	LL	Significantly less onsite workers will reduce risk
			Significantly less trade overlap
			More risk of Ad Hoc alterations on site to fit` correctly "as built"

Notes – Off site Production is called modularisation in the engineering construction sector.
Notes:- Assumption that Source plant usually based in basement.

Risk change code (insitu>>pre-assembled): S = same (no change) R = Risk removed N = New risk LL = Less likely ML = More likely LC = less serious consequence MC = more serious consequence C = more controllable

Mechanical Services Vertical (Commercial)

Activities based on site installation of vertical Mechanical services verses an Mechanical vertical service distribution module

Main H&S issues: Working at height, crouching, congested/restricted space work, wet work, interaction of trades, material handling

Site Installation of Vertical Mechanical Services			
Opinions/Evidence		**Hazards**	**Off Site Activities**
Industrialised processes – outside HASPREST scope		Industrialised processes – outside the scope of this project	Manufacture of materials and fittings etc
Ad hoc		Road traffic etc	Transport
Ad hoc – often poorly controlled	ML	Manual handling etc	Delivery
Opinions/Evidence		**Hazards**	**On Site Activities**
	A	Man hand materials, MSDs, bending, cleaning area	Prepare site for plant and services.
Plinths may be insitu concrete, or steel truss/frames	A	Manual handling materials, MSDs, crouching, bending, dermatitis	
	ML	MSDs, work overhead, step ladders, working at height, falls of material	Fix pipe brackets to shaft wall.
	ML	Power tools, cuts, crouching, bending, congested work areas, craneage/mechanical handling (depending on size of plant)	Install switchgear and control panels to plinths, align and secure
	ML	Electrocution, Manual-handling materials, MSDs, crouching, bending, restricted work areas.	Install fuse box, Make 33Kv cabling connections to switchgear / distribution boards.
Removing overlapping trades is the main benefit of packaged plant rooms modules	ML	Cuts, crouching, bending, congested work areas, overlapping interfacing trades, electrocution	Connect power to Bus bar and boards.
	ML	Work overhead, cuts step ladders	
	ML	MSDs, crouching, bending	Miscellaneous items
	ML/A	Cuts, crouching, bending, congested work areas, overlapping interfacing trades	
	ML	Congested, restricted work areas, electrocution	Commissioning
More site labour	ML	Slips, trips falls	Ancillary site risks
Major benefit of OSP	A	Especially overlapping trades issues	

Mechanical services: vertical services distribution module			
Off Site Activities	**Hazards**	**Cf insitu**	**Opinions/Evidence**
Manufacture of materials and fittings etc	Industrialised processes – outside HASPREST scope		Industrialised processes – outside the scope of this project
Deliver materials etc to factory	Various	LL, C	More controlled as fixed location
Assemble frame structure	Manual / mechanical handling	LL, C	More chance to mechanise
Weld channels / box sections	MSDs, cuts etc burns, fumes	LL, C	Should be easier to control in factory
Paint frame	Overhead work, COSHH		
Install brackets for switchgear	MH, mechanical handling	MC, C	More control, clean environment less risk of contamination, electrical shorts.
	Manual handling, crouching, cuts, HAVS, MSD's.	C	Should be easier to control in factory
assembled risers			
Install pipe-work, pre-assembled risers within module	Crouching, restricted work area.	LL	More control over installation and possible site test of High voltage supply
	Manual handling	C	Should be easier to control in factory
		LL	Materials can be mechanically handled right to workface
Final fix services, valves, taps	MSDs, HAVS, cuts etc	S, C	Should be easier to control in factory
Commissioning	Congested/restricted work areas	C	Should be easier to control in factory
	Electrocution	LL	Better control of 'power-on' etc
Doors etc	MSDs, cuts etc	C	Should be easier to control in factory
Trade overlap, interfaces etc	Various, slips, trips, falls	LL, C	Less overlap, multi-skilling
Prepare for transportation	MSDs, cuts etc	C	Should be easier to control in factory
Load onto transport	MSDs, cuts etc	C	Should be easier to control in factory
	Craneage	MC, C	Heavier loads – however, more controllable and usually mechanically handled
	Road traffic etc	S, C	Same as insitu but fewer, larger loads. Overhead craneage etc – but controllable
Delivery	Craneage	MC, C	Heavier loads, more craneage but less ad-hoc
Delivery	Manual handling	LL	Craneage not man handling
On Site Activities	**Hazards**	**Cf insitu**	**Opinions/Evidence**
Installation of vertical riser module source module.	Craneage	N, MC, LL, C	Onto loading platform or launched onto slab – heavier / more complex but very much fewer / more controllable
	Temporary works collapse	MC	Loading platform
Movement of packaged plant room module across floor	MSDs, slips & trips	N	New risk as pulling/pushing heavy load across floor – but not ad hoc and should be controllable
	MSDs	N	New risk as pulling/pushing heavy load into place – but not ad hoc and should be controllable
	Cuts, MSDs, Electrocution	LL	More straight forward with modules
	Cuts, MSDs, Electrocution, congested work areas	LL	Less on-site commissioning needed
	Various (see ConCA)	LL	Significantly less onsite workers will reduce risk
			Significantly less trade overlap
			Major Risk: Protection of ducts especially when worked on high: High risk of fall and injury.

Notes – Off site Production is called modularisation in the engineering construction sector.

Risk change code (insitu>>pre-assembled): S = same (no change) R = Risk removed N = New risk LL = Less likely ML = More likely LC = less serious consequence MC = more serious consequence C = more controllable

Mechanical Services Horizontal distribution (Commercial)

Activities based on site installation of horizontal services verses a horizontal services module

Main H&S issues: working at height crouching, congested/restricted space work, interaction of trades, material handling

Site Installation of horizontal distribution Services

Opinions/Evidence		Main Hazards	Off Site Activities
Industrialised processes – outside HASPREST scope		Industrialised processes – outside the scope of this project	Manufacture of materials and fittings etc
Ad hoc		Road traffic etc	Transport
Ad hoc often poorly controlled	ML	Manual handling etc	Delivery
Opinions/Evidence		**Hazards**	**On Site Activities**
Main issue, working at height eliminated in OSP case.	A	Ladders / aluminium towers. Man hand materials, MSDs, bending, cleaning area, overhead work	Prepare site for horizontal distribution services.
	A	Ladders / aluminium towers, overhead work, Manual handling materials, MSDs, crouching, bending, dermatitis COSHH, crouching	Fix brackets and hanger supports for individual pipes and air handling units
	ML	MSD's, work overhead, step ladders, cuts, repetitive tasks	Fix cable trays, services conduits
	ML	Ladders/ aluminium towers , overhead work, cuts, crouching, bending, congested work areas. MH, MSD's.	Install pipework (various chilled water, rainwater, sprinkler pipe), install air handling fan units.
Overlapping trades issues	ML	Ladders / aluminium towers, overhead work, Manual handling materials, MSDs, crouching, bending, restricted work areas, dermatitis	Install cable power, communications
Removing overlapping trades is the main benefit of vertical services modules.	ML	Ladders / aluminium towers, overhead work, cuts, crouching, bending, congested work areas, overlapping interfacing trades solvent welding on site (removed in OSP especially in freezing conditions)	Connect services / ductwork/ power
	ML	Ladders / aluminium towers, overhead work, cuts, repetitive tasks.	
Reducing site labour	ML	Ladders / aluminium towers, overhead work, MSD's, crouching, bending	Accessory fix
	ML/A	Cuts, crouching, bending, congested work areas, overlapping interfacing trades	
	ML	Ladders, overhead work, congested, restricted work areas, electrocution	Commissioning
More site labour, Major benefit of OSP	ML	Slips, trips, falls. Especially overlapping trades issues	Ancillary site risks

Mechanical services module / horizontal distribution

Off Site Activities	Main Hazards	Cf insitu	Opinions/Evidence
Manufacture of materials and fittings	Industrialised processes – outside HASPREST scope		Industrialised processes – outside the scope of this project
Deliver materials to factory	Various	LL, C	More controlled as fixed location
Assemble frame structure	Manual / mechanical handling	LL, C	More chance to mechanise
Weld channels / box sections	MSDs, cuts etc burns, fumes	LL, C	Should be easier to control in factory
Paint frame	Overhead work, COSHH		
Install uni-strut supports etc for ductwork	MH, mechanical handling	MC, C	Overhead craneage etc – but controllable
		LL, C	Should be easier to control in factory
	MSDs, cuts	S?	Same as site installation but easier to control in factory
	Manual handling	LL	Materials mechanically handled right to workface
Install cable trays	MSDs, cuts etc	C	Should be easier to control in factory
		C	Should be easier to control in factory
Install Ductwork, rainwater pipes, chilled water supply (Durapipe), sprinkler pipes	MSDs, cuts etc, fusion welded plastic pipework, COSHH, burns etc	S C	Same as site installation but easier to control in factory
	Manual handling mechanical handling	LL	Materials mechanically handled right to workface
Install taps, valves stopcocks etc	MSDs, crouching, restricted work area etc	C	Should be easier to control in factory
	Manual handling	LL	Materials can be mechanically handled right to workface
	MSDs, HAVS, crouching, restricted work area etc	S, C	Should be easier to control in factory
Final fix services	MSD's, HAVS, cuts etc	S, C	Should be easier to control in factory
Commissioning	Congested/restricted work areas	C	Should be easier to control in factory
Commissioning	Electrocution	LL	Better control of 'power-on' etc
	MSD's, cuts etc	C	Should be easier to control in factory
etc			
	Various, slips, trips, falls	LL, C	
Prepare for transportation	MSD's, cuts etc	C	Should be easier to control in factory
Load onto transport	MSD's, cuts etc	C	Should be easier to control in factory
Load onto transport	Craneage	MC, C	Heavier loads – however, more controllable and usually mechanically handled
Transport	Road traffic etc	S, C	Same as insitu but fewer, larger loads
Delivery	Craneage	MC, C	Heavier loads, more craneage but less ad-hoc
	Manual handling	LL	Craneage not man handling
On Site Activities	**Hazards**	**Cf insitu**	**Opinions/Evidence**
Movement of horizontal services module across floor Movement of horizontal services module across floor	Craneage or mechanical handling	N, MC, LL, C	Onto loading platform or launched onto slab – heavier / more complex but very much fewer / more controllable
	MSD's, slips & trips		Loading platform
		N	New risk as pulling/pushing heavy load across floor – but not ad hoc and should be controllable
	MSD's	N	New risk as pulling/pushing heavy load into place – but not ad hoc and should be controllable
modules. Positioning of subsequent service modules to adjacent units			
		R	Reduction of site based labour and trade overlap
	Cuts, MSD's, Electrocution	LL	More straight forward with modules
	Cuts, MSD's, Electrocution, congested work areas	LL	Less on-site commissioning needed
	Slips, trips, falls	LL	Significantly less onsite workers will reduce risk
			Significantly less trade overlap
			In-situ "hanging" still required. Emphasis on horizontal

Notes – Off site Production is called modularisation in the engineering construction sector.

Risk change code (insitu>>pre-assembled): S = same (no change) R = Risk removed N = New risk LL = Less likely ML = More likely LC = less serious consequence MC = more serious consequence C = more controllable

Mechanical Services Horizontal distribution lagged modules (Commercial)

Activities based on site installation of horizontal services (lagged) verses a horizontal services (Lagged) module

Main H&S issues: working at height crouching, congested/restricted space work, interaction of trades, material handling

Site Installation of horizontal distribution Services (lagged)

Opinions/Evidence		Main Hazards	Off Site Activities
Industrialised processes – outside HASPREST scope		Industrialised processes – outside the scope of this project	Manufacture of materials and fittings etc
Ad hoc		Road traffic etc	Transport
Ad hoc – often poorly controlled	ML	Manual handling etc	Delivery
Opinions/Evidence		**Main Hazards**	**On Site Activities**
Main issue, working at height eliminated in OSP case.	A	Ladders, Man hand materials, MSDs, bending, cleaning area, overhead work	Prepare site for horizontal distribution services.
	A	Ladders, overhead work, Manual handling materials, MSDs, crouching, bending, dermatitis	Fix brackets and hanger supports for individual pipes and air handling units
		COSHH, crouching	
	ML	MSD's, work overhead, step ladders, cuts, repetitive tasks	Fix cable trays, services conduits
	ML	Ladders, overhead work, cuts, crouching, bending, congested work areas. MH, MSD's.	Install pipework (various chilled water, rainwater, sprinkler pipe).
Overlapping trades issues	ML	Ladders, overhead work, Manual handling materials, MSDs, crouching, bending, restricted work areas, dermatitis	Install cable power, communications etc
Removing overlapping trades is the main benefit of vertical services modules.	ML	Ladders, overhead work, cuts, crouching, bending, congested work areas, overlapping interfacing trades solvent welding on site (removed in OSP especially in freezing conditions)	Connect services / ductwork/ power etc
	ML	COSHH, MH, RSI (confined space work) , working at height.	Install lagging
	ML	Ladders, overhead work, cuts, repetitive tasks.	
Reducing site labour	ML	Ladders, overhead work, MSDs, crouching, bending	Accessory fix
	ML/A	Cuts, crouching, bending, congested work areas, overlapping interfacing trades	
	ML	Ladders, overhead work, congested, restricted work areas, electrocution	Commissioning
More site labour, Major benefit of OSP	ML	Slips, trips, falls, Especially overlapping trades issues	Ancillary site risks

Mechanical services module / horizontal distribution (lagged)

Off Site Activities	Main Hazards	Cf insitu	Opinions/Evidence
Manufacture of materials and fittings etc	Industrialised processes – outside HASPREST scope		Industrialised processes – outside the scope of this project
Deliver materials etc to factory	Various	LL, C	More controlled as fixed location
Assemble frame structure	Manual / mechanical handling	LL, C	More chance to mechanise
Weld channels / box sections	MSD's, cuts etc burns, fumes	LL, C	Should be easier to control in factory
Paint frame	Overhead work, COSHH		
Install uni-strut supports etc for ductwork	MH, mechanical handling	MC, C	Overhead craneage etc – but controllable
		LL, C	Should be easier to control in factory
	MSD's, cuts	S	Same as site installation but easier to control in factory
	Manual handling	LL	Materials mechanically handled right to workface
Install cable trays	MSDs, cuts etc	C	Should be easier to control in factory
		C	Should be easier to control in factory
Install Ductwork, rainwater pipes, chilled water supply (Durapipe), sprinkler pipes	MSD's, cuts etc, fusion welded plastic pipework, COSHH, burns etc	S C	Same as site installation but easier to control in factory
	Manual handling mechanical handling	LL	Materials mechanically handled right to workface
Install taps, valves stopcocks etc	MSD's, crouching, restricted work area etc	C	Should be easier to control in factory
	Manual handling	LL	Materials can be mechanically handled right to workface
	MSDs, HAVS, crouching, restricted work area etc	S, C	Should be easier to control in factory
	MSD's, HAVS, cuts etc	S, C	Should be easier to control in factory
Install lagging	RSI, confined space work etc	S, C	Should be easier to control.
Commissioning	Congested/restricted work areas	C	Should be easier to control in factory
	Electrocution	LL	Better control of 'power-on' etc
Inspection covers access doors etc	MSDs, cuts etc	C	Should be easier to control in factory
	Various, slips, trips, falls	LL, C	
Prepare for transportation	MSDs, cuts etc	C	Should be easier to control in factory
Load onto transport	MSDs, cuts etc	C	Should be easier to control in factory
	Craneage	MC, C	Heavier loads – however, more controllable and usually mechanically handled
Transport	Road traffic etc	S, C	Same as insitu but fewer, larger loads
Delivery	Craneage	MC, C	Heavier loads, more craneage but less ad-hoc
	Manual handling	LL	Craneage not man handling
On Site Activities	**Main Hazards**	**Cf insitu**	**Opinions/Evidence**
Movement of horizontal services module across floor Movement of horizontal services module across floor	Craneage or mechanical handling	N, MC, LL, C	Onto loading platform or launched onto slab – heavier / more complex but very much fewer / more controllable
	MSD's, slips & trips		Loading platform
		N	New risk as pulling/pushing heavy load across floor – but not ad hoc and should be controllable
modules	MSD's	N	New risk as pulling/pushing heavy load into place – but not ad hoc and should be controllable
Positioning of subsequent service modules to adjacent units		R	Reduction of site based labour and trade overlap
	Cuts, MSDs, Electrocution	LL	More straight forward with modules
	Cuts, MSDs, Electrocution, congested work areas	LL	Less on-site commissioning needed
	Slips, trips, falls	LL	Significantly less onsite workers will reduce risk Significantly less trade overlap

Notes – Off site Production is called modularisation in the engineering construction sector.

Risk change code (insitu>>pre-assembled): S = same (no change) R = Risk removed N = New risk LL = Less likely ML = More likely LC = less serious consequence MC = more serious consequence C = more controllable

Mechanical Services Horizontal distribution (Commercial)

Activities based on site installation of horizontal services verses a horizontal services multi service module

Main H&S issues: working at height crouching, congested/restricted space work, interaction of trades, material handling

Site Installation of horizontal distribution Services

Opinions/Evidence		Main Hazards	Off Site Activities
Industrialised processes – outside HASPREST scope		Industrialised processes – outside the scope of this project	Manufacture of materials and fittings etc
Ad hoc		Road traffic etc	Transport
Ad hoc – often poorly controlled	ML	Manual handling etc	Delivery

Opinions/Evidence		Main Hazards	On Site Activities
Main issue, working at height eliminated in OSP case.	A	Ladders, Man hand materials, MSDs, bending, cleaning area, overhead work	Prepare site for horizontal distribution services.
	A	Ladders, overhead work, Manual handling materials, MSDs, crouching, bending, dermatitis	Fix brackets and hanger supports for individual pipes and air handling units
		COSHH, crouching	
	ML	MSDs, work overhead, step ladders, cuts, repetitive tasks	Fix cable trays, services conduits
	ML	Ladders, overhead work, cuts, crouching, bending, congested work areas. MH, MSD's.	Install pipework (various chilled water, rainwater, sprinkler pipe)
Overlapping trades issues	ML	Ladders, overhead work, Manual handling materials, MSDs, crouching, bending, restricted work areas, dermatitis	Install cable power, communications etc
Removing overlapping trades is the main benefit of vertical services modules.	ML	Ladders, overhead work, cuts, crouching, bending, congested work areas, overlapping interfacing trades solvent welding on site (removed in OSP especially in freezing conditions)	Connect services / ductwork/ power etc
	ML	Ladders, overhead work, cuts, repetitive tasks.	
Reducing site labour	ML	Ladders, overhead work, MSDs, crouching, bending	Accessory fix
	ML/A	Cuts, crouching, bending, congested work areas, overlapping interfacing trades	
	ML	Ladders, overhead work, congested, restricted work areas, electrocution	Commissioning
More site labour, Major benefit of OSP	ML	Slips, trips, falls, Especially overlapping trades issues	Ancillary site risks

Mechanical services module / horizontal distribution multi service

Off Site Activities	Main Hazards	Cf insitu	Opinions/Evidence
Manufacture of materials and fittings etc	Industrialised processes – outside HASPREST scope		Industrialised processes – outside the scope of this project
Deliver materials etc to factory	Various	LL, C	More controlled as fixed location
Assemble frame structure	Manual / mechanical handling	LL, C	More chance to mechanise
Weld channels / box sections	MSDs, cuts etc burns, fumes	LL, C	Should be easier to control in factory
Paint frame	Overhead work, COSHH		
Install uni-strut supports etc for ductwork	MH, mechanical handling	MC, C	Overhead craneage etc – but controllable
		LL, C	Should be easier to control in factory
	MSD's, cuts	S	Same as site installation but easier to control in factory
	Manual handling	LL	Materials mechanically handled right to workface
Install cable trays	MSD's, cuts etc	C	Should be easier to control in factory
		C	Should be easier to control in factory
Install Ductwork, rainwater pipes, chilled water supply (Durapipe), sprinkler pipes	MSDs, cuts etc, fusion welded plastic pipework, COSHH, burns etc	S C	Same as site installation but easier to control in factory
Install Fan coil units, supply and return ducts, pipework, insulation	Manual handling mechanical handling, COSHH.	LL	Materials mechanically handled right to workface
Install taps, valves stopcocks etc	MSDs, crouching, restricted work area etc	C	Should be easier to control in factory
	Manual handling	LL	Materials can be mechanically handled right to workface
	MSDs, HAVS, crouching, restricted work area etc	S, C	Should be easier to control in factory
Final fix services	MSDs, HAVS, cuts etc	S, C	Should be easier to control in factory
Commissioning	Congested/restricted work areas	C	Should be easier to control in factory
Commissioning	Electrocution	LL	Better control of 'power-on' etc
Inspection covers access doors etc	MSD's, cuts etc	C	Should be easier to control in factory
	Various, slips, trips, falls	LL, C	
Prepare for transportation	MSDs, cuts etc	C	Should be easier to control in factory
Load onto transport	MSDs, cuts etc	C	Should be easier to control in factory
	Craneage	MC, C	Heavier loads – however, more controllable and usually mechanically handled
Transport	Road traffic etc	S, C	Same as insitu but fewer, larger loads
Delivery	Craneage	MC, C	Heavier loads, more craneage but less ad-hoc
	Manual handling	LL	Craneage not man handling

On Site Activities	Main Hazards	Cf insitu	Opinions/Evidence
Movement of horizontal services module across floor Movement of horizontal services module across floor	Craneage or mechanical handling	N, MC, LL, C	Onto loading platform or launched onto slab – heavier / more complex but very much fewer / more controllable
	MSD's, slips & trips		Loading platform
		N	New risk as pulling/pushing heavy load across floor – but not ad hoc and should be controllable
	MSD's	N	New risk as pulling/pushing heavy load into place – but not ad hoc and should be controllable
modules			
Positioning of subsequent service modules to adjacent units		R	Reduction of site based labour and trade overlap
	Cuts, MSD's, Electrocution	LL	More straight forward with modules
	Cuts, MSD's, Electrocution, congested work areas	LL	Less on-site commissioning needed
	Slips, trips, falls	LL	Significantly less onsite workers will reduce risk Significantly less trade overlap

Notes – Off site Production is called modularisation in the engineering construction sector.

Risk change code (insitu>>pre-assembled): S = same (no change) R = Risk removed N = New risk LL = Less likely ML = More likely LC = less serious consequence MC = more serious consequence C = more controllable

Electrical Services Source (Commercial)

Activities based on site installation of electrical services verses an electrical source module / packaged plant room
Main H&S issues: crouching, congested/restricted space work, wet work, interaction of trades, material handling

Site Installation of Electrical Services

Opinions/Evidence		Main Hazards	Off Site Activities
Industrialised processes – outside HASPREST scope		Industrialised processes – outside the scope of this project	Manufacture of materials and fittings etc
Ad hoc		Road traffic etc	Transport
Ad hoc – often poorly controlled	ML	Manual handling etc	Delivery
Opinions/Evidence		**Main Hazards**	**On Site Activities**
	A	Man hand materials, MSD's, bending, cleaning area	Prepare site for plant and services.
Plinths may be insitu concrete, or steel truss/frames	A	Manual handling materials, MSD's, crouching, bending, dermatitis	Plinths/ up-stands for electronic control panels and switchgear.
	ML	MSD's, work overhead, step ladders, dermatitis	Fix cable trays, services conduits
	ML	Power tools, cuts, crouching, bending, congested work areas, craneage/mechanical handling (depending on size of plant)	Install switchgear and control panels to plinths, align and secure
	ML	Electrocution, Manual handling materials, MSD's, crouching, bending, restricted work areas.	Install fuse box, Make 33Kv cabling connections to switchgear / distribution boards.
Removing overlapping trades is the main benefit of packaged plant rooms modules	ML	Cuts, crouching, bending, congested work areas, overlapping interfacing trades, electrocution	Connect power to Bus bar and boards.
	ML	Work overhead, cuts step ladders	
	ML	MSD's, crouching, bending	Miscellaneous items
	ML/A	Cuts, crouching, bending, congested work areas, overlapping interfacing trades	
	ML	Congested, restricted work areas, electrocution	Commissioning
More site labour	ML	Slips, trips, falls	Ancillary site risks
Major benefit of OSP	A	Especially overlapping trades issues	

Electrical services module / packaged plant room

Off Site Activities	Main Hazards	Cf insitu	Opinions/Evidence
Manufacture of materials and fittings etc	Industrialised processes – outside HASPREST scope		Industrialised processes – outside the scope of this project
Deliver materials etc to factory	Various	LL, C	More controlled as fixed location
Assemble frame structure	Manual / mechanical handling	LL, C	More chance to mechanise
Weld channels / box sections	MSD's, cuts etc burns, fumes	LL, C	Should be easier to control in factory
Paint frame	Overhead work, COSHH		
Install plinth/box sections for switchgear	MH, mechanical handling	MC, C	More control, clean environment less risk of contamination, electrical shorts.
Install cable trays	MSD's, cuts etc	C	Should be easier to control in factory
	Manual handling	C	Should be easier to control in factory
	Crouching, restricted work area.	LL	More control over installation and possible site test of High voltage supply
power bus bar			
	Manual handling	C	Should be easier to control in factory
		LL	Materials can be mechanically handled right to workface
Miscellaneous fittings, light fittings, storage bays etc	MSD's, HAVS, crouching, restricted work area etc	S, C	Should be easier to control in factory
Final fix services	MSD's, HAVS, cuts etc	S, C	Should be easier to control in factory
	Congested / restricted work areas	C	Should be easier to control in factory
	Electrocution	LL	Better control of 'power-on' etc
Doors etc	MSD's, cuts etc	C	Should be easier to control in factory
Trade overlap, interfaces etc	Various, slips, trips, falls	LL, C	Less overlap, multi-skilling
Prepare for transportation	MSD's, cuts etc	C	Should be easier to control in factory
Load onto transport	MSD's, cuts etc	C	Should be easier to control in factory
	Craneage	MC, C	Heavier loads – however, more controllable and usually mechanically handled
Transport	Road traffic etc	S, C	Same as insitu but fewer, larger loads. Overhead craneage etc – but controllable
Delivery	Craneage	MC, C	Heavier loads, more craneage but less ad-hoc
	Manual handling	LL	Craneage not man handling
On Site Activities	**Main Hazards**	**Cf insitu**	**Opinions/Evidence**
Installation of packaged plant room module to floor level	Craneage	N, MC, LL, C	Onto loading platform or launched onto slab – heavier / more complex but very much fewer / more controllable
	Temporary works collapse	MC	Loading platform
Movement of packaged plant room module across floor	MSD's, slips & trips	N	New risk as pulling/pushing heavy load across floor – but not ad hoc and should be controllable
	MSD's	N	New risk as pulling/pushing heavy load into place – but not ad hoc and should be controllable
	Cuts, MSD's, Electrocution	LL	More straight forward with modules
	Cuts, MSD's, Electrocution, congested work areas	LL	Less on-site commissioning needed
	Slips, trips, falls	LL	Significantly less onsite workers will reduce risk
			Significantly less trade overlap
			Cable trays, vertical risers, main feed (power) etc still carried out as "in-situ".

Notes – Off site Production is called modularisation in the engineering construction sector.
Notes:- Assumption that Source plant usually based in basement.

Risk change code (insitu>>pre-assembled): S = same (no change) R = Risk removed N = New risk LL = Less likely ML = More likely LC = less serious consequence MC = more serious consequence C = more controllable

Electrical Services Vertical distribution (Commercial)

Activities based on site installation of electrical services verses a vertical electrical services module

Main H&S issues: working at height crouching, congested/restricted space work, wet work, interaction of trades, material handling

Site Installation of vertical distribution Services

Opinions/Evidence		Main Hazards	Off Site Activities
Industrialised processes – outside HASPREST scope		Industrialised processes – outside the scope of this project	Manufacture of materials and fittings etc
Ad hoc		Road traffic etc	Transport
Ad hoc – often poorly controlled	ML	Manual handling etc	Delivery
Opinions/Evidence		**Main Hazards**	**On Site Activities**
Main issue, working at height eliminated in OSP case.	A	Working at height, Man hand materials, MSD's, bending, cleaning area	Prepare site for vertical electrical services.
	A	Working at height, Manual handling materials, MSDs, crouching, bending, dermatitis COSHH, crouching	Fix brackets and support for trays to services shaft
	ML	Working at height, MSD's, work overhead, step ladders, dermatitis	Fix cable trays, services conduits
	ML	Working at height Cuts, crouching, bending, congested work areas.	Install electrical services
Overlapping trades issues	ML	Working at height Manual handling materials, MSD's, crouching, bending, restricted work areas, dermatitis	Install fire proofing / insulation
Removing overlapping trades is the main benefit of vertical services modules.	ML	Working at height Cuts, crouching, bending, congested work areas, overlapping interfacing trades electrocution (removed in OSP especially in freezing conditions)	Connect services / electrical looms/ power etc
	ML	Working at height Work overhead, cuts step ladders	
Reducing site labour	ML	MSD's, crouching, bending	Miscellaneous items
	ML/A	Cuts, crouching, bending, congested work areas, overlapping interfacing trades	
	ML	Congested, restricted work areas, electrocution	Commissioning
More site labour	ML	Slips, trips, falls	Ancillary site risks
Major benefit of OSP	A	Especially overlapping trades issues	

Electrical services module / vertical distribution

Off Site Activities	Main Hazards	Cf insitu	Opinions/Evidence
Manufacture of materials and fittings etc	Industrialised processes – outside HASPREST scope		Industrialised processes – outside the scope of this project
Deliver materials etc to factory	Various	LL, C	More controlled as fixed location
Assemble frame structure	Manual / mechanical handling	LL, C	More chance to mechanise
Weld channels / box sections	MSD's, cuts etc burns, fumes	LL, C	Should be easier to control in factory
Paint frame	Overhead work, COSHH		
Install uni-strut supports etc for ductwork	MH, mechanical handling	MC, C	Overhead craneage etc – but controllable
		LL, C	Should be easier to control in factory
	MSD's, cuts	S	Same as site installation but easier to control in factory
	Manual handling	LL	Materials mechanically handled right to workface
Install cable trays	MSD's, cuts etc	C	Should be easier to control in factory
		C	Should be easier to control in factory
Install electrical cables / looms	MSD's, cuts, COSHH, burns.	S C	Same as site installation but easier to control in factory
Install insulation	MSD's, crouching, restricted work area etc	C	Should be easier to control in factory
	Manual handling	LL	Materials can be mechanically handled right to workface
	MSD's, HAVS, crouching, restricted work area.	S, C	Should be easier to control in factory
Miscellaneous services	MSD's, HAVS, cuts etc	S, C	Should be easier to control in factory
	Congested/restricted work areas	C	Should be easier to control in factory
	Electrocution	LL	Better control of 'power-on' etc
Inspection covers access doors etc	MSD's, cuts etc	C	Should be easier to control in factory
	Various, slips, trips, falls	LL, C	
	MSD's, cuts etc	C	Should be easier to control in factory
Load onto transport	MSD's, cuts etc	C	Should be easier to control in factory
	Craneage	MC, C	Heavier loads – however, more controllable and usually mechanically handled
Transport	Road traffic etc	S, C	Same as insitu but fewer, larger loads
Delivery	Craneage	MC, C	Heavier loads, more craneage but less ad-hoc
	Manual handling	LL	Craneage not man handling
On Site Activities	**Main Hazards**	**Cf insitu**	**Opinions/Evidence**
Movement of vertical electrical services module across floor Movement of vertical services module across floor	Craneage	N, MC, LL, C	Onto loading platform or launched onto slab – heavier / more complex but very much fewer / more controllable
	Temporary works collapse	MC	Loading platform
	MSD's, slips & trips	N	New risk as pulling/pushing heavy load across floor – but not ad hoc and should be controllable
modules	MSD's	N	New risk as pulling/pushing heavy load into place – but not ad hoc and should be controllable
Positioning of subsequent service modules within shaft		R	Working at height eliminated, (may work at storey height but much less risk of serious fall from height)
	Cuts, MSD's, Electrocution	LL	More straight forward with modules
	Cuts, MSD's, Electrocution, congested work areas	LL	Less on-site commissioning needed
	Slips, trips, falls	LL	Significantly less onsite workers will reduce risk
			Significantly less trade overlap

Notes – Off site Production is called modularisation in the engineering construction sector.

Notes:- Electrical services module, containing partitioning and insulation material

Risk change code (insitu>>pre-assembled): S = same (no change) R = Risk removed N = New risk LL = Less likely ML = More likely LC = less serious consequence MC = more serious consequence C = more controllable

Electrical Services Horizontal distribution (Commercial)

Activities based on site installation of electrical services verses a horizontal electrical services module.
Main H&S issues: working on an access platform, crouching, congested/restricted space, wet work, interaction of trades, material handling

Site Installation of horizontal distribution Services

Opinions/Evidence		Hazards	Off Site Activities
Industrialised processes – outside HASPREST scope		Industrialised processes – outside the scope of this project	Manufacture of materials and fittings etc
Ad hoc		Road traffic etc	Transport
Ad hoc – often poorly controlled	ML	Manual handling etc	Delivery
Opinions/Evidence		**Hazards**	**On Site Activities**
Main issue, working at height eliminated in OSP case.	A	Working at height, Man hand materials, MSD's, bending, cleaning area	Prepare site for vertical electrical services.
	A	Working at height, Manual handling materials, MSD's, crouching, bending, dermatitis COSHH, crouching	Fix brackets and support for trays to services shaft
	ML	Working at height, MSD's, work overhead, step ladders, dermatitis	Fix cable trays, services conduits
	ML	Working at height Cuts, crouching, bending, congested work areas.	Install electrical services
Overlapping trades issues	ML	Working at height Manual handling materials, MSD's, crouching, bending, restricted work areas, dermatitis	Install fire proofing / insulation
Removing overlapping trades is the main benefit of vertical services modules.	ML	Working at height Cuts, crouching, bending, congested work areas, overlapping interfacing trades electrocution (removed in OSP especially in freezing conditions)	Connect services / electrical looms/ power etc
	ML	Working at height Work overhead, cuts step ladders	
Reducing site labour	ML	MSD's, crouching, bending	Miscellaneous items
	ML/A	Cuts, crouching, bending, congested work areas, overlapping interfacing trades	
	ML	Congested, restricted work areas, electrocution	Commissioning
More site labour	ML	Slips, trips, falls.	Ancillary site risks
Major benefit of OSP	A	Especially overlapping trades issues	------ " -------

Electrical services module / horizontal distribution

Off Site Activities	Hazards	Cf insitu	Opinions/Evidence
Manufacture of materials and fittings etc	Industrialised processes – outside HASPREST scope		Industrialised processes – outside the scope of this project
Deliver materials etc to factory	Various	LL, C	More controlled as fixed location
Assemble frame structure	Manual / mechanical handling	LL, C	More chance to mechanise
Weld channels / box sections	MSD's, cuts etc burns, fumes	LL, C	Should be easier to control in factory
Paint frame	Overhead work, COSHH		
Install unistrut supports etc for ductwork	MH, mechanical handling	MC, C	Overhead craneage etc – but controllable
		LL, C	Should be easier to control in factory
	MSD's, cuts	S	Same as site installation but easier to control in factory
	Manual handling	LL	Materials mechanically handled right to workface
Install cable trays	MSD's, cuts etc	C	Should be easier to control in factory
		C	Should be easier to control in factory
Install electrical cables / looms	MSD's, cuts, COSHH, burns.	S C	Same as site installation but easier to control in factory
Install insulation	MSD's, crouching, restricted work area etc	C	Should be easier to control in factory
	Manual handling	LL	Materials can be mechanically handled right to workface
	MSD's, HAVS, crouching, restricted work area.	S, C	Should be easier to control in factory
Miscellaneous services	MSD's, HAVS, cuts etc	S, C	Should be easier to control in factory
	Congested/restricted work areas	C	Should be easier to control in factory
	Electrocution	LL	Better control of 'power-on' etc
Inspection covers access doors etc	MSD's, cuts etc	C	Should be easier to control in factory
	Various, slips, trips, falls	LL, C	
	MSD's, cuts etc	C	Should be easier to control in factory
Load onto transport	MSD's, cuts etc	C	Should be easier to control in factory
	Craneage	MC, C	Heavier loads – however, more controllable and usually mechanically handled
Transport	Road traffic etc	S, C	Same as insitu but fewer, larger loads
Delivery	Craneage	MC, C	Heavier loads, more craneage but less ad-hoc
	Manual handling	LL	Craneage not man handling
On Site Activities	**Hazards**	**Cf insitu**	**Opinions/Evidence**
Movement of horizontal electrical services module across floor Movement of horizontal services module across floor	Craneage	N, MC, LL, C	Onto loading platform or launched onto slab – heavier / more complex but very much fewer / more controllable
------ " -------	Temporary works collapse	MC	Loading platform
	MSD's, slips & trips	N	New risk as pulling/pushing heavy load across floor – but not ad hoc and should be controllable
	MSD's	N	New risk as pulling/pushing heavy load into place – but not ad hoc and should be controllable
modules			
Positioning of subsequent service modules		R	Working at height eliminated, (may work at storey height but much less risk of serious fall from height)
	Cuts, MSDs, Electrocution	LL	More straight forward with modules
	Cuts, MSDs, Electrocution, congested work areas	LL	Less on-site commissioning needed
	Slips, trips, falls	LL	Significantly less onsite workers will reduce risk Significantly less trade overlap Cable trays, vertical risers, main feed (power) etc still carried out as "in-situ".

Notes – Off site Production is called modularisation in the engineering construction sector.
Notes:- Electrical services module, containing partitioning and insulation material

Risk change code (insitu>>pre-assembled): S = same (no change) R = Risk removed N = New risk LL = Less likely ML = More likely LC = less serious consequence MC = more serious consequence C = more controllable

Electrical Services Horizontal distribution (Commercial)

Activities based on site installation of horizontal services verses a horizontal multi service module

Main H&S issues: working at height crouching, congested/restricted space work, interaction of trades, material handling

Site Installation of horizontal distribution Services				Electrical services module / horizontal distribution			
Opinions/Evidence		**Main Hazards**	**Off Site Activities**	**Off Site Activities**	**Main Hazards**	**Cf insitu**	**Opinions/Evidence**
Industrialised processes – outside HASPREST scope		Industrialised processes – outside the scope of this project	Manufacture of materials and fittings etc	Manufacture of materials and fittings etc	Industrialised processes – outside HASPREST scope		Industrialised processes – outside the scope of this project
				Deliver materials etc to factory	Various	LL, C	More controlled as fixed location
Ad hoc		Road traffic etc	Transport	Assemble frame structure	Manual / mechanical handling	LL, C	More chance to mechanise
				Weld channels / box sections	MSD's, cuts etc burns, fumes	LL, C	Should be easier to control in factory
				Paint frame	Overhead work, COSHH		
Ad hoc – often poorly controlled	ML	Manual handling etc	Delivery	Install unistrut supports etc for ductwork	MH, mechanical handling	MC, C	Overhead craneage etc – but controllable
						LL, C	Should be easier to control in factory
					MSD's, cuts	S?	Same as site installation but easier to control in factory
Opinions/Evidence		**Main Hazards**	**On Site Activities**		Manual handling	LL	Materials mechanically handled right to workface
Main issue, working at height eliminated in OSP case.	A	Ladders, Man hand materials, MSDs, bending, cleaning area, overhead work	Prepare site for horizontal distribution services.	Install cable trays	MSD's, cuts etc	C	Should be easier to control in factory
						C	Should be easier to control in factory
	A	Ladders, overhead work, Manual handling materials, MSD's, crouching, bending, dermatitis	Fix brackets and hanger supports for individual pipes and air handling units	Install Ductwork, rainwater pipes, chilled water supply (Durapipe), sprinkler pipes	MSD's, cuts etc, fusion welded plastic pipework, COSHH, burns etc	S C	Same as site installation but easier to control in factory
		COSHH, crouching		Install Fan coil units, supply and return ducts, LPHW pipework, insulation	Manual handling mechanical handling, COSHH.	LL	Materials mechanically handled right to workface
	ML	MSDs, work overhead, step ladders, cuts, repetitive tasks	Fix cable trays, services conduits	Install taps, valves stopcocks etc	MSD's, crouching, restricted work area etc	C	Should be easier to control in factory
					Manual handling	LL	Materials can be mechanically handled right to workface
	ML	Ladders, overhead work, cuts, crouching, bending, congested work areas. MH, MSD's.	Install pipework (various chilled water, rainwater, sprinkler pipe)		MSD's, HAVS, crouching, restricted work area etc	S, C	Should be easier to control in factory
Overlapping trades issues	ML	Ladders, overhead work, Manual handling materials, MSD's, crouching, bending, restricted work areas, dermatitis	Install cable power, communications	Final fix services	MSD's, HAVS, cuts etc	S, C	Should be easier to control in factory
				Commissioning	Congested/restricted work areas	C	Should be easier to control in factory
Removing overlapping trades is the main benefit of vertical services modules.	ML	Ladders, overhead work, cuts, crouching, bending, congested work areas, overlapping interfacing trades solvent welding on site (removed in OSP especially in freezing conditions)	Connect services / ductwork/ power etc		Electrocution	LL	Better control of 'power-on' etc
				Inspection covers access doors etc	MSD's, cuts etc	C	Should be easier to control in factory
	ML	Ladders, overhead work, cuts, repetitive tasks.			Various, slips, trips, falls	LL, C	
				Prepare for transportation	MSD's, cuts etc	C	Should be easier to control in factory
Reducing site labour	ML	Ladders, overhead work, MSD's, crouching, bending	Accessory fix	Load onto transport	MSD's, cuts etc	C	Should be easier to control in factory
					Craneage	MC, C	Heavier loads – however, more controllable and usually mechanically handled
	ML/A	Cuts, crouching, bending, congested work areas, overlapping interfacing trades		Transport	Road traffic etc	S, C	Same as insitu but fewer, larger loads
				Delivery	Craneage	MC, C	Heavier loads, more craneage but less ad-hoc
	ML	Ladders, overhead work, congested, restricted work areas, electrocution	Commissioning		Manual handling	LL	Craneage not man handling
				On Site Activities	**Main Hazards**	**Cf insitu**	**Opinions/Evidence**
More site labour, Major benefit of OSP	ML	Slips, trips, falls, Especially overlapping trades issues	Ancillary site risks	Movement of horizontal services module across floor Movement of horizontal services module across floor	Craneage or mechanical handling	N, MC, LL, C	Onto loading platform or launched onto slab – heavier / more complex but very much fewer / more controllable
					MSD's, slips & trips		Loading platform
						N	New risk as pulling/pushing heavy load across floor – but not ad hoc and should be controllable
					MSD's	N	New risk as pulling/pushing heavy load into place – but not ad hoc and should be controllable
				modules			
				Positioning of subsequent service modules to adjacent units		R	Reduction of site based labour and trade overlap
					Cuts, MSDs, Electrocution	LL	More straight forward with modules
					Cuts, MSDs, Electrocution, congested work areas	LL	Less on-site commissioning needed
					Slips, trips, falls	LL	Significantly less onsite workers will reduce risk
							Significantly less trade overlap

Notes – Off site Production is called modularisation in the engineering construction sector.

Risk change code (insitu>>pre-assembled): S = same (no change) R = Risk removed N = New risk LL = Less likely ML = More likely LC = less serious consequence MC = more serious consequence C = more controllable

Internals Washrooms (Commercial)
Activities based on blockwork with insitu plaster and tiling with site installed services, sanitary ware etc verses internally fully finished factory built pc concrete framed modules
Main H&S issues: crouching, congested/restricted space work, wet work, interaction of trades, material handling

Insitu Washrooms/Toilets			
Opinions/Evidence		**Main Hazards**	**Off Site Activities**
Industrialised processes outside HASPREST scope		Industrialised processes – outside the scope of this project	Manufacture of materials and fittings etc
Ad hoc		Road traffic etc	Transport
Ad hoc – often poorly controlled	ML	Manual handling etc	Delivery
Opinions/Evidence		**Main Hazards**	**On Site Activities**
	A	Man hand materials, MSD's, bending, dermatitis	Blockwork
As floor screed	A	Manual handling materials, MSD's, crouching, bending, dermatitis, pumping of screed	Floor Screed
	ML	MSD's, work overhead, step ladders, dermatitis	Plaster / render to walls / ceilings
Removing overlapping trades is the main benefit of pods	ML	Cuts, crouching, bending, congested work areas, overlapping interfacing trades	1st fix joinery / plumbing / electrical
	ML	Manual handling materials, MSD's, crouching, bending, restricted work areas, dermatitis	Tiling
Removing overlapping trades is the main benefit of pods	ML	Cuts, crouching, bending, congested work areas, overlapping interfacing trades	2nd fix Joinery / plumbing / electrical
As suspended ceilings	ML	Work overhead, cuts (hangers), step ladders	Suspended ceilings (if required)
	ML	MSD's, crouching, bending	Accessory fix
Removing overlapping trades is the main benefit of pods	ML/A	Cuts, crouching, bending, congested work areas, overlapping interfacing trades	3rd Fix Joinery / plumbing / electrical
	ML	Congested, restricted work areas, electrocution	Commissioning
More site labour	ML	Slips, trips, falls	Ancillary site risks
Major benefit of OSP	A	Especially overlapping trades issues	

Washrooms Pods PC Concrete			
Off Site Activities	**Main Hazards**	**Cf insitu**	**Opinions/Evidence**
Manufacture of materials and fittings etc	Industrialised processes – outside HASPREST scope		Industrialised processes – outside the scope of this project
Deliver materials etc to factory	Various	LL, C	More controlled as fixed location
Assemble pod moulds	Manual / mechanical handling	LL, C	More chance to mechanise
Position grid/mesh reinforcement	MSD's, cuts etc	LL, C	Should be easier to control in factory
Pour concrete	MSD's, concrete burns, cuts, MH.	MC, C	Overhead craneage etc – but controllable
	MSD's, cuts etc	LL, C	Should be easier to control in factory
	MSD's, cuts	S	Same as site drylining but easier to control in factory
	Manual handling	LL	Materials mechanically handled right to workface
Install supports etc for fittings	MSD's, cuts etc	C	Should be easier to control in factory
	MSD's, cuts etc	C	Should be easier to control in factory
Internal partitions	MSD's, cuts etc	S?, C	Same as site drylining but easier to control in factory
	Manual handling	LL	Materials mechanically handled right to workface
Wall and floor tiling	MSD's, crouching, restricted work area etc	C	Should be easier to control in factory Could consider pre-assembled pre-tiled panels
	Manual handling	LL	Materials can be mechanically handled right to workface
Install fittings	MSD's, HAVS, crouching, restricted work area etc	S, C	Should be easier to control in factory
Decoration	MSD's, step ladders etc	S, C	Should be easier to control in factory
Final fix services	MSD's, HAVS, cuts etc	S, C	Should be easier to control in factory
	Congested/restricted work areas	C	Should be easier to control in factory
	Electrocution	LL	Better control of 'power-on' etc
Doors etc	MSD's, cuts etc	C	Should be easier to control in factory
Trade overlap, interfaces etc	Various, slips, trips, falls	LL, C	Less overlap, multi-skilling
	MSD's, cuts etc	C	Should be easier to control in factory
Load onto transport	MSD's, cuts etc	C	Should be easier to control in factory
	Craneage	MC, C	Heavier loads – however, more controllable and usually mechanically handled
Transport	Road traffic etc	S, C	Same as insitu but fewer, larger loads
Delivery	Craneage	MC, C	Heavier loads, more craneage but less ad-hoc
	Manual handling	LL	Craneage not man handling
On Site Activities	**Main Hazards**	**Cf insitu**	**Opinions/Evidence**
Installation of pod to floor level	Craneage	N, MC, LL, C	Onto loading platform or launched onto slab – heavier / more complex but very much fewer / more controllable
	Temporary works collapse	MC	Loading platform
Movement of pod across floor	MSD's, slips & trips	N	New risk as pulling/pushing heavy load across floor – but not ad hoc and should be controllable
	MSD's	N	New risk as pulling/pushing heavy load into place – but not ad hoc and should be controllable
	Cuts, MSD's, Electrocution	LL	More straight forward with pods
	Cuts, MSD's, Electrocution, congested work areas	LL	Less on-site commissioning needed
	Slips, trips, falls	LL	Significantly less onsite workers will reduce risk Significantly less trade overlap

NB – Very similar issues apply to kitchen pods, shower-room pods etc

Risk change code (insitu>>pre-assembled): S = same (no change) R = Risk removed N = New risk LL = Less likely ML = More likely LC = less serious consequence MC = more serious consequence C = more controllable

Internals Toilets/Washrooms (Commercial)

Activities based on blockwork with insitu plaster and tiling with site installed services, sanitary ware etc verses internally fully finished factory built steel framed modules

Main H&S issues: crouching, congested/restricted space work, wet work, interaction of trades, material handling

Insitu Washrooms/Toilets

Opinions/Evidence		Main Hazards	Off Site Activities
Industrialised processes – outside HASPREST scope		Industrialised processes – outside the scope of this project	Manufacture of materials and fittings etc
Ad hoc		Road traffic etc	Transport
Ad hoc – often poorly controlled	ML	Manual handling etc	Delivery
Opinions/Evidence		**Main Hazards**	**On Site Activities**
	A	Man hand materials, MSDs, bending, dermatitis	Blockwork
As floor screed	A	Manual handling materials, MSD's, crouching, bending, dermatitis, pumping of screed	Floor Screed
	ML	MSD's, work overhead, step ladders, dermatitis	Plaster / render to walls / ceilings
Removing overlapping trades is the main benefit of pods	ML	Cuts, crouching, bending, congested work areas, overlapping interfacing trades	1st fix joinery / plumbing / electrical
	ML	Manual handling materials, MSD's, crouching, bending, restricted work areas, dermatitis	Tiling
Removing overlapping trades is the main benefit of pods	ML	Cuts, crouching, bending, congested work areas, overlapping interfacing trades	2nd fix Joinery / plumbing / electrical
As suspended ceilings	ML	Work overhead, cuts (hangers), step ladders	Suspended ceilings (if required)
	ML	MSD's, crouching, bending	Accessory fix
Removing overlapping trades is the main benefit of pods	ML/A	Cuts, crouching, bending, congested work areas, overlapping interfacing trades	3rd Fix Joinery / plumbing / electrical
	ML	Congested, restricted work areas, electrocution	Commissioning
More site labour	ML	Slips, trips, falls	Ancillary site risks
Major benefit of OSP	A	Especially overlapping trades issues	

Toilet Pods

Off Site Activities	Main Hazards	Cf insitu	Opinions/Evidence
Manufacture of materials and fittings etc	Industrialised processes – outside HASPREST scope		Industrialised processes – outside the scope of this project
Deliver materials etc to factory	Various	LL, C	More controlled as fixed location
Assemble pod structure	Manual / mechanical handling	LL, C	More chance to mechanise
	MSD's, cuts etc	LL, C	Should be easier to control in factory
	Overhead work	MC, C	Overhead craneage etc – but controllable
	MSD's, cuts etc	LL, C	Should be easier to control in factory
	MSD's, cuts	S	Same as site drylining but easier to control in factory
	Manual handling	LL	Materials mechanically handled right to workface
Install supports etc for fittings	MSD's, cuts etc	C	Should be easier to control in factory
	MSD's, cuts etc	C	Should be easier to control in factory
Internal partitions	MSD's, cuts etc	S, C	Same as site drylining but easier to control in factory
	Manual handling	LL	Materials mechanically handled right to workface
Wall and floor tiling	MSD's, crouching, restricted work area etc	C	Should be easier to control in factory
			Could consider pre-assembled pre-tiled panels
	Manual handling	LL	Materials can be mechanically handled right to workface
Install fittings	MSDs, HAVS, crouching, restricted work area etc	S, C	Should be easier to control in factory
Decoration	MSD's, step ladders etc	S, C	Should be easier to control in factory
Final fix services	MSD's, HAVS, cuts etc	S, C	Should be easier to control in factory
	Congested/restricted work areas	C	Should be easier to control in factory
	Electrocution	LL	Better control of 'power-on' etc
Doors etc	MSD's, cuts etc	C	Should be easier to control in factory
Trade overlap, interfaces etc	Various, slips, trips, falls	LL, C	Less overlap, multi-skilling
	MSD's, cuts etc	C	Should be easier to control in factory
Load onto transport	MSD's, cuts etc	C	Should be easier to control in factory
	Craneage	MC, C	Heavier loads – however, more controllable and usually mechanically handled
Transport	Road traffic etc	S, C	Same as insitu but fewer, larger loads
Delivery	Craneage	MC, C	Heavier loads, more craneage but less ad-hoc
	Manual handling	LL	Craneage not man handling
On Site Activities	**Main Hazards**	**Cf insitu**	**Opinions/Evidence**
Installation of pod to floor level	Craneage	N, MC, LL, C	Onto loading platform or launched onto slab – heavier / more complex but very much fewer / more controllable
	Temporary works collapse	MC	Loading platform
Movement of pod across floor	MSDs, slips & trips	N	New risk as pulling/pushing heavy load across floor – but not ad hoc and should be controllable
	MSDs	N	New risk as pulling/pushing heavy load into place – but not ad hoc and should be controllable
	Cuts, MSD's, Electrocution	LL	More straight forward with pods
	Cuts, MSD's, Electrocution, congested work areas	LL	Less on-site commissioning needed
	Slips, trips, falls	LL	Significantly less onsite workers will reduce risk
			Significantly less trade overlap

NB – Very similar issues apply to kitchen pods, shower-room pods etc

Risk change code (insitu>>pre-assembled): S = same (no change) R = Risk removed N = New risk LL = Less likely ML = More likely LC = less serious consequence MC = more serious consequence C = more controllable

Internals Kitchens (Commercial)

Activities based on site installed kitchens sanitary ware etc verses internally fully finished factory built kitchen modules
Main H&S issues: crouching, congested/restricted space work, wet work, interaction of trades, material handling

Insitu kitchens

Opinions/Evidence		Main Hazards	Off Site Activities
Industrialised processes – outside HASPREST scope		Industrialised processes – outside the scope of this project	Manufacture of materials and fittings etc
Ad hoc		Road traffic etc	Transport
Ad hoc – often poorly controlled	ML	Manual handling etc	Delivery
Opinions/Evidence		**Main Hazards**	**On Site Activities**
	A	Man hand materials, MSD's, bending, dermatitis	Prepare site for trades
As floor screed	A	Manual handling materials, MSD's, crouching, bending, dermatitis, pumping of screed	Floor Screed
	ML	MSD's, work overhead, step ladders, dermatitis	Plaster / render to walls / ceilings
Removing overlapping trades is the main benefit of pods	ML	Cuts, crouching, bending, congested work areas, overlapping interfacing trades	1st fix joinery / plumbing / electrical
	ML	Manual handling materials, MSD's, crouching, bending, restricted work areas, dermatitis	Tiling
Removing overlapping trades is the main benefit of pods	ML	Cuts, crouching, bending, congested work areas, overlapping interfacing trades	2nd fix Joinery / plumbing / electrical
As suspended ceilings	ML	Work overhead, cuts (hangers), step ladders	Suspended ceilings (if required)
	ML	MSD's, crouching, bending	Accessory fix, carcass, sink, appliances etc.
Removing overlapping trades is the main benefit of pods	ML/A	Cuts, crouching, bending, congested work areas, overlapping interfacing trades	3rd Fix Joinery / plumbing / electrical
	ML	Congested, restricted work areas, electrocution	Commissioning
More site labour	ML	Slips, trips, falls	Ancillary site risks
Major benefit of OSP	A	Especially overlapping trades issues	

Kitchens Pods

Off Site Activities	Main Hazards	Cf insitu	Opinions/Evidence
Manufacture of materials and fittings etc	Industrialised processes – outside HASPREST scope		Industrialised processes – outside the scope of this project
Deliver materials etc to factory	Various	LL, C	More controlled as fixed location
Assemble pod structure	Manual / mechanical handling	LL, C	More chance to mechanise
Fix steel floor frame	MSD's, cuts etc	LL, C	Should be easier to control in factory
Fix wall steel frame	Overhead work	MC, C	Overhead craneage etc – but controllable
	MSD's, cuts etc	LL, C	Should be easier to control in factory
	MSD's, cuts	S	Same as site drylining but easier to control in factory
	Manual handling	LL	Materials mechanically handled right to workface
Install supports etc for fittings	MSD's, cuts etc	C	Should be easier to control in factory
	MSD's, cuts etc	C	Should be easier to control in factory
Internal partitions	MSD's, cuts etc	S, C	Same as site drylining but easier to control in factory
	Manual handling	LL	Materials mechanically handled right to workface
Wall and floor tiling	MSD's, crouching, restricted work area etc	C	Should be easier to control in factory Could consider pre-assembled pre-tiled panels
	Manual handling	LL	Materials can be mechanically handled right to workface
Install carcass, sink, appliances	MSD's, HAVS, crouching, restricted work area etc	S, C	Should be easier to control in factory
Decoration	MSD's, step ladders etc	S, C	Should be easier to control in factory
Final fix services	MSD's, HAVS, cuts etc	S, C	Should be easier to control in factory
	Congested/restricted work areas	C	Should be easier to control in factory
	Electrocution	LL	Better control of 'power-on' etc
Doors etc	MSD's, cuts etc	C	Should be easier to control in factory
Trade overlap, interfaces etc	Various, slips, trips, falls	LL, C	Less overlap, multi-skilling
	MSD's, cuts etc	C	Should be easier to control in factory
Load onto transport	MSD's, cuts etc	C	Should be easier to control in factory
	Craneage	MC, C	Heavier loads – however, more controllable and usually mechanically handled
Transport	Road traffic etc	S, C	Same as insitu but fewer, larger loads
Delivery	Craneage	MC, C	Heavier loads, more craneage but less ad-hoc
	Manual handling	LL	Craneage not man handling
On Site Activities	**Main Hazards**	**Cf insitu**	**Opinions/Evidence**
Installation of pod to floor level	Craneage	N, MC, LL, C	Onto loading platform or launched onto slab – heavier / more complex but very much fewer / more controllable
	Temporary works collapse	MC	Loading platform
Movement of pod across floor	MSD's, slips & trips	N	New risk as pulling/pushing heavy load across floor – but not ad hoc and should be controllable
	MSD's	N	New risk as pulling/pushing heavy load into place – but not ad hoc and should be controllable
	Cuts, MSD's, Electrocution	LL	More straight forward with pods
	Cuts, MSD's, Electrocution, congested work areas	LL	Less on-site commissioning needed
	Slips, trips, falls	LL	Significantly less onsite workers will reduce risk Significantly less trade overlap

Risk change code (insitu>>pre-assembled): S = same (no change) R = Risk removed N = New risk LL = Less likely ML = More likely LC = less serious consequence MC = more serious consequence C = more controllable

Internals Kitchens (Commercial)

Activities based on site installed kitchens sanitary ware etc verses timber frame internally fully finished factory built kitchen modules
Main H&S issues: crouching, congested/restricted space work, wet work, interaction of trades, material handling

Insitu kitchens

Opinions/Evidence		Main Hazards	Off Site Activities
Industrialised processes – outside HASPREST scope		Industrialised processes – outside the scope of this project	Manufacture of materials and fittings etc
Ad hoc		Road traffic etc	Transport
Ad hoc – often poorly controlled	ML	Manual handling etc	Delivery
Opinions/Evidence		**Main Hazards**	**On Site Activities**
	A	Man hand materials, MSD's, bending, dermatitis	Prepare site for trades
As floor screed	A	Manual handling materials, MSD's, crouching, bending, dermatitis, pumping of screed	Floor Screed
	ML	MSD's, work overhead, step ladders, dermatitis	Plaster / render to walls / ceilings
Removing overlapping trades is the main benefit of pods	ML	Cuts, crouching, bending, congested work areas, overlapping interfacing trades	1st fix joinery / plumbing / electrical
	ML	Manual handling materials, MSD's, crouching, bending, restricted work areas, dermatitis	Tiling
Removing overlapping trades is the main benefit of pods	ML	Cuts, crouching, bending, congested work areas, overlapping interfacing trades	2nd fix Joinery / plumbing / electrical
As suspended ceilings	ML	Work overhead, cuts (hangers), step ladders	Suspended ceilings (if required)
	ML	MSD's, crouching, bending	Accessory fix, carcass, sink, appliances etc.
Removing overlapping trades is the main benefit of pods	ML/A	Cuts, crouching, bending, congested work areas, overlapping interfacing trades	3rd Fix Joinery / plumbing / electrical
	ML	Congested, restricted work areas, electrocution	Commissioning
More site labour	ML	Slips, trips, falls	Ancillary site risks
Major benefit of OSP	A	Especially overlapping trades issues	

Kitchens Pods

Off Site Activities	Main Hazards	Cf insitu	Opinions/Evidence
Manufacture of materials and fittings etc	Industrialised processes – outside HASPREST scope		Industrialised processes – outside the scope of this project
Deliver materials etc to factory	Various	LL, C	More controlled as fixed location
Assemble timber frame pod structure	Manual / mechanical handling	LL, C	More chance to mechanise
	MSD's, cuts etc	LL, C	Should be easier to control in factory
	Overhead work	MC, C	Overhead craneage etc – but controllable
	MSD's, cuts etc	LL, C	Should be easier to control in factory
	MSD's, cuts	S	Same as site drylining but easier to control in factory
	Manual handling	LL	Materials mechanically handled right to workface
Install supports etc for fittings	MSD's, cuts etc	C	Should be easier to control in factory
	MSD's, cuts etc	C	Should be easier to control in factory
Internal partitions	MSD's, cuts etc	S, C	Same as site drylining but easier to control in factory
	Manual handling	LL	Materials mechanically handled right to workface
Wall and floor tiling	MSD's, crouching, restricted work area etc	C	Should be easier to control in factory Could consider pre-assembled pre-tiled panels
	Manual handling	LL	Materials can be mechanically handled right to workface
Install carcass, sink, appliances	MSD's, HAVS, crouching, restricted work area etc	S, C	Should be easier to control in factory
Decoration	MSD's, step ladders etc	S, C	Should be easier to control in factory
Final fix services	MSD's, HAVS, cuts etc	S, C	Should be easier to control in factory
	Congested/restricted work areas	C	Should be easier to control in factory
	Electrocution	LL	Better control of 'power-on' etc
Doors etc	MSD's, cuts etc	C	Should be easier to control in factory
Trade overlap, interfaces etc	Various, slips, trips, falls	LL, C	Less overlap, multi-skilling
	MSD's, cuts etc	C	Should be easier to control in factory
Load onto transport	MSD's, cuts etc	C	Should be easier to control in factory
	Craneage	MC, C	Heavier loads – however, more controllable and usually mechanically handled
Transport	Road traffic etc	S, C	Same as insitu but fewer, larger loads
Delivery	Craneage	MC, C	Heavier loads, more craneage but less ad-hoc
	Manual handling	LL	Craneage not man handling
On Site Activities	**Main Hazards**	**Cf insitu**	**Opinions/Evidence**
Installation of pod to floor level	Craneage	N, MC, LL, C	Onto loading platform or launched onto slab – heavier / more complex but very much fewer / more controllable
	Temporary works collapse	MC	Loading platform
Movement of pod across floor	MSD's, slips & trips	N	New risk as pulling/pushing heavy load across floor – but not ad hoc and should be controllable
	MSD's	N	New risk as pulling/pushing heavy load into place – but not ad hoc and should be controllable
	Cuts, MSD's, Electrocution	LL	More straight forward with pods
	Cuts, MSD's, Electrocution, congested work areas	LL	Less on-site commissioning needed
	Slips, trips, falls	LL	Significantly less onsite workers will reduce risk Significantly less trade overlap

Risk change code (insitu>>pre-assembled): S = same (no change) R = Risk removed N = New risk LL = Less likely ML = More likely LC = less serious consequence MC = more serious consequence C = more controllable

Process Plant – Site Installation vs Modules (Civil)

Main H&S issues, working at height, Hot work, contaminated land, craneage, dis-investment of existing material, structure.
Activities based on site installation of process plant (petrochemical,) vs OSP Process plant modules

Site installation of process plant

Opinions/Evidence	cf OSP	Main Hazards	Off-Site Activities
Industrialised process should be well organised with risks minimised		Various – but outside scope of HASPREST	Manufacture of base materials
Same for OSP factory		Transport, handling etc	Deliveries of base materials to suppliers
Should be well organised with risks minimised		Various – but outside scope of HASPREST	Manufacture of components
More ad hoc deliveries	ML	Road traffic	Transport components to site
More ad hoc deliveries	ML	Craneage, plant, access etc	Deliveries

Opinions/Evidence	cf OSP	Main Hazards	On-Site Activities
	S		Prepare site for installation of process plant and equipment
	A	MH, MSD's, contaminated land. Electrocution, gas explosion. COSHH	Trial dig on site, determine location of services, gas, electric
Details depend on formwork design –crane-handled pre-formed systems reduce many of these risks	A	MH, MSD's, cuts, hand injuries, power tools, falls from height, (concrete risks), (Rebar risks)	Foundation formwork (assume site-made timber shutters)
	A	Craneage, skip (maybe pump), falls from height, dermatitis,	Place foundation concrete
	A	HAVS, MSD's, MH	Vibrate foundation concrete
	A	Material falling, cuts from nails etc, MSD's, MH	Strike foundation formwork
	A	MH, MSD's, hand injuries, falls from height	Prepare site for erection of steelwork for dressed towers
	A	MH, MSD's, cuts, hand injuries, falls from height, power tools, material falling.	Erect steel columns and connect beams.
	A	Craneage, MH, MSD's, cuts, working in confined areas, trips, falls from height. HAVS (power tool usage)	Install main process plant equipment, pipework
Interaction of trades	ML	MH, MSD's RSI, HAVS (power tool usage)	Install taps, valves and instrumentation
Inter-action of trades	ML	Falls from height, electrocution, confined space work	Install main cabling and test
	ML	HAVS, MSD's, MH, trips, falls from height HAVS (power tool usage)	Miscellaneous components
	S	MH, MSD's, HAVS (if power float), COSHH (curing agent), MSDs & slips (polythene to cure)	
	A	Material falling, cuts from nails etc, MSD's, MH, falls from height	Pressure testing
	ML	MSD's, MH, COSHH (Release agent), cuts (scrapers)	Power on "live" tests
		Material falling, MSD's, MH, falls from height	Final commissioning
	ML	Slips, trips, falls	Ancillary site risks

Process Plant modules

Off-Site Activities	Main Hazards	cf insitu	Opinions/Evidence
Manufacture of materials and fittings etc	Industrialised processes – outside HASPREST scope		Industrialised processes – outside the scope of this project
Deliver materials etc to factory	Various	LL, C	More controlled as fixed location
Assemble frame structure	Manual / mechanical handling	LL, C	More chance to mechanise
Weld channels / box sections	MSD's, cuts etc burns, fumes	LL, C	Should be easier to control in factory
Paint frame	Overhead work, COSHH		
Install plinth/box sections for switchgear	MH, mechanical handling	MC, C	More control, clean environment less risk of contamination, electrical shorts.
Install main plant items, pumps, process control equipment			
Install pipework, fittings valves			
Install cable trays, and cables	MSD's, cuts etc	C	Should be easier to control in factory
Install switchgear, instrumentation and control panels	Manual handling	C	Should be easier to control in factory
Final fix services	MSD's, HAVS, cuts etc	S, C	Should be easier to control in factory
Commissioning	Congested/restricted work areas	C	Should be easier to control in factory
------ " -------	Electrocution	LL	Better control of 'power-on' etc
Doors access covers, walkways etc	MSD's, cuts welds, burns fumes etc	C	Should be easier to control in factory
Trade overlap, interfaces etc	Various, slips, trips, falls	LL, C	Less overlap, multi-skilling
Prepare for transportation	MSD's, cuts etc	C	Should be easier to control in factory
Load onto transport	MSD's, cuts etc	C	Should be easier to control in factory
------ " -------	Craneage	MC, C	Heavier loads – however, more controllable and usually mechanically handled
Transport	Road traffic etc	S, C	Same as insitu but fewer, larger loads. Overhead craneage etc – but controllable

On-Site Activities	Main Hazards	cf insitu	Opinions/Evidence
Installation of packaged plant room module to floor level	Craneage	N, MC, LL, C	Onto loading platform or launched onto slab – heavier / more complex but very much fewer / more controllable
------ " -------	Temporary works collapse	MC	Loading platform
Movement of packaged plant room module across floor	MSD's, slips & trips	N	New risk as pulling/pushing heavy load across floor – but not ad hoc and should be controllable
	Cuts, MSD's, Electrocution	LL	More straight forward with modules
	Cuts, MSD's, Electrocution, congested work areas	LL	Less on-site commissioning needed
	Slips, trips, falls	LL	Significantly less onsite workers will reduce risk Significantly less trade overlap

Risk change code (insitu>>pre-assembled): S = same (no change) R = Risk removed A = Additional (new) risk LL = Less likely ML = More likely LC = less serious consequence MC = more serious consequence C = more controllable

Process Plant – Site Installation vs Modules (Civil)

Main H&S issues, working at height, Hot work, contaminated land, craneage, dis-investment of existing material, structure.
Activities based on site installation of process plant (petrochemical,) vs OSP Process plant distribution

Site installation of process plant

Opinions/Evidence	cf OSP	Main Hazards	Off-Site Activities
Industrialised process should be well organised with risks minimised		Various – but outside scope of HASPREST	Manufacture of base materials
Same for OSP factory		Transport, handling etc	Deliveries of base materials to suppliers
Should be well organised with risks minimised		Various – but outside scope of HASPREST	Manufacture of components
More ad hoc deliveries	ML	Road traffic	Transport components to site
More ad hoc deliveries	ML	Craneage, plant, access etc	Deliveries

Opinions/Evidence	cf OSP	Main Hazards	On-Site Activities
	S		Prepare site for installation of process plant and equipment
	A	MH, MSD's, contaminated land. Electrocution, gas explosion. COSHH	Trial dig on site, determine location of services, gas, electric
Details depend on formwork design –crane-handled pre-formed systems reduce many of these risks	A	MH, MSD's, cuts, hand injuries, power tools, falls from height, (concrete risks), (Rebar risks)	Plinth formwork (assume site-made timber shutters)
	A	Craneage, skip (maybe pump), falls from height, dermatitis,	Place plinth concrete
	A	HAVS, MSD's, MH	Vibrate plinth concrete
	A	Material falling, cuts from nails etc, MSD's, MH	Strike plinth formwork
	A	MH, MSD's, hand injuries, falls from height	Prepare site for erection of steel angle support cradles for pipework
	A	MH, MSD's, cuts, hand injuries, falls from height, power tools, material falling.	Erect steel support cradles.
	A	Craneage, MH, MSD's, cuts, working in confined areas, trips, falls from height. HAVS (power tool usage)	Install pipework
Interaction of trades	ML	MH, MSD's RSI, HAVS (power tool usage)	Install taps, valves and instrumentation
Inter-action of trades	ML	Falls from height, electrocution, confined space work	Install main cabling and test
	ML	HAVS, MSD's, MH, trips, falls from height HAVS (power tool usage)	Miscellaneous components
	S	MH, MSD's, HAVS (if power float), COSHH (curing agent), MSDs & slips (polythene to cure)	
	A	Material falling, cuts from nails etc, MSD's, MH, falls from height	Pressure testing
	ML	MSD's, MH, COSHH (Release agent), cuts (scrapers)	Power on "live" tests
		Material falling, MSD's, MH, falls from height	Final commissioning
	ML	Slips, trips, falls	Ancillary site risks

Process Plant distribution modules

Off-Site Activities	Main Hazards	cf insitu	Opinions/Evidence
Manufacture of materials and fittings etc	Industrialised processes – outside HASPREST scope		Industrialised processes – outside the scope of this project
Deliver materials etc to factory	Various	LL, C	More controlled as fixed location
Assemble frame structure	Manual / mechanical handling	LL, C	More chance to mechanise
Weld channels / box sections	MSD's, cuts etc burns, fumes	LL, C	Should be easier to control in factory
Paint frame	Overhead work, COSHH		
Install brackets for pipework	MH, mechanical handling	MC, C	More control, clean environment less risk of contamination, electrical shorts.
Install main pipework,			
Install fittings and valves			
Install cable trays, and cables	MSD's, cuts etc	C	Should be easier to control in factory
Install switchgear, instrumentation and control panels	Manual handling	C	Should be easier to control in factory
Final fix services	MSD's, HAVS, cuts etc	S, C	Should be easier to control in factory
Commissioning	Congested/restricted work areas	C	Should be easier to control in factory
	Electrocution	LL	Better control of 'power-on' etc
Doors access covers, walkways etc	MSD's, cuts welds, burns fumes etc	C	Should be easier to control in factory
Trade overlap, interfaces etc	Various, slips, trips, falls	LL, C	Less overlap, multi-skilling
Prepare for transportation	MSD's, cuts etc	C	Should be easier to control in factory
Load onto transport	MSD's, cuts etc	C	Should be easier to control in factory
	Craneage	MC, C	Heavier loads – however, more controllable and usually mechanically handled
Transport	Road traffic etc	S, C	Same as insitu but fewer, larger loads. Overhead craneage etc – but controllable

On-Site Activities	Main Hazards	cf insitu	Opinions/Evidence
Installation of packaged plant room module to floor level	Craneage	N, MC, LL, C	Onto loading platform or launched onto slab – heavier / more complex but very much fewer / more controllable
	Temporary works collapse	MC	Loading platform
Movement of packaged plant room module across floor	MSD's, slips & trips	N	New risk as pulling/pushing heavy load across floor – but not ad hoc and should be controllable
	Cuts, MSD's, Electrocution	LL	More straight forward with modules
	Cuts, MSD's, Electrocution, congested work areas	LL	Less on-site commissioning needed
	Slips, trips, falls	LL	Significantly less onsite workers will reduce risk Significantly less trade overlap

Risk change code (insitu>>pre-assembled): S = same (no change) R = Risk removed A = Additional (new) risk LL = Less likely ML = More likely LC = less serious consequence MC = more serious consequence C = more controllable

Bridges – Insitu concrete vs PC concrete (Civil)
Main H&S issues, working at height, craneage, insitu concrete risks, rebar risks, overlapping trades,
Activities based on insitu abutments piers, deck and parapets vs PC concrete earth retaining panels "Re-co" system, PC columns, and PC decking slabs

Insitu Concrete

Opinions/Evidence	cf OSP	Main Hazards	Off-Site Activities
Industrialised process should be well organised with risks minimised		Various – but outside scope of HASPREST	Manufacture of base materials
Same for OSP factory		Transport, handling etc	Deliveries of base materials to ready-mix plant
Should be well organised with risks minimised		Various – but outside scope of HASPREST	Ready-mix concrete manufacture
More ad hoc deliveries	ML	Road traffic	Transport materials to site
More ad hoc deliveries	ML	Craneage, plant, access etc	Deliveries

Opinions/Evidence	cf OSP	Main Hazards	On-Site Activities
	S	Concrete burns, dermatitis	Excavate to formation level
	A	MH, MSD's, cuts, RSI tying bars	Place blinding concrete
Details depend on formwork design – crane-handled pre-formed systems reduce many of these risks	A	MH, MSD's, cuts, hand injuries, power tools, falls from height	Set out place and fix reinforcement main abutment slabs
	A	Craneage, skip (maybe pump), falls from height, dermatitis,	Place and erect formwork to abutment base
	A	HAVS, MSD's, MH	Place abutment concrete
	A	Material falling, cuts from nails etc, MSD's, MH	Strike abutment formwork
			Reinforcement to abutment wall and wing wall
Details depend on falsework design – crane-handled pre-formed systems reduce many of these risks	A	MH, MSD's, hand injuries, material falling, falls from height	Abutment wall and wing wall false work
Details depend on formwork design – crane-handled pre-formed systems reduce many of these risks	A	MH, MSD's, cuts, hand injuries, falls from height, power tools	Abutment wall and wing wall formwork
Access across slab rebar is particularly hazardous for all workers	A	MH, MSD's, cuts, RSI tying bars, trips, falls from height	Place abutment wall and wing wall reinforcement
Much more slab concrete required cf PC slab topping	ML	Pump – Plant, MH pipes, falls (knocked by pipe), dermatitis, blow-out (maybe crane/skip), clean out pipes	Place Abutment wall and wing wall concrete
Much more slab concrete required cf PC slab topping	ML	Concrete – dermatitis, concrete burns, trips (on rebar), falls from height	Prepare site for intermediate pier wall piles
Danger of hand injury at "clinch"	A	HAVS, whole body vibration	Drive intermediate larrson piles
Manual excavation often necessary at Larrson pile "bust"	A	Plant, weils disease, collapse of material, falls,	Excavate to pier slab foundation level
	A	Concrete burns, wet work,	Blinding concrete
Normally large 50mm bars, heavy MH	A	Cuts, RSI, MH	Place reinforcement
	A	RSI, MH	Falsework, formwork to pier wall slab foundation,
	A	Vibration, dermatitis, MH, MSD's	Place concrete
	A	Cuts, MSD's RSI, MH, falling material	Strike formwork
	A	Cuts, RSI, MH	Reinforcement to pier walls
Manual handling of bearings	A	RSI, MH	Falsework / formwork to intermediate pier walls including box outs for "Glacier" deck

Pre Cast Concrete

Off-Site Activities	Main Hazards	cf insitu	Opinions/Evidence
Deliveries of base materials	Transport, handling etc	S	Same for insitu
Set up PC moulds	Craneage, Mechanical handling, some MH, MSDs, cuts, COSHH (release agent)	LL,C	Work at ground level, or 'bench-height', more available purpose-made craneage, More industrialised process
Install & fix reinforcement	Craneage, mechanical handling, some MH, MSDs, cuts, RSI (rebar tying)	LL, C	Work at ground level, or 'bench-height', more available purpose-made craneage, more industrialised process
Place concrete	Craneage, Mechanical handling, some MH, MSDs, cuts, dermatitis	LL, C	Work at ground level, or 'bench-height', more available purpose-made craneage, more industrialised process
Finish top surface	Dermatitis, MSDs, COSHH (curing agent)	LL, C	Work at ground level, or 'bench-height', more available purpose-made craneage, more industrialised process
Remove mould formwork	MSDs, hand-injury,	LL,C	Should be easier to control in factory
Remove PC unit	Craneage, some MH, 'struck-by', 'trapped-by'	A	
Clean reusable moulds	COSHH, HAVS (power tools)	LL,C	
Ready-mix concrete manufacture	Various – but outside scope of HASPREST	LL	Should be well organised with risks minimised – less concrete required cf insitu
Transport PC units to site	Road traffic	LL	More organised deliveries
Transport ready-mix concrete to site	Road traffic	LL	Less concrete required cf insitu
Deliveries	Craneage, plant, access etc	LL	More organised deliveries

On-Site Activities	Main Hazards	cf insitu	Opinions/Evidence
Prepare site for abutment construction.	Concrete burns, dermatitis	S	
Excavate to formation level.	Hand injuries, dermatitis	A	
Formwork for strip foundation	Craneage, MH, 'struck-by', trapped hand, power tools/HAVS (bolts), falls from height (upper floors only)	A	
Install initial course of panels "reco" panels to bridge abutments	Craneage, MH, 'struck-by', trapped hand, power tools/HAVS (bolts), falls from height	A	Design to aid connections can significantly reduce many of these risks
compact			
back of panel			Operation of plant is stable on every level of backfill
			Regardless of height or length the structure is stable during construction. No need for scaffolding

Risk change code (insitu>>pre-assembled): S = same (no change) R = Risk removed A = Additional (new) risk LL = Less likely ML = More likely LC = less serious consequence MC = more serious consequence C = more controllable

Bridges – Insitu concrete vs PC concrete (Civil)

Main H&S issues, working at height, craneage, insitu concrete risks, rebar risks, overlapping trades,

Activities based on insitu abutments piers, deck and parapets vs PC concrete earth retaining panels “Re-co” system, PC columns, and PC decking slabs

			bearings				
	A	Vibration, dermatitis, MH, MSD’s	Place concrete to walls				
	A	Cuts, MSD’s RSI, MH, falling material	Strike formwork				
	A	MH, MSD’s	Prepare site for deck construction				
	A	RSI, MH	Falsework to deck				
	A	RSI, MH	Formwork to deck				
	A	Cuts, RSI, MH	Reinforcement to bridge deck				
	A	MH, MSD’s, RSI, falling material,	Formwork to bridge deck, including box outs and drainage channels services channels etc				
	A	Vibration, dermatitis, MH, MSD’s	Place concrete to bridge deck				
	A	Cuts, MSD’s RSI, MH, falling material	Strike formwork to bridge deck (after 30 days)				
Same surface area as PC insitu topping	S	MH, MSD’s, HAVS (if power float), COSHH (curing agent), MSDs & slips (polythene to cure)	Finish deck concrete	Formwork to connections, edges etc (fix and strike)	MH, MSD’s, cuts, hand injuries, falls from height, power tools	LL	Much less formwork than insitu option
		Cuts, RSI, MH	Reinforcement to parapets				
		MH, MSD’s, RSI, falling material	Formwork to parapets				
		Vibration, dermatitis, MH, MSD’s	Place concrete to parapets				
		Cuts, MSD’s RSI, MH, falling material	Strike concrete to parapets				
	S	MH, Falls, cuts	Install deck crash barrier				
	S	MH	Install rainwater drainage pipework				
	S	Mechanical handling	Place rip rap at abutment base and pier base				
	S	MSD’s asphalt/bitumen, plant, COSHH, fumes, burns etc, MH	Place wearing course to deck				
	S		accommodation works				
	S		Miscellaneous items				
	S		Landscape and				
Much more slab concrete required cf PC slab topping	ML	HAVS, MSD’s, MH, trips, falls from height		Make connections	HAVS & noise (bolt power tools), falls from height, bolts dropped, MH/MSD’s (adjust beam position), hand trap	A	Design to aid connections can significantly reduce many of these risks
Almost no formwork required for PC option	A	Material falling, cuts from nails etc, MSD’s, MH, falls from height	Strike slab/beam formwork	Concrete to connections	Craneage, skip, ‘struck-by’, falls from height, dermatitis	LL	Much less than insitu or metal deck options
Almost no formwork required for PC option	ML	MSD’s, MH, COSHH (Release agent), cuts (scrapers)	Refurbish ALL formwork	Place concrete topping	Pump – Plant, MH pipes, falls (knocked by pipe), dermatitis, blow-out (maybe crane/skip), clean out pipes	LL	Much less concrete that insitu concrete option
Details depend on falsework design – crane-handled pre-formed systems reduce many of these risks		Material falling, MSD’s, MH, falls from height	Move slab/beam formwork	Ancillary site risks	Slips, trips, falls	LL	Less site labour than insitu
More site labour required	ML	Slips, trips, falls	Ancillary site risks				

Notes: Highway bridge construction

Risk change code (insitu>>pre-assembled): S = same (no change) R = Risk removed A = Additional (new) risk LL = Less likely ML = More likely LC = less serious consequence MC = more serious consequence C = more controllable

Bridges – Insitu concrete vs Steel (Civil)

Main H&S issues, working at height, craneage, insitu concrete risks, rebar risks, overlapping trades,
Activities based on insitu abutments piers, deck and parapets vs steel girder / deck bridge construction

Insitu Concrete

Opinions/Evidence	cf OSP	Main Hazards	Off-Site Activities
Industrialised process should be well organised with risks minimised		Various – but outside scope of HASPREST	Manufacture of base materials
Same for OSP factory		Transport, handling etc	Deliveries of base materials to ready-mix plant
Should be well organised with risks minimised		Various – but outside scope of HASPREST	Ready-mix concrete manufacture
More ad hoc deliveries	ML	Road traffic	Transport materials to site
More ad hoc deliveries	ML	Craneage, plant, access etc	Deliveries
Opinions/Evidence	**cf OSP**	**Main Hazards**	**On-Site Activities**
	S	Concrete burns, dermatitis	Excavate to formation level
	A	MH, MSD's, cuts, RSI tying bars	Place blinding concrete
Details depend on formwork design – crane-handled pre-formed systems reduce many of these risks	A	MH, MSD's, cuts, hand injuries, power tools, falls from height	Set out place and fix reinforcement main abutment slabs
	A	Craneage, skip (maybe pump), falls from height, dermatitis,	Place and erect formwork to abutment base
	A	HAVS, MSD's, MH	Place abutment concrete
	A	Material falling, cuts from nails etc, MSD's, MH	Strike abutment formwork
			Reinforcement to abutment wall and wing wall
Details depend on falsework design – crane-handled pre-formed systems reduce many of these risks	A	MH, MSD's, hand injuries, material falling, falls from height	Abutment wall and wing wall falsework
Details depend on formwork design – crane-handled pre-formed systems reduce many of these risks	A	MH, MSD's, cuts, hand injuries, falls from height, power tools	Abutment wall and wing wall formwork
Access across slab rebar is particularly hazardous for all workers	A	MH, MSD's, cuts, RSI tying bars, trips, falls from height	Place abutment wall and wing wall reinforcement
Much more slab concrete required cf PC slab topping	ML	Pump – Plant, MH pipes, falls (knocked by pipe), dermatitis, blow-out (maybe crane/skip), clean out pipes	Place Abutment wall and wing wall concrete
Much more slab concrete required cf PC slab topping	ML	Concrete – dermatitis, concrete burns, trips (on rebar), falls from height	Prepare site for intermediate pier wall piles
Danger of hand injury at "clinch"	A	HAVS, whole body vibration	Drive intermediate larrson piles
Manual excavation often necessary at Larrson pile "bust"	A	Plant, weils disease, collapse of material, falls,	Excavate to pier slab foundation level
	A	Concrete burns, wet work,	Blinding concrete
Normally large 50mm bars, heavy MH	A	Cuts, RSI, MH	Place reinforcement
	A	RSI, MH	Falsework, formwork to pier wall slab foundation,
	A	Vibration, dermatitis, MH, MSD's	Place concrete
	A	Cuts, MSD's RSI, MH, falling material	Strike formwork
	A	Cuts, RSI, MH	Reinforcement to pier walls
Manual handling of bearings	A	RSI, MH	Falsework / formwork to intermediate pier walls including box outs for "Glacier" deck bearings
	A	Vibration, dermatitis, MH, MSD's	Place concrete to walls
	A	Cuts, MSD's RSI, MH, falling material	Strike formwork
	A	MH, MSD's	Prepare site for deck construction
	A	RSI, MH	Falsework to deck

Pre Cast Concrete

Off-Site Activities	Main Hazards	cf insitu	Opinions/Evidence
Deliveries of base materials	Transport, handling etc	S	Same for insitu
Roll / cut steel I and H Beams	Various – but outside scope of HASPREST	LL	Industrial process outside scope of HASPREST Should be well organised with risks minimised – less concrete required cf insitu
Transport Steel members to site	Road traffic	LL	More organised deliveries
	Road traffic	LL	Less concrete required cf insitu
Deliveries	Craneage, plant, access etc	LL	More organised deliveries
On-Site Activities	**Main Hazards**	**cf insitu**	**Opinions/Evidence**
Prepare site for abutment construction.	General site hazards, slips trips, plant etc	S	
Excavate to formation level.	Falling material, weils disease, working below ground level.	A	
Formwork for strip foundation	Craneage, MH, 'struck-by', trapped hand, power tools/HAVS (bolts), falls from height (upper floors only)	A	
Install beams, columns to bridge abutments	Craneage, MH, 'struck-by', trapped hand, power tools/HAVS (bolts), falls from height	A	Design to aid connections can significantly reduce many of these risks
Install deck substructure, beams, ties etc	Craneage, MH, 'struck-by', trapped hand, power tools/HAVS (bolts), falls from height		
Install steel decking	Craneage, MH, 'struck-by', trapped hand, power tools/HAVS (bolts), falls from height		
Make connections	HAVS & noise (bolt power tools), falls from height, bolts dropped, MH/MSDs (adjust beam position), hand trap	A	Design to aid connections can significantly reduce many of these risks
Ancillary site risks	Slips, trips, falls	LL	Less site labour than insitu

Risk change code (insitu>>pre-assembled): S = same (no change) R = Risk removed A = Additional (new) risk LL = Less likely ML = More likely LC = less serious consequence MC = more serious consequence C = more controllable

Bridges – Insitu concrete vs Steel (Civil)
Main H&S issues, working at height, craneage, insitu concrete risks, rebar risks, overlapping trades,
Activities based on insitu abutments piers, deck and parapets vs steel girder / deck bridge construction

	A	RSI, MH	Formwork to deck				
	A	Cuts, RSI, MH	Reinforcement to bridge deck				
	A	MH, MSD's, RSI, falling material,	Formwork to bridge deck, including box outs and drainage channels services channels etc				
			Place concrete to bridge deck				
			Strike formwork to bridge deck (after 30 days)				
Same surface area as PC insitu topping	S	MH, MSD's, HAVS (if power float), COSHH (curing agent), MSD's & slips (polythene to cure)	Finish deck concrete				
		Cuts, RSI, MH	Reinforcement to parapets				
			Formwork to parapets				
			Place concrete to parapets				
			Strike concrete to parapets				
			Install deck crash barrier				
			Install rainwater drainage pipework				
			Place rip rap at abutment base and pier base				
		MSD's asphalt/bitumen, plant, COSHH, fumes, burns etc, MH	Place wearing course to deck				
			accommodation works				
			Miscellaneous items				
			Landscape and				
Much more slab concrete required cf PC slab topping	ML	HAVS, MSD's, MH, trips, falls from height					
Almost no formwork required for PC option	A	Material falling, cuts from nails etc, MSDs, MH, falls from height	Strike slab/beam formwork				
Almost no formwork required for PC option	ML	MSDs, MH, COSHH (Release agent), cuts (scrapers)	Refurbish ALL formwork				
Details depend on falsework design – crane-handled pre-formed systems reduce many of these risks		Material falling, MSDs, MH, falls from height	Move slab/beam formwork				
More site labour required	ML	Slips, trips, falls	Ancillary site risks				

Notes: Highway bridge construction

Risk change code (insitu>>pre-assembled): S = same (no change) R = Risk removed A = Additional (new) risk LL = Less likely ML = More likely LC = less serious consequence MC = more serious consequence C = more controllable

Bridges – Insitu concrete vs Hybrid (Civil)

Main H&S issues, working at height, craneage, insitu concrete risks, rebar risks, overlapping trades,
Activities based on insitu abutments piers, deck and parapets vs hybrid steel/concrete / deck bridge construction

nsitu Concrete			
Opinions/Evidence	**cf OSP**	**Main Hazards**	**Off-Site Activities**
Industrialised process should be well organised with risks minimised		Various – but outside scope of HASPREST	Manufacture of base materials
Same for OSP factory		Transport, handling etc	Deliveries of base materials to ready-mix plant
Should be well organised with risks minimised		Various – but outside scope of HASPREST	Ready-mix concrete manufacture
More ad hoc deliveries	ML	Road traffic	Transport materials to site
More ad hoc deliveries	ML	Craneage, plant, access etc	Deliveries
Opinions/Evidence	**cf OSP**	**Main Hazards**	**On-Site Activities**
	S	See 'substructure concrete'	Excavate to formation level
	A	MH, MSDs, cuts, RSI tying bars	Place blinding concrete
Details depend on formwork design – crane-handled pre-formed systems reduce many of these risks	A	MH, MSDs, cuts, hand injuries, power tools, falls from height	Set out place and fix reinforcement main abutment slabs
	A	Craneage, skip (maybe pump), falls from height, dermatitis,	Place and erect formwork to abutment base
	A	HAVS, MSDs, MH	Place abutment concrete
	A	Material falling, cuts from nails etc, MSDs, MH	Strike abutment formwork
			Reinforcement to abutment wall and wing wall
Details depend on falsework design – crane-handled pre-formed systems reduce many of these risks	A	MH, MSDs, hand injuries, material falling, falls from height	Abutment wall and wing wall falsework
Details depend on formwork design – crane-handled pre-formed systems reduce many of these risks	A	MH, MSDs, cuts, hand injuries, falls from height, power tools	Abutment wall and wing wall formwork
Access across slab rebar is particularly hazardous for all workers	A	MH, MSDs, cuts, RSI tying bars, trips, falls from height	Place abutment wall and wing wall reinforcement
Much more slab concrete required cf PC slab topping	ML	Pump – Plant, MH pipes, falls (knocked by pipe), dermatitis, blow-out (maybe crane/skip), clean out pipes	Place Abutment wall and wing wall concrete
Much more slab concrete required cf PC slab topping	ML	Concrete – dermatitis, concrete burns, trips (on rebar), falls from height	Prepare site for intermediate pier wall piles
			Drive intermediate larrson piles Excavate to pier slab foundation level Blinding concrete Place reinforcement Falsework, forwork to pier wall slab foundation, Place concrete Strike formwork Reinforcement to peir walls Falsework / formwork to intermediate pier walls including box outs for "Glacier" deck bearings Place concrete to walls Strike formwork Prepare site for deck construction Falsework to deck Formwork to deck Reinforcement to bridge deck Formwork to bridge deck, including box outs and drainage channels services channels etc Place concrete to bridge deck

Steel/pre cast Concrete			
Off-Site Activities	**Main Hazards**	**cf insitu**	**Opinions/Evidence**
Deliveries of base materials	Transport, handling etc	S	Same for insitu
Roll / cut steel I and H Beams	Various – but outside scope of HASPREST	LL	Industrial process outside scope of HASPREST Should be well organised with risks minimised – less concrete required cf insitu
Transport Steel members to site	Road traffic	LL	More organised deliveries
	Road traffic	LL	Less concrete required cf insitu
Deliveries	Craneage, plant, access etc	LL	More organised deliveries
On-Site Activities	**Main Hazards**	**cf insitu**	**Opinions/Evidence**
Prepare site for abutment construction.	General site hazards, slips trips, plant etc	S	
Excavate to formation level.	*"See excavation"*	A	
Formwork for strip foundation	Craneage, MH, 'struck-by', trapped hand, power tools/HAVS (bolts), falls from height (upper floors only)	A	
Install beams, columns to bridge abutments	Craneage, MH, 'struck-by', trapped hand, power tools/HAVS (bolts), falls from height	A	Design to aid connections can significantly reduce many of these risks
Install deck substructure, beams, ties etc	Craneage, MH, 'struck-by', trapped hand, power tools/HAVS (bolts), falls from height		
Install steel decking	Craneage, MH, 'struck-by', trapped hand, power tools/HAVS (bolts), falls from height		
Make connections	HAVS & noise (bolt power tools), falls from height, bolts dropped, MH/MSDs (adjust beam position), hand trap	A	Design to aid connections can significantly reduce many of these risks
Ancillary site risks	Various (see ConCA)	LL	Less site labour than insitu

Risk change code (insitu>>pre-assembled): S = same (no change) R = Risk removed A = Additional (new) risk LL = Less likely ML = More likely LC = less serious consequence MC = more serious consequence C = more controllable

Bridges – Insitu concrete vs Hybrid (Civil)

Main H&S issues, working at height, craneage, insitu concrete risks, rebar risks, overlapping trades,
Activities based on insitu abutments piers, deck and parapets vs hybrid steel/concrete / deck bridge construction

			Strike formwork to bridge deck (after 30 days)				
Same surface area as PC insitu topping	S	MH, MSDs, HAVS (if powerfloat), COSHH (curing agent), MSDs & slips (polythene to cure)	Finish deck concrete				
			Reinforcement to parapets				
			Formwork to parapets				
			Place concrete to parapets				
			Strike concrete to parapets				
			Install deck crash barrier				
			Install rainwater drainage pipework				
			Place rip rap at abutment base and pier base				
		MSD's asphalt/bitumen, plant, COSHH, fumes, burns etc, MH	Place wearing course to deck				
			accommodation works				
			Miscellaneous items				
			Landscape and				
Much more slab concrete required cf PC slab topping	ML	HAVS, MSDs, MH, trips, falls from height					
Almost no formwork required for PC option	A	Material falling, cuts from nails etc, MSDs, MH, falls from height	Strike slab/beam formwork				
Almost no formwork required for PC option	ML	MSDs, MH, COSHH (Release agent), cuts (scrapers)	Refurbish ALL formwork				
Details depend on falsework design – crane-handled pre-formed systems reduce many of these risks		Material falling, MSDs, MH, falls from height	Move slab/beam formwork				
More site labour required	ML	Various (see ConCA)	Ancillary site risks				

Notes: Highway bridge construction

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Infrastructure – Insitu concrete culverts vs PC concrete culverts (Civil)

Main H&S issues, working below ground level, exposed open trenches, craneage, insitu concrete risks, rebar risks, overlapping trades,
Activities based on insitu concrete culvert vs PC concrete culvert box sections

Insitu Concrete

Opinions/Evidence	cf OSP	Main Hazards	Off-Site Activities
Industrialised process should be well organised with risks minimised		Various – but outside scope of HASPREST	Manufacture of base materials
Same for OSP factory		Transport, handling etc	Deliveries of base materials to ready-mix plant
Should be well organised with risks minimised		Various – but outside scope of HASPREST	Ready-mix concrete manufacture
More ad hoc deliveries	ML	Road traffic	Transport materials to site
More ad hoc deliveries	ML	Craneage, plant, access etc	Deliveries

Opinions/Evidence	cf OSP	Main Hazards	On-Site Activities
	S	Working below ground level, trench collapse, weils disease,	Excavate to formation level
	A	MH, MSDs, cuts, dermatitis	Place blinding concrete
Access across slab rebar is particularly hazardous for all workers	A	MH, MSDs, cuts, RSI tying bars, trips, falls from height	Set out place and fix reinforcement to culvert ground slab
Details depend on formwork design – crane-handled pre-formed systems reduce many of these risks	A	MH, MSDs, cuts, hand injuries, falls from height, power tools	Place and erect formwork to culvert base slab
Much more slab concrete required cf PC slab topping	ML	Pump – Plant, MH pipes, falls (knocked by pipe), dermatitis, blow-out (maybe crane/skip), clean out pipes	Place culvert slab concrete
Much more slab concrete required cf PC slab topping	ML	HAVS, MSDs, MH, trips, falls from height	Vibrate / compact slab concrete
	A	Material falling, cuts from nails etc, MSDs, MH	Strike slab concrete
Access across slab rebar is particularly hazardous for all workers	A	MH, MSDs, cuts, RSI tying bars, trips, falls from height	Reinforcement to culvert walls.
Details depend on formwork design – crane-handled pre-formed systems reduce many of these risks	A	MH, MSDs, cuts, hand injuries, falls from height, power tools	Formwork to culvert walls
Much more slab concrete required cf PC slab topping	ML	Pump – Plant, MH pipes, falls (knocked by pipe), dermatitis, blow-out (maybe crane/skip), clean out pipes	Place concrete
Much more slab concrete required cf PC slab topping	ML	HAVS, MSDs, MH, trips, falls from height	Vibrate concrete
	A	Material falling, cuts from nails etc, MSDs, MH	Strike concrete
Details depend on falsework design – crane-handled pre-formed systems reduce many of these risks	A	MH, MSDs, hand injuries, material falling, falls from height	Falsework, forms to roof slab
Access across slab rebar is particularly hazardous for all workers	A	MH, MSDs, cuts, RSI tying bars, trips, falls from height	Reinforcement to roof slab
Details depend on formwork design – crane-handled pre-formed systems reduce many of these risks	A	MH, MSDs, cuts, hand injuries, falls from height, power tools	Formwork to roof slab
Much more slab concrete required cf PC slab topping	ML	Pump – Plant, MH pipes, falls (knocked by pipe), dermatitis, blow-out (maybe crane/skip), clean out pipes	Place concrete
Much more slab concrete required cf PC slab topping	ML	HAVS, MSDs, MH, trips, falls from height	Vibrate concrete
	A	Material falling, cuts from nails etc, MSDs, MH	Strike formwork
Same surface area as PC insitu topping	S	MH, MSDs, HAVS (if power float), COSHH (curing agent), MSDs & slips (polythene to cure)	Concrete finishes
			Accommodation works
	A		Miscellaneous items

Pre Cast Concrete

Off-Site Activities	Main Hazards	cf insitu	Opinions/Evidence
Deliveries of base materials	Transport, handling etc	S	Same for insitu
Set up PC moulds	Craneage, Mechanical handling, some MH, MSDs, cuts, COSHH (release agent)	LL,C	Work at ground level, or 'bench-height', more available purpose-made craneage, More industrialised process
Install & fix reinforcement	Craneage, mechanical handling, some MH, MSDs, cuts, RSI (rebar tying)	LL, C	Work at ground level, or 'bench-height', more available purpose-made craneage, more industrialised process
Place concrete grade 50 RHPC	Craneage, Mechanical handling, some MH, MSDs, cuts, dermatitis	LL,C	Work at ground level, or 'bench-height', more available purpose-made craneage, more industrialised process
Finish top surface	Dermatitis, MSDs, COSHH (curing agent)	LL, C	Work at ground level, or 'bench-height', more available purpose-made craneage, more industrialised process
Remove mould formwork	MSDs, hand-injury,	LL,C	Should be easier to control in factory
Remove PC unit	Craneage, some MH, 'struck-by', 'trapped-by'	A	
Clean reusable moulds	COSHH, HAVS (power tools)	LL,C	
Ready-mix concrete manufacture	Various – but outside scope of HASPREST	LL	Should be well organised with risks minimised – less concrete required cf insitu
Transport PC culvert units to site	Road traffic	LL	More organised deliveries
Deliveries	Craneage, plant, access etc	LL	More organised deliveries

On-Site Activities	Main Hazards	cf insitu	Opinions/Evidence
Prepare site for culvert installation.	Concrete burns, dermatitis, kin allergy	S	
Culverts bedded on 500mm granular fill	Plant, material handling and bedded. (Plant)		
Position culvert units on bed	Craneage, MH, 'struck-by', trapped hand, power tools/HAVS (bolts), falls from height (upper floors only)	A	
Transport mechanical handling device to site and set up	Craneage, mechanical handling, some MH, MSDs, cuts.	LL, C	Training in use of "puller" mechanical handling device improved health & safety
Apply joint material to culvert sockets			
Join Culvert units using mechanical "Puller"	Hand injuries, MH, MSD's		
Spray waterproof membrane (Stirling Lloyd) or equivalent	Fumes, Dermatitis, COSHH,		
Apply 50mm protection screed			
Structural backfill placed and compacted	Material handling, plant.		

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Infrastructure – Insitu concrete culverts vs PC concrete culverts (Civil)

Main H&S issues, working below ground level, exposed open trenches, craneage, insitu concrete risks, rebar risks, overlapping trades,
Activities based on insitu concrete culvert vs PC concrete culvert box sections

			Landscape and				
Much more slab concrete required cf PC slab topping	ML	HAVS, MSDs, MH, trips, falls from height		Make connections			
Almost no formwork required for PC option	A	Material falling, cuts from nails etc, MSDs, MH, falls from height	Strike slab/beam formwork				
Almost no formwork required for PC option	ML	MSDs, MH, COSHH (Release agent), cuts (scrapers)	Refurbish ALL formwork	Place concrete topping			
Details depend on falsework design – crane-handled pre-formed systems reduce many of these risks		Material falling, MSDs, MH, falls from height	Move slab/beam formwork	Ancillary site risks			
More site labour required	ML	Slips, trips, falls.	Ancillary site risks				

Notes: Highway culvert construction.

Risk change code (insitu>>pre-assembled): S = same (no change) R = Risk removed A = Additional (new) risk LL = Less likely ML = More likely LC = less serious consequence MC = more serious consequence C = more controllable

Infrastructure – Insitu concrete tunnels vs PC concrete tunnels (Civil)
Main H&S issues, working below ground level, exposed open trenches, craneage, insitu concrete risks, rebar risks, overlapping trades,
Activities based on insitu concrete tunnels vs PC concrete tunnel ring sections

Insitu Concrete tunnel

Opinions/Evidence	cf OSP	Main Hazards	Off-Site Activities
Industrialised process should be well organised with risks minimised		Various – but outside scope of HASPREST	Manufacture of base materials
Same for OSP factory		Transport, handling etc	Deliveries of base materials to ready-mix plant
Should be well organised with risks minimised		Various – but outside scope of HASPREST	Ready-mix concrete manufacture
More ad hoc deliveries	ML	Road traffic	Transport materials to site
More ad hoc deliveries	ML	Craneage, plant, access etc	Deliveries
Opinions/Evidence	**cf OSP**	**Main Hazards**	**On-Site Activities**
	S	See 'Excavation'	Excavate vertical access shaft
	A	MH, MSDs, cuts, dermatitis Working below ground level.	Shore shaft
Access across slab rebar is particularly hazardous for all workers	A	MH, MSDs, cuts, RSI tying bars, trips, falls from height	Set out place and fix reinforcement to shaft wall ground slab
Details depend on formwork design –crane-handled pre-formed systems reduce many of these risks	A	MH, MSDs, cuts, hand injuries, falls from height, power tools	Place and erect formwork to shaft all and base slab
Much more slab concrete required cf PC slab topping	ML	Pump – Plant, MH pipes, falls (knocked by pipe), dermatitis, blow-out (maybe crane/skip), clean out pipes	Place shaft base and wall concrete
Much more slab concrete required cf PC slab topping	ML	HAVS, MSDs, MH, trips, falls from height	Vibrate / compact slab wall concrete
	A	Material falling, cuts from nails etc, MSDs, MH	Strike slab / wall concrete
Access across slab rebar is particularly hazardous for all workers	A	MH, MSDs, cuts, trips, working below ground level, working in compressed air, confined space, COSHH, noise dust, tunnelling plant risks, tunnel collapse	Commence tunnel excavation.
Details depend on formwork design –crane-handled pre-formed systems reduce many of these risks	A	MH, MSDs, cuts, hand injuries, falls from height, power tools	Formwork to tunnel walls
Much more slab concrete required cf PC slab topping	ML	Pump – Plant, MH pipes, falls (knocked by pipe), dermatitis, blow-out (maybe	Place concrete

Pre Cast Concrete

Off-Site Activities	Main Hazards	cf insitu	Opinions/Evidence
Deliveries of base materials	Transport, handling etc	S	Same for insitu
Set up PC moulds	Craneage, Mechanical handling, some MH, MSDs, cuts, COSHH (release agent)	LL,C	Work at ground level, or 'bench-height', more available purpose-made craneage, More industrialised process
Install & fix reinforcement	Craneage, mechanical handling, some MH, MSDs, cuts, RSI (rebar tying)	LL, C	Work at ground level, or 'bench-height', more available purpose-made craneage, more industrialised process
Place concrete grade 50 RHPC	Craneage, Mechanical handling, some MH, MSDs, cuts, dermatitis	LL,C	Work at ground level, or 'bench-height', more available purpose-made craneage, more industrialised process
Finish top surface	Dermatitis, MSDs, COSHH (curing agent)	LL, C	Work at ground level, or 'bench-height', more available purpose-made craneage, more industrialised process
Remove mould formwork	MSDs, hand-injury,	LL,C	Should be easier to control in factory
Remove PC unit	Craneage, some MH, 'struck-by', 'trapped-by'	A	
Clean reusable moulds	COSHH, HAVS (power tools)	LL,C	
Ready-mix concrete manufacture	Various – but outside scope of HASPREST	LL	Should be well organised with risks minimised – less concrete required cf insitu
Transport PC tunnel rings/segment units to site	Road traffic	LL	More organised deliveries
Deliveries	Craneage, plant, access etc	LL	More organised deliveries
On-Site Activities	**Main Hazards**	**cf insitu**	**Opinions/Evidence**
Excavate vertical access shaft	See 'Excavation'	S	
Shore shaft	MH, MSDs, cuts, dermatitis Working below ground level.	A	
slab and PC ring segments to shaft wall.	MH, MSDs, cuts, trips, falls working at height, working below ground level.	A	
	MH, MSDs, cuts, trips, working below ground level, working in compressed air, confined space, COSHH, noise dust, tunnelling plant risks	S	
	MH, MSD's working in compressed air, Noise, confined space, COSHH, fall of material , tunnel collapse	S	
Commence installation of PC segments to tunnel wall.	Plant, mechanical handling, damage to hands, fall of material, tunnel collapse,	LL, C	Use of PC more control, less time exposed to compressed air and tunnel hazards, e.g. tunnel collapse.

Risk change code (insitu>>pre-assembled): S = same (no change) R = Risk removed A = Additional (new) risk LL = Less likely ML = More likely LC = less serious consequence MC = more serious consequence C = more controllable

Infrastructure – Insitu concrete tunnels vs PC concrete tunnels (Civil)
Main H&S issues, working below ground level, exposed open trenches, craneage, insitu concrete risks, rebar risks, overlapping trades,
Activities based on insitu concrete tunnels vs PC concrete tunnel ring sections

		crane/skip), clean out pipes					
Much more slab concrete required cf PC slab topping	ML	HAVS, MSDs, MH, trips, falls from height	Vibrate concrete				
	A	Material falling, cuts from nails etc, MSDs, MH	Strike concrete	Apply joint material to tunnel segments	COSHH, dermatitis, working in compressed air, danger of tunnel collapse, falling material, fire/explosion.		
Details depend on falsework design –crane-handled pre-formed systems reduce many of these risks	A	MH, MSDs, hand injuries, material falling, falls from height	Falsework, forms to tunnel roof	Join tunnel segments	Hand injuries, MH, MSD’s		
Access across slab rebar is particularly hazardous for all workers	A	MH, MSDs, cuts, RSI tying bars, trips, falls from height	Reinforcement to roof slab	Spray waterproof membrane (Stirling Lloyd) or equivalent	Fumes, Dermatitis, COSHH,		
Details depend on formwork design –crane-handled pre-formed systems reduce many of these risks	A	MH, MSDs, cuts, hand injuries, falls from height, power tools	Formwork to roof slab				
Much more slab concrete required cf PC slab topping	ML	Pump – Plant, MH pipes, falls (knocked by pipe), dermatitis, blow-out (maybe crane/skip), clean out pipes	Place concrete	Place tunnel lining material	Material handling, plant.		
Much more slab concrete required cf PC slab topping	ML	HAVS, MSDs, MH, trips, falls from height	Vibrate concrete	Ancillary site risks			
	A	Material falling, cuts from nails etc, MSDs, MH	Strike formwork				
Same surface area as PC insitu topping	S	MH, MSDs, HAVS (if power float), COSHH (curing agent), MSDs & slips (polythene to cure)	Concrete finishes				
			Accommodation works				
	A		Miscellaneous items				
Much more slab concrete required cf PC slab topping	ML	HAVS, MSDs, MH, trips, falls from height					
Almost no formwork required for PC option	A	Material falling, cuts from nails etc, MSDs, MH, falls from height	Strike slab/wall formwork				
Almost no formwork required for PC option	ML	MSDs, MH, COSHH (Release agent), cuts (scrapers)	Refurbish ALL formwork				
Details depend on falsework design –crane-handled pre-formed systems reduce many of these risks		Material falling, MSDs, MH, falls from height	Move slab/beam formwork				
More site labour required	ML	Various (see ConCA)	Ancillary site risks				

Risk change code (insitu>>pre-assembled): S = same (no change) R = Risk removed A = Additional (new) risk LL = Less likely ML = More likely LC = less serious consequence MC = more serious consequence C = more controllable