

This item was submitted to Loughborough's Institutional Repository (<https://dspace.lboro.ac.uk/>) by the author and is made available under the following Creative Commons Licence conditions.



CC creative commons  
COMMONS DEED

**Attribution-NonCommercial-NoDerivs 2.5**

**You are free:**

- to copy, distribute, display, and perform the work

**Under the following conditions:**

 **Attribution.** You must attribute the work in the manner specified by the author or licensor.

 **Noncommercial.** You may not use this work for commercial purposes.

 **No Derivative Works.** You may not alter, transform, or build upon this work.

- For any reuse or distribution, you must make clear to others the license terms of this work.
- Any of these conditions can be waived if you get permission from the copyright holder.

**Your fair use and other rights are in no way affected by the above.**

This is a human-readable summary of the [Legal Code \(the full license\)](#).

[Disclaimer](#) 

For the full text of this licence, please go to:  
<http://creativecommons.org/licenses/by-nc-nd/2.5/>



Changing Occupational Health and Safety Practices in  
the Manual Handling Of Highway Kerbs: Cultural  
Impediments and Obstacles to Innovation.

.....

By

Philip D. Bust BSc. MSc.

I.D. Number: A289718

Submitted in partial fulfilment of the requirements  
for the award of  
Doctoral Thesis of Loughborough University

© Philip D. Bust

November 2010

---

---

# Declaration

I hereby declare that this thesis is entirely my own work, and has not been submitted for any other awards at this or any other academic establishment. Where use has been made to the work of other people it has been fully acknowledged and referenced.

---

Philip D. Bust

---

---

# Acknowledgements

I would like to thank the following people for their help in the course of this work:

My supervisor, Professor Alistair Gibb, for his encouragement and guidance and Frank Garnet for making work on the 'Back to Design' project a pleasurable experience.



---

---

# Table of Contents

<b>1</b>	<b>INTRODUCTION.....</b>	<b>15</b>
1.1	Background.....	15
1.1.1	Manual handling in construction.....	17
1.1.2	Concrete kerbs.....	19
1.1.3	Lifting aids.....	20
1.1.4	Alternatives .....	20
1.2	Objectives of research.....	21
1.3	Thesis outline .....	22
<b>2</b>	<b>LITERATURE REVIEW .....</b>	<b>25</b>
2.1	Introduction and Overview .....	25
2.2	Background to Manual Materials Handling (MMH) .....	27
2.2.1	Risk assessment.....	28
2.2.2	From craft to industry .....	29
2.2.3	Research .....	30
2.3	Design.....	34
2.3.1	International Perspective.....	35
2.3.2	Europe .....	36
2.3.3	Support for designers.....	37
2.3.4	In practice.....	38
2.4	Equipment.....	44
2.5	Training .....	51
2.6	Ergonomics in the Construction Industry .....	59

---

---

<b>2.7</b>	<b>Methods .....</b>	<b>65</b>
2.7.1	Postural analysis.....	65
2.7.2	Task analysis .....	67
2.7.3	Multilevel system approaches.....	68
<b>2.8</b>	<b>Culture.....</b>	<b>72</b>
2.8.1	Introduction .....	72
2.8.2	Industry culture.....	73
2.8.3	Organisational culture.....	74
2.8.4	Safety Culture .....	75
2.8.5	Safety Climate.....	76
2.8.6	Safety systems.....	77
2.8.7	Summary .....	79
<b>2.9</b>	<b>Innovation .....</b>	<b>83</b>
2.9.1	Introduction .....	83
2.9.2	Types of innovation .....	84
2.9.3	Types of innovators .....	84
2.9.4	Management of innovation.....	86
2.9.5	Supporting innovation .....	87
<b>2.10</b>	<b>Culture and Innovation.....</b>	<b>91</b>
2.10.1	Introduction .....	91
2.10.2	Research.....	91
2.10.3	Health and safety .....	92
2.10.4	Developments .....	92
2.10.5	Summary .....	98
2.10.6	Research Questions .....	100
2.10.6.1	Research Question I .....	100
2.10.6.2	Research Question II.....	100
2.10.6.3	Research Question III.....	100
2.10.6.4	Research Question IV .....	101
2.10.6.5	Research Question V.....	101

---

---

<b>3</b>	<b>METHODOLOGY</b> .....	<b>102</b>
3.1	Introduction.....	102
3.2	Research methodology.....	103
3.3	Research Design.....	105
3.4	Sampling.....	106
3.5	Research methods.....	108
3.6	Data collection.....	110
3.6.1	Literature review.....	110
3.6.2	Case studies.....	111
3.6.3	Observation.....	111
3.6.4	Task breakdown/analysis.....	112
3.6.5	Postural analysis.....	112
3.6.6	Interviews.....	113
3.6.7	Focus groups.....	114
3.7	Data Analysis.....	115
3.7.1	Task observation.....	115
3.7.2	Task and postural analysis.....	115
3.7.3	Analysis of text (safety meetings, focus groups, interviews)...	115
3.8	Quality Criteria.....	117
3.9	Adopted Research Methodology.....	119
3.9.1	Literature review.....	119
3.9.2	Case studies.....	120
3.9.3	Observation.....	121
3.9.4	Task breakdown/analysis.....	122
3.9.5	Postural analysis.....	123
3.9.6	Interviews.....	127
3.9.7	Focus groups.....	127

---

---

<b>3.10</b>	<b>Summary</b> .....	<b>130</b>
<b>4</b>	<b>RESULTS (SITE VISITS)</b> .....	<b>132</b>
<b>4.1</b>	<b>Introduction</b> .....	<b>132</b>
<b>4.2</b>	<b>Manual Kerb Laying - Unversity Campus</b> .....	<b>133</b>
<b>4.3</b>	<b>Manual Kerb Laying - Road Works</b> .....	<b>134</b>
4.3.1	Task analysis .....	135
4.3.2	Postural analysis.....	136
<b>4.4</b>	<b>Manual Kerb Laying - Car Park</b> .....	<b>137</b>
4.4.1	Task analysis .....	137
4.4.2	Postural analysis.....	138
<b>4.5</b>	<b>Vacuum Lifter Set Up - Public House Car Park</b> .....	<b>139</b>
4.5.1	Task analysis .....	140
4.5.2	Postural analysis.....	140
<b>4.6</b>	<b>Manual Kerb Laying - City Centre</b> .....	<b>141</b>
4.6.1	Task Analysis .....	142
4.6.2	Postural analysis.....	143
<b>4.7</b>	<b>Manual Handling of Kerbs - Footpath Widening</b> .....	<b>144</b>
4.7.1	Task analysis .....	144
4.7.2	Postural analysis.....	145
<b>4.8</b>	<b>Use of Scissor Clamps - Housing Estate</b> .....	<b>146</b>
4.8.1	Task analysis .....	147
4.8.2	Postural analysis.....	147
<b>4.9</b>	<b>Slip Forming - Motorway Dublin</b> .....	<b>148</b>
4.9.1	Task analysis .....	149
4.9.2	Postural analysis.....	150
<b>4.10</b>	<b>Kerb Race Installation - Housing Estate</b> .....	<b>151</b>

---



---

4.10.1	Task analysis.....	152
4.10.2	Postural analysis .....	152
<b>4.11</b>	<b>Vacuum Lifter Operation - Rural Road .....</b>	<b>153</b>
4.11.1	Task analysis.....	155
4.11.2	Postural analysis .....	156
<b>4.12</b>	<b>Equipment Demonstrations .....</b>	<b>157</b>
<b>4.13</b>	<b>Summary .....</b>	<b>162</b>
<b>5</b>	<b>RESULTS (TEXT ANALYSIS).....</b>	<b>163</b>
<b>5.1</b>	<b>Introduction .....</b>	<b>163</b>
5.1.1	Safety Meetings .....	163
5.1.2	Interviews .....	164
5.1.3	Focus groups .....	164
5.1.4	Kerbs forums .....	165
<b>5.2</b>	<b>Analysis of Text .....</b>	<b>165</b>
5.2.1	Designer .....	168
5.2.2	Manufacturer.....	169
5.2.3	Contractor .....	170
5.2.4	Trainer .....	173
5.2.5	Client .....	174
5.2.6	Health and Safety Executive .....	176
5.2.7	Culture.....	177
5.2.8	Finances.....	179
5.2.9	Legislation.....	181
5.2.10	Technical .....	182
5.2.11	Organisation .....	185
<b>5.3</b>	<b>Distribution of text analysis comments .....</b>	<b>187</b>
<b>5.4</b>	<b>Focus Group Questions .....</b>	<b>190</b>

---



---

5.4.1	Questions prepared for focus group meeting on manufacturing and lifting equipment .....	191
5.4.2	Questions prepared for focus group meeting on design issues	201
5.4.3	Questions prepared for focus group meeting on training issues	209
<b>5.5</b>	<b>Focus Group Exercises.....</b>	<b>214</b>
5.5.1	Focus group 1 exercise – Lifting equipment .....	215
5.5.2	Focus group 2 exercise – Appropriate design solutions.....	217
5.5.3	Focus group 3 exercises – Targetting the trainer .....	218
<b>5.6</b>	<b>Summary .....</b>	<b>220</b>
<b>6</b>	<b>DISCUSSION .....</b>	<b>221</b>
<b>6.1</b>	<b>Introduction.....</b>	<b>221</b>
6.1.1	Answering the research questions.....	221
6.1.1.1	What are the key functions and considerations of the training of workers in the installation of highway kerbs? .....	222
6.1.1.2	Do alternatives to the manual handling of concrete highway kerbs pose any risks? .....	225
6.1.1.3	How could the Design for Safety concept improve the installation of highway kerbs? .....	227
6.1.1.4	How is the risk of injury to the workers affected by the organisation of the work? .....	229
6.1.1.5	In what way can the culture of those in the supply chain affect the introduction of technical innovations? .....	235
<b>6.2</b>	<b>Manufacturers.....</b>	<b>237</b>
<b>6.3</b>	<b>Designers .....</b>	<b>238</b>
<b>6.4</b>	<b>Contractors.....</b>	<b>239</b>
<b>6.5</b>	<b>Clients.....</b>	<b>240</b>

---

---

6.6	Workers.....	241
6.7	Summary .....	242
<b>7</b>	<b>PRACTICAL OUTCOMES.....</b>	<b>244</b>
7.1	Back to Design.....	244
7.2	Interpave handling guidance .....	245
7.3	CECA Health Management Toolkit.....	246
7.3.1	Potential benefits of the CECA Toolkit.....	247
7.3.2	Work system factors and roles and responsibilities for various kerb installation operations examples .....	248
7.3.3	Kerb installation operations scenarios.....	249
7.3.4	Key Stakeholder – Roles and Responsibilities.....	250
7.3.5	Install kerbs on new housing estate .....	253
7.3.6	Install kerbs in new supermarket car park .....	254
7.3.7	Replace kerbs on trunk road .....	255
7.3.8	Install new kerbs on rural road .....	256
7.3.9	Replace existing kerbs on high street.....	257
7.3.10	Replace kerbs on access or slip road .....	258
<b>8</b>	<b>CONCLUSIONS.....</b>	<b>259</b>
8.1	Kerb installation .....	259
8.2	Culture .....	260
8.3	Cost.....	261
8.4	Enforcement/ Guidance .....	261
8.5	Technical issues .....	262
8.6	Organisation .....	262

---

---

<b>8.7</b>	<b>Communication .....</b>	<b>263</b>
<b>8.8</b>	<b>Strengths and limitations of the research.....</b>	<b>264</b>
<b>8.9</b>	<b>Contribution of thesis .....</b>	<b>266</b>
8.9.1	Research knowledge .....	266
8.9.2	Producing construction industry guidance for the management of highway kerb installation .....	268
8.9.3	Providing input to construction industry bodies for their occupational health guidance literature. ....	269
<b>8.10</b>	<b>Recommendations for further research .....</b>	<b>269</b>
<b>9</b>	<b>REFERENCES .....</b>	<b>274</b>
<b>10</b>	<b>APPENDICES .....</b>	<b>288</b>
<b>10.1</b>	<b>Task analyses .....</b>	<b>288</b>
<b>10.2</b>	<b>HSE Hand out at second kerbs forum.....</b>	<b>288</b>
<b>10.3</b>	<b>Back to Design report.....</b>	<b>288</b>
<b>10.4</b>	<b>Interpave kerb installation guidance .....</b>	<b>288</b>
<b>10.5</b>	<b>Interpave slab installation guidance .....</b>	<b>288</b>



---

---

## Tables of data

<i>Table 1 Health and safety legislation related to manual handling of kerbs.....</i>	<i>18</i>
<i>Table 2 Manual materials handling research.....</i>	<i>33</i>
<i>Table 3 Safety in Design research.....</i>	<i>43</i>
<i>Table 4 Construction and lifting equipment research.....</i>	<i>50</i>
<i>Table 5 Manual handling training research.....</i>	<i>58</i>
<i>Table 6 Construction ergonomics research.....</i>	<i>64</i>
<i>Table 7 Holistic or multilevel approach elements.....</i>	<i>69</i>
<i>Table 8 Research methods research.....</i>	<i>71</i>
<i>Table 9 Culture research.....</i>	<i>82</i>
<i>Table 10 Innovation research.....</i>	<i>90</i>
<i>Table 11 Culture and innovation research.....</i>	<i>97</i>
<i>Table 12 Site visits.....</i>	<i>123</i>
<i>Table 13 Key postures of practical relevance in the workplace.....</i>	<i>124</i>
<i>Table 14 Risk ratings used in the REBA postural analysis tool.....</i>	<i>125</i>
<i>Table 15 Breakdown of focus group participants.....</i>	<i>128</i>
<i>Table 16 Questions used in focus group one.....</i>	<i>129</i>
<i>Table 17 Questions used in focus group two.....</i>	<i>129</i>
<i>Table 18 Questions used in focus group three.....</i>	<i>130</i>
<i>Table 19 Showing an extract from the text analysis table.....</i>	<i>166</i>
<i>Table 20 Referencing of research groupings and make up of participants in groups .....</i>	<i>167</i>
<i>Table 21 Sum of comments for each stakeholder/category.....</i>	<i>188</i>
<i>Table 22 Sum of positive comments for each stakeholder/category.....</i>	<i>189</i>
<i>Table 23 Sum of negative comments for each stakeholder/category.....</i>	<i>189</i>
<i>Table 24 Focus group exercise – Lifting equipment.....</i>	<i>217</i>
<i>Table 25 Focus group exercise – Design issues.....</i>	<i>218</i>
<i>Table 26 Focus group exercise – Training issues.....</i>	<i>219</i>
<i>Table 27 Kerbs Research – Publications and Presentations.....</i>	<i>272</i>
<i>Table 28 Negative and positive aspects of kerb installation associated with key stakeholders.....</i>	<i>273</i>



---

---

## Abstract

It is regularly reported that the construction industry has one of the highest levels of incidents of work-related injury in the UK. Research to date involving the management of health and safety in construction has concentrated on safety and in particular fatalities of construction workers. Yet the manual handling of heavy loads leading to occupational health problems is widespread in the industry.

The aim of this research was to better understand the continued use of manual handling for the installation of concrete highway kerbs in the construction industry. The initial objectives were to review alternatives to and research on kerb handling; compare kerb handling methods; investigate the design process; and finally produce information for the supply chain. Due to time constraints on the project and the nature of the investigation an exploratory interpretive investigation was used to provide a flexible approach. A literature review led to research questions on training, risk of injury, designing for safety, organisation of the work and culture which narrowed the scope of the enquiry. The research used qualitative methods with observation of the work and a survey of key members of the supply chain through interviews and focus groups which provided rich data for analysis.

The observation work, including postural analysis, has added to existing research mainly from other industries confirming the risk of injury of the manual handling operation and the reduced risks through using alternatives. The survey collected a considerable amount of rich data from the supply chain members. This recorded their perceptions of the culture of other members and the change occurring with the introduction of new innovative technology. Results from the data analysis have been used to produce guidance material, including a process model, to support the industry with the management of highway kerb installation.

Further research is required, collaborating with members of the supply chain, to validate the process model with practical applications. Data of the supply chain members' perceptions can also be used for further examination of communication failings between members.

---

---

# 1 INTRODUCTION

## 1.1 Background

Instances of accidents and ill health involving construction workers are probably as old as construction itself. Over the centuries large numbers of workers have died, been injured or suffered ill-health in order for governments and rulers to realise their dreams. The numbers involved are impossible to prove because of the lack of adequate records. Even today, in construction, the overall standard of recording of health and safety information is not adequate enough to assist health and safety professionals to improve the management of health and safety.

Examples showing the need for health and safety management in construction and its slow introduction over the last two centuries can be seen in some of the major projects for infrastructure, transportation and commerce. The Box Tunnel (1836 to 1841), designed and managed by Brunel, cost the lives of around 100 railway construction workers (Buchanan 2006) for a tunnel which was 2 miles long. During the construction of The Manchester Ship Canal (1887 to 1894) around 14,000 men were used, on average, with as many as 17,000 at the peak of construction. Above-average care for the time was offered to the men with provision of housing, a full-time medical officer and alternative work found for those who lost limbs (Seddon 1961). The canal was 36 miles long and required 41,000,000 m<sup>3</sup> of material to be excavated and *only* 130 workers died.

The Panama Canal which was started by the French (1881 to 1889) and then completed by the United States (1904 to 1914). During the first period of construction, around 21,900 workers died from disease (malaria and yellow fever) and landslides. Improvements to tackle disease were put in place (Litsios 2001) before the second period of construction but still

---

---

another 5600 died. From the earliest surveying exercises for the Hoover Dam (1931 to 1936) it is estimated that 112 people died, 96 of them during construction. In the construction period many accidents occurred due to drowning; blasting of rock; falling rocks or rock slides; falls from canyon walls; being struck by heavy equipment; and truck accidents (DuTemple 2003). Concerns for workers' safety on the construction of the Golden Gate Bridge (1933 to 1937) led to the use of hard hats, respirator helmets, glare-free goggles, special hand- and face-cream to protect against the wind, and special diets to help fight dizziness. The most conspicuous precaution was the installation of safety netting slung below construction activities. The netting was reported to have saved the lives of 19 workers but unfortunately when the net itself failed 10 workers died (Fandel 2006). The total number of workers who died on the construction of the bridge was 11. So it can be seen that where efforts have been made to secure the safety and health of workers this has made a difference.

Today ill-health kills and costs. Designing for healthier construction is a key industry objective set out in the UK Government strategy document Revitalising Health and Safety (Department of the Environment, Transport and Regions 2000). Results from a self-reported work-related illness survey carried out in 1998/99 (Jones et al. 2001) showed that 84,000 construction employees have an illness caused or made worse by work, with over half suffering from musculoskeletal disorders (MSDs). Despite specific legislation requiring health action by employers, less effort has been directed towards health in construction (Gibb 2004) in favour of the more immediate, high profile (and perhaps more easily solvable) safety problems.

---

---

### **1.1.1 Manual handling in construction**

The use of manual handling has been prevalent throughout the history of construction. On smaller construction projects such as domestic properties in the United Kingdom the use of traditional methods (concrete footings, masonry walls, timber floors, and timber framed roofs clad with slate or tiles) require manual handling of all the component parts. Prefabrication has reduced, to some extent, the manual handling of small components on larger structures. However, whilst heavy prefabricated panels and units can be lifted using mechanical devices, to deliver them to their final position requires site workers to manoeuvre them by hand. Thus, the repetitive manual handling of relatively small components is replaced with a small amount of heavy operations.

Another problem in the construction industry is that the manual handling work can be carried out in any geographical location; the shape and size of building can vary enormously; adjacent work operations can change from day to day; and the worker can be exposed to wind, rain and temperature changes dependent upon the location of the site, time of year and stage of the project.

The UK construction industry has lagged behind the manufacturing industry when it comes to up-to-date management methods (Sebestyén 1998). This has had an effect on the protection of workers as companies failed to implement health and safety legislation (Table 1). Campaigns by the UK Health and Safety Executive over the years (Cement bags were reduced from 50 kg to 25 kg; the use of heavy masonry blocks was targeted; and then the installation of concrete highway kerbs was placed on the Health and Safety Executive's priorities list for inspectors) have assisted small step changes in manual handling operations in construction.

Regulation	Requirements
The Health and Safety at Work, etc Act 1974 (HSWA)	In these regulations it states “it shall be the duty of every employer to ensure, so far as is reasonably practicable, the health, safety and welfare at work of all his employees.”
	The employer must provide safe systems of work; ensuring safety and absence of risk in connection with handling and transportation of articles and provide information, instruction, training and supervision as is necessary. All of these duties are qualified by the term “reasonably practicable”.
	As well as employers, designers, manufacturers and suppliers of articles and substances for use at work have responsibilities under these regulations. They must ensure that articles are designed and constructed so that they can be installed, used, cleaned or maintained without risks to health and provide information about the use of the product to ensure that when it is put to use a product would be safe and without health risks.
	Employees are required to take reasonable care of both his or her own health and safety and also that of other persons when carrying out work and to co-operate with his or her employer or any other person as is necessary to enable the employer to satisfy any statutory duties or requirements to be complied with.
The Construction (Health, Safety and Welfare) Regulations 1996	These regulations refer to the physical environment on a construction site and will not specifically targeted manual handling operations.
The Management of Health and Safety at Work Regulations 1999 (MHSWR)	In these regulations employers are required to undertake an assessment of the risks to the health and safety of their employees arising out of or in connection with their work. They must then put into place any preventative or protective measures identified and undertake any appropriate health surveillance where risks to employees’ health have been identified. They must also pay competent persons to undertake these assessments and provide relevant information to employees.
The Construction (Design and Management) regulations 2007	These regulations were introduced to provide a control framework that covered design, commissioning of work, its planning and execution, for construction work that is likely to pose significant risks to workers and others. Clients, under these regulations, are required to appoint a CDM coordinator and the principal contractor. They must also ensure that a health and safety plan is in place before work starts. Designers are required to co-operate with the CDM coordinator in order to avoid foreseeable risks and combat risks at source.
The Manual Handling Operations Regulations 1992	In these regulations manual handling is defined as ‘the transporting or supporting of a load by bodily force.’ They recommend that manual handling activities are avoided so far as is reasonably practicable. And, if the activity cannot be avoided, it should be assessed and the risk of injury reduced to the lowest level reasonably practicable. Employers are required to provide information on the weight of materials as well as the centre of gravity of asymmetrical loads. Employees are to make use of equipment provided by the employer to assist with lifting of loads.

Table 1 Health and safety legislation related to manual handling of kerbs

---

---

## 1.1.2 Concrete kerbs

Kerbs are one of the ubiquitous construction components and of themselves may not appear to be particularly noteworthy. There are millions of kilometres of kerbs in the UK and they are handled and re-handled many times during their lives. Handling risks arise at various stages (manufacturing, order preparation, delivery, off-loading, installation, realignment), however these risks are rarely taken seriously. Kerb design has not changed for more than 30 years and this design pays no regard to the health of installers. Since regulations on manual handling have been implemented, limits of 30 kg have meant that most kerbs should now be installed using various types of lifting equipment. However, there is strong evidence that the operatives find this equipment inconvenient as it reduces productivity so they often choose to lift and manoeuvre the stones manually.

In 2003 the Health and Safety Executive made kerb handling a priority activity and across the UK they targeted this operation and requested that contractors look for alternative methods of installing concrete kerbs.

Under pressure from the construction industry, the Health and Safety Executive organised an industry forum in December 2003 to discuss the continued use of manual handling for concrete kerb installation. In the forum transitional timeframes were agreed for the industry to move from the manual handling of kerbs to machine-assisted installation.

The timeframes were reviewed at a second industry forum held in London in July 2004. Over 80 stakeholders, including manufacturers, contractors and local authorities attended to review the HSE's initiative.



---

---

### **1.1.3 Lifting aids**

Assistive lifting technology has been developed over recent years the simplest form being metal hand-clamps usually held by two operatives gripping the kerb with some form of scissor mechanism. The use of the hand clamps is limited to short movements, lifting off a pallet or lifting up and onto the concrete bed, because it is difficult to walk once lifted.

The use of manual lifting clamps improves the operation of lifting providing the lift can be at waist height and allowance made for a specific user population. Similar forms of equipment have also been used, attached to motorised construction equipment, in order to lift kerbs and larger concrete items. Remote handling increases time taken to lay the kerbs and clamps do not work well with the setting-out strings.

A newer method of installing concrete kerbs is by means of vacuum lifters. These work on the basis that a machine and a pallet of kerbs are carried on the forks of a loader-shovel or telescopic loader. The vacuum lifter has a boom along which the vacuum tube and suction plate are supported and allows considerable positional movement of the suspended kerb. Machines differ in the boom type and hand controls.

### **1.1.4 Alternatives**

Extrusion (slip-form concrete) was used on large projects in the UK in the 1980's (Cirencester A419, the Semington by-pass in Wiltshire), and central reservations on motorways were often slip formed. This is not the answer in all situations as it is no good in urban situations with lots of dropped kerbs. Local Authorities do not like this method as they have a fixed budget and look for the most cost effective solution. If manual handling restrictions increase on concrete kerbs the cost may go up so slip-forming may become more viable.

---

---

Extrusion work has been carried out in the UK on the A46 with a slip-formed concrete base to support concrete kerbs. The old kerbs were broken up and laid down as a sub-base by the “cut-a-kerb” process formally known as “National Road Planing”. The kerbs are not slip formed at the same time because they tend to suffer damage.

Acco Drainage is an excellent product if drainage is required. It is impregnated with resin but not that much lighter. It is seen as a value added product being wet cast and requires one mould per day per product. It is not feasible as a mass-produced product because of the wet process - pressed kerbs are one every 5 seconds. The Acco product does not have to satisfy kerb standard criteria but DIN 19580. The cost of the Acco combined drain/kerb is £35/m compared to concrete kerbs at £3/m. The Acco product has not been tested for impact, whilst a vertical test in the form of a static load is used for kerbs.

Recycled rubber kerbs have been used in local authority maintenance work where kerbs are regularly broken by heavy traffic. There is some doubt if there are any benefits as they still require aggregate fines and thus weight savings would be minimal. Also their durability is questionable.

The use of British Standard profile kerbs made from recycled plastic has become more widespread especially with local authorities who are then able to satisfy environmental agendas along with manual handling requirements.

## **1.2 Objectives of research**

This research was carried out for the Construction Health and Safety Group (CHSG) of Chertsey and was funded as part of their jubilee celebrations. As such, the findings needed to be of benefit to their members and to health and safety in the construction industry generally.

---

---

The aim of this research was to identify reasons for the continued use of manual handling for the installation of concrete highway kerbs in the construction industry and the changes produced by the HSE enforcement. It was decided that the research needed to consider the full life cycle of the concrete kerbs from design, through manufacture, installation and to final removal.

In order to achieve this, the research had to include the key stakeholders in the lifecycle and how their roles affected the health of construction workers, particularly those handling highway kerbs. Musculoskeletal disorders are a serious problem in construction and it was important to consider them from a broad industry perspective whilst at the same time concentrating on specific work activities.

It was not the intention of this research to prove that the manual installation of concrete highway kerbs was a risk to workers as the risks associated with manual handling of similarly heavy objects was well proven; rather to identify reasons why the industry as a whole continued to use this method when any required risk assessment would lead to action to remove it.

### **1.3 Thesis outline**

The outline of the thesis is presented in Figure 1. Chapter 2 examines the relevant scientific literature and Chapter 3 develops this into the methodology for the research.

The existing kerb installation tasks (manually, with assistive technology, and with alternatives) are examined in Chapter 4 and data gathered from industry experts are presented in Chapter 5. The discussion of findings is presented in Chapter 6.

---

---

Chapter 7 outlines the practical outcomes of the research and the conclusions and recommendations for further research can be found in Chapter 8.

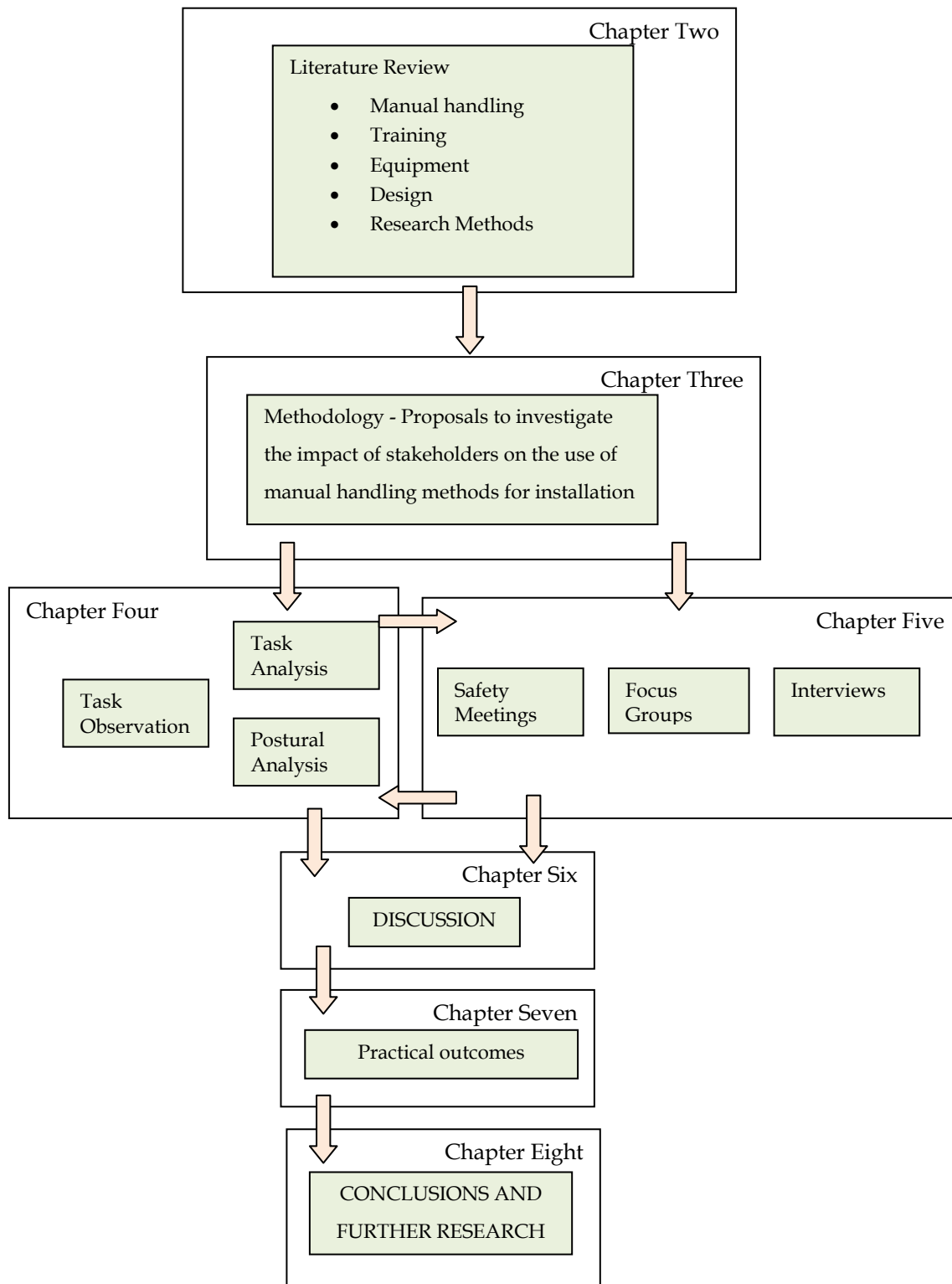


Figure 1 Outline of Research

---

---

## 2 LITERATURE REVIEW

### 2.1 Introduction and Overview

Concrete kerbs are used in many countries throughout the world as an element to separate the roads from pedestrian footpaths and to control the flow of surface water from roads into drainage systems. They are an integral part of housing estates, industrial and retail complexes and transport networks and in the UK around 4% are replaced every year. In this country, concrete kerbs, weighing around 70kg, are widely used. As the kerbs are installed at ground level this represents a considerable risk to the health of the workers who install them by hand (Bust, Gibb & Haslam 2005).

The three main strategies proposed by Pheasant (Pheasant 1991) for dealing with the risks associated with lifting and handling tasks are selection, training and work design (ergonomics). All three approaches proceed on the assumption that lifting and handling injuries result from a mismatch between the demands of the task and the capacities of the person. Selection and training are aimed at solving the problem by fitting the person to the job and work design is aimed at fitting the job to the person.

Designers have the earliest opportunity to affect a change in work-related accidents and injuries. Safety through design is becoming an accepted concept in occupational safety and health. The hierarchy of controls that is central to occupational hygiene and safety recognises that engineering controls and the elimination of hazards through design are preferable to administrative controls and personal protective equipment in limiting worker exposure. Similarly, ergonomics in the workplace is premised on designing the job and the workplace to meet the capabilities and limitations of the worker (Hecker, Gambatese 2004).

---

---

In order for the construction industry to depart from reliance on manual handling for many of its operations, advances in the mechanisation of construction activities are required. It is not uncommon for industrialised countries to have their own construction equipment companies. According to Sebestyén (Sebestyén 1998), heavy machinery for the construction industry, such as excavators and tower cranes, are manufactured by large specialised companies. The UK company JCB export construction equipment to countries around the world and construction equipment in the UK can be imported from countries such as Germany, Japan and the United States.

An in-depth review funded by the UK's Health and Safety Executive (Haslam et al. 2007) found little evidence that manual handling training which is focused on handling techniques was effective in promoting safer working practices or reducing manual handling injuries in the workplace. These techniques were not found to transfer into the workplace. The research went on to say that training to assess risks and report problems was more effective and that using multidimensional ergonomic interventions (ensuring participation from workers and managers) was more likely to reduce manual handling injuries.

Research into bricklaying activities began as early as 1907 (Taylor 1911). Research into bricklaying is easier than some trades and tasks because bricklayers often carry out no other operations, the work is easily quantifiable and has distinct movements and is repetitive. Research into the laying of concrete kerbs has proved more difficult because the operation can be one of several carried out by ground workers (those workers responsible for laying of kerbs, slabs and drains as well as the installation of building footings and various excavations). It can also be a small element of larger tasks and operatives doing the work can vary from specialists to those with virtually no previous experience of kerb laying.

---

---

However research has been done in the handling of precast concrete products in manufacturing (Grandjean 1983).

Postural analysis has been used to assess construction work operations and an holistic approach recommended to deal with the kind of multivariate parameters involved in the kerb laying operation. The following chapter expands on those individual factors associated with the worker laying kerbs (training, physical, behavioural) and the effects on this work by other stakeholders (designers of roads and equipment, enforcing bodies etc).

## **2.2 Background to Manual Materials Handling (MMH)**

Across all industries, wherever tasks require workers to manually handle materials, there is a risk to the worker that they might be affected by some form of injury, usually a back disorder. In a review of epidemiological evidence on the role of manual materials handling in the occurrence of back disorders, Kuiper et al, (Kuiper et al. 1999) concluded that manual materials handling can be considered a risk factor for back disorders. Davis and Shepherd (Davis, Sheppard 1980) examined accident records of 100,000 telecommunications engineers over a 12 month period and found that back injuries gave rise to 25% of the three day accidents and handling accidents alone gave rise to 65% of back injuries. In research (Törner et al. 1991) looking at welders, fishermen and office clerks, subjective and objective symptoms for most parts of the body were more common in the welders and fishermen (who had physically heavy jobs) than among the office clerks.

It is commonly thought that the back is the part of the body that is most likely to be injured during lifting and handling activities and that back



---

---

injuries in industry are usually attributable to lifting and handling. Pheasant (Pheasant 1991) states that neither is completely correct and that overexertion (of which manual handling is a part) accounts for the greater percentage of back injuries and that the back accounts for only 28% of handling injuries when contact accidents are taken into account.

### **2.2.1 Risk assessment**

Revitalising Health and Safety in Construction (Health and Safety Executive 2003) refers to awareness and states that “Both workers and employers need to be aware of the major health risks and how to make sure that they do not make people ill. The key risks are asbestos, musculoskeletal disorders, hand-arm vibration, dermatitis, respiratory sensitizers, occupational lung disease, skin cancer (from exposure to sunlight), noise and stress/psychosocial factors. Action regarding risks should follow the normal hierarchy (elimination, substitution and control) and risk assessments should identify circumstances in which health surveillance is required. The advantage of health surveillance is that it can detect adverse health effects at an early stage, thereby enabling managers and those at risk to make sure that further harm is prevented.”

Guidelines for materials handling have been produced by ergonomics and biomechanics researchers for over 40 years. These have been developed for lifting, lowering, pushing, pulling and carrying both as individual tasks and various combinations of the same. Work at the Ergonomics Research Unit, Robens Institute (Buckle et al. 1992) stated that guidelines were frequently generated to address specific circumstances and were only pertinent to limited environments failing to consider interaction between system components. This work was used to evaluate the effectiveness of guidelines in existence at that time to state their assumptions and limitations. This was done by examining the guidelines

---

---

against the manual handling system and then to show their limitations when used in a number of case studies. Buckle et al's case studies showed the models are difficult to use in industrial settings and that existing models are perhaps only of real use to those experts in the area who have a real understanding of their limitations and underlying assumptions.

### **2.2.2 From craft to industry**

Great Britain, as a colony, obtained much of its wealth from the exploitation of slaves and then indentured labour systems combined with the expansion of the New World's plantations and mines (Castles 2004). This wealth was used to fuel the industrial revolution in the 18<sup>th</sup> Century. Industry grew with new inventions leading to the creation of factories replacing cottage industries particularly in the clothing industry. Each new invention speeding up one part of a process pushing the need for further inventions to improve the remaining parts (improvements in spinning led to an increased demand for yarn). Water power was then replaced with steam power. The factories needed to be populated with people and the country's population migrated to the coalfields where the factories had been situated.

The possibilities opened up by technological advances have led to self paced craft working being replaced by industrial large scale operations. Even the crude machinery of the 18th century could do some work that the labourer could not perform with tools, and no wage, however low, would have permitted men to compete with machines in many lines of work (Hamilton 1942). People were used within industry as tools, but rather than a tool that is maintained and kept in its best condition, one that was thrown away and replaced when broken.

---

---

The human body has evolved to meet the demands in its surrounding environment. It is the most complex tool available in any work system with qualities such as agility, dexterity, thermoregulation, ability to fight or flee (adrenalin production), and special senses (vision, hearing, touch, taste), and thus has been impossible to replace with machines. The transition from the manual handling of concrete highway kerbs to their installation by mechanical means is related to innovation and mechanisation in the construction industry.

Over the years, people have observed the overuse of bodies through work, whether it be that of craftsmen, munitions workers or miners or office workers. Stephen Pheasant in "Ergonomics, Work and Health" (Pheasant 1991) uses quotes from a variety of authors to illustrate this: Bernardino Ramazzini (1713) referring to clerks being afflicted with maladies from constant sitting, incessant movement of the hand and the strain on the mind; James Kay-Shuttleworth (1832) describing the demands on workers in cotton manufacture, "whilst the engine runs the people must work", during the industrial revolution; and Friedrich Engels (1845) giving an account of London East End sweat shops "pains in the shoulders, back and hips, but especially headache, begin very soon".

### **2.2.3 Research**

In the Principles of Scientific Management (Taylor 1911) there is a description of experiments carried out by Frank Bunker Gilbreth reducing the motions used by bricklayers from 18 to five. The changes included removal of unnecessary movements, introduction of adjustable scaffold and using simple motions with both hands at the same time. Experiments with the revised method resulted in a threefold increase in efficiency. This was a rare use of Scientific Management on a construction-related task as opposed to manufacturing activities.

---

---

However the lessons learned were not widely used because in a study (Schneider, Susi 1994) around 80 years later bricklayers are described as spending up to 75% of their time in a bent posture, primarily when stooping to lay a course of bricks on a low wall and stooping to get bricks and mortar. The researchers in this study then found that an increase in productivity of up to 100% was achieved by the introduction of adjustable scaffolds. In the conclusions of the same study it said that construction workers had high rates of ergonomic injuries, and that construction sites, unlike industrial worksites, did not have a fixed work station which could be modified on a permanent basis. Solutions did exist, however, through tool and materials engineering and it was necessary to promote these types of solutions amongst manufacturers and contractors.

Younger workers are particularly at risk in the construction industry (Stubbs, Nicholson 1979); (Merlino et al. 2003). There is a high incidence of industrial accidents involving construction workers and particularly handling accidents in the younger population. The percentage of these accidents occurring in the first year of employment can be as high as 60% (Stubbs, Nicholson 1979). This can be due to inexperience, inadequate training, and attitudes to manual handling in the younger age groups. Injuries for younger workers tend to be of acute type whilst older workers suffer more from a cumulative exposure to manual handling. Symptoms of work related musculoskeletal disorders start early in the construction worker's career and have a high prevalence among apprentice construction workers. These musculoskeletal symptoms are widespread, and increase with the increasing number of years worked in the trade. The high prevalence seen in apprentices may lead to future disability and/or attrition in the construction industry.

The work of bricklayers was also studied by Latza et al (Latza, Pfahlberg & Gefeller 2002) in Germany. In this study physical work characteristics of working in bent positions and manipulating heavy stones together with

---

---

time pressures were seen to increase the risk of developing chronic low back pain. It was noted that bricklayers can spend almost 95% of their time in a standing position with 50% of their time spent in a bent position and moving anything between 800 and 1000 kilograms per hour.

Details of the research mentioned in the above section including experimental design, manual handling subject, and outline findings are presented in Table 2.

Author and Year	Experimental Design	Manual Handling Subject	Findings
Buckle et al (1992)	Review and three case studies	Limitations in applying guidelines	Existing models only of use to experts who understand their limitations
Kuiper et al (1999)	Review of existing data	Manual materials handling as a risk factor for back disorder	The bigger part of the evidence on MMH as a risk factor comes from cross-sectional studies. More high-quality longitudinal studies are needed
Latza (2002)	Longitudinal study using structured interviews, 488 participants	Impact of manual materials handling of low back pain among construction workers	Repetitive work involving bent positions and handling heavy stone suggests increase in risk of future chronic low back pain
Merlino et al (2003)	Cross-sectional questionnaire survey 996 subjects	Symptoms of MSDs among apprentice construction workers	Symptoms of work-related musculoskeletal disorders start early in a construction workers career. High prevalence may lead to future disability
Schneider (1994)	15 month field study of construction work for new office building	Potential hazards in new construction	Construction workers have high rates of ergonomic injuries. Workstations not fixed in construction and solutions do exist through tall and materials engineering.
Stubbs and Nicholson (1979)	Investigation of accident reports	Manual handling and back injuries in construction	Accidents more frequent in younger population. Injuries arise from direct accidents or accumulation of minor injuries.
Torner et al (1991)	Cross-sectional study 58 welders and 33 clerks	Relating musculoskeletal problems with physical workload	Heavy dynamic work and heavy static work may both result in shoulder injuries

Table 2 Manual materials handling research

---

---

## 2.3 Design

The central part played by workers in the 1950s and 1960s in post-war rebuilding work and economic expansion in the West had resulted in unacceptable increases in workplace accidents and injuries. Subsequent legislation (USA OSH act 1970, UK health and safety at work act 1974) was introduced to protect workers. Initial improvements to workplace health and safety statistics in the 1970s (partially due to oil price rises slowing economic advances) gave way to further increases to work accidents and injuries in the 1980s. Although the health and safety legislation had required employers to make certain provisions within their organisations (safe working environment, welfare facilities, and worker training) investigation of accidents was centred on human error and did not investigate working environments and organisational factors. Health and safety practice, to be successful, required commitment not only from workers but also their managers and the company directors.

In Europe, the European Community was requested to comply with new directives which included health and safety. The introduction of the Mobile Worksite directive of 1992 clearly outlined responsibilities of clients to appoint competent designers and contractors in any buildings they wished to construct. In the UK, this directive was used to produce the Construction Design and Management Regulations 1994. When these regulations failed to have the desired impact, an industry consultation in 2002 pointed to the regulations complexity and the bureaucratic approach taken to its use undermining its intended health and safety objectives. This led to a revision of the regulations in 2007 which addressed the industry concerns as well as incorporating the Construction (Health Safety and Welfare) Regulations 1996.

---

---

### 2.3.1 International Perspective

Internationally the focus of research into industrial accidents has moved towards the role of designers. A growing body of research has pointed to the significance of design decisions in the causation of accidents on the construction site.

In 2005, the National Occupational Health and Safety Commission in Australia, as part of their occupational health and safety strategy, funded research into design related fatalities and injuries that occurred between 1997 and 2002. In the report it was concluded that similar design problems are involved in many fatal incidents; design is an important contributor to fatal injury in many industries, and solutions already exist for most of the identified design problems.

In the United Kingdom, research was carried out for the Health and Safety Executive (Haslam et al. 2003) to investigate 100 construction accidents. An ergonomics system approach was adopted for the study which concluded that up to half of 100 accidents could have been mitigated by design changes. Other UK research (Gibb 2003) said that innovations were being used to reduce both health and safety risks and that these were being implemented prior to construction. However, these were initiated by the supply chain rather than the clients design team. It was also found that non-construction experts such as ergonomists and human factors personnel saw all aspects of work up to construction as design.

In the United States of America a research review of statistics relating to construction fatalities (Behm 2005) showed that 42% of fatalities reviewed were linked to the design of the construction safety concept. It concluded that the concept itself was not a panacea and that a team-orientated approach of designer, owner and constructor was necessary for the intervention to be meaningful.



---

---

A research and practice symposium was held in the United States (Eugene, Oregon) in September 2003 with the title *Designing for Safety and Health in Construction* where an international selection of researchers and practitioners involved with the safety and health in construction concept presented their work. Proceedings with the same title were published in 2004 and in the concluding chapter referred to the paradox of why an apparently good idea was slow to be adopted. It went on to say that economic barriers (cost benefit of implementation and possible increased liability to designers) and institutional barriers (conservative construction industry slow to change; incorporation of ideas into university curricula; and relationships between safety and health professionals and design and construction disciplines) were holding up the uptake of the concept. Recommendations included the provision of knowledge about 'design for construction safety' to practitioners and institutional changes for which there was a general consensus but suggested insurance programmes and legal mandates found considerable differences among the attendees.

### **2.3.2 Europe**

Despite reservations regarding the scope of legislative powers, setting lowest common denominator standards and the interpretation of the phrase *working environment*, the framework directive and the accompanying directives adopted under its umbrella are the most significant alterations to UK health and safety legislation since the passage of the *Health And Safety At Work Act* (James 1993).

The European Directive 92/57/EEC on the implementation of minimum safety and health requirements at temporary or mobile construction sites was the first explicit legislation to enforce particular duties upon designers. Until the introduction of this Directive, designers had limited

---

---

responsibilities for assessing risk under common law provisions depending on which country they worked in. All EU countries must comply with the safety and health provisions in this Directive. However, each member state has done this in a different way with regard to legislative content, specificity, adaptation, and implementation (Martínez Aires, Rubio Gámez & Gibb 2010).

In the United Kingdom the European Directive 92/57/EEC is implemented in the form of the Construction (Design and Management) Regulations. Research investigating the progress of these regulations (Baxendale, Jones 2000) two years after implementation found that designers were not always taking a significantly different view regarding the build ability of the structure and information on risk was not being passed down to the operatives on site. They went on to say that designers' qualifications should not be the sole criteria by which competence should be assessed as they should also require a knowledge and understanding of how risks and hazards to health and safety can arise in construction and how they can be avoided or reduced through design.

### **2.3.3 Support for designers**

With regard to support organisations and institutes, there have been various initiatives set up internationally. In the United States The National Safety Council's Business and Industry Division formed the Institute Of Safety through Design in 1995. The Institute has been active in organising symposia, establishing a coalition of universities, developing materials and offering free software on hazards analysis on risk assessment.

Publicity surrounding the revised regulations as they came into force raised awareness amongst those duty holders who were not already

---

---

complying with them as well as provoking debate concerning each duty holder's responsibilities under the regulation. Meanwhile the UK had seen the formation of groups (Designers' Initiative on Health and Safety DIOHAS, Safety in Design SiD) with a specific agenda to assist designers in understanding the role in designing out health and safety risks. Parallel to this there have been several movements in Australia (Australia Work Safe) and the USA (USA Prevention through Design)

For designers to begin to get involved with construction site health and safety the driving force in Europe has been directive 92/57/EEC of 24 June 1992 on the implementation of minimum safety and health requirements at is temporary or mobile worksites.

### **2.3.4 In practice**

An investigation into the research needs for the Prevention through Design (PtD) concept (Gambatese 2008) stated that research was needed to understand how to account for human interaction with machines, their work environment and creating a design. The ways in which workers approach, operate, and view machines can impact the hazards that they experience. Barriers identified included the large size, complexity, and fragmentation of the industry sectors, and difficulties in analysing safety and health hazards and identifying the design as a causal factor. It was thought that while some tools exist that can facilitate the design process, such as checklists and computer-aided design (CAD) systems, PtD research is needed to develop supporting design tools and processes.

Research into the development of a Design For Safety Process (DFSP) tool (Hadikusumo, Rowlinson 2002) used the integration of a virtual reality construction model, virtual reality functions and a design for safety process database to allow the user to walk through a virtual project and

---

---

identify safety hazards within construction components and processes, as well as to select accident precautions needed to prevent occurrence of accidents. In other words designers were able to identify safety hazards inherited during the building construction phase that are actually produced during the design phase.

In a Safety in Design intervention study in the United States (Hecker, Gambatese 2003) the task force made an early decision on the project to change the name of the process from Safety in Design to Life Cycle Safety. The group felt the former name implied that all safety responsibility lay with the design firm, and they wanted it to be clear that all parties had something to contribute in creating a safer design. Preliminary conclusions from the intervention found that input from trade contractors' personnel added value to the design process. Therefore, a Safety in Design effort needs to consider other design processes in addition to that conducted by the owners' design contractor; better education and tools were needed for designers on construction safety and health issues; and growing dialogue between contractors and designers can offer benefits to both groups.

The Prevention through Design process has been used in the United States' mining industry to tackle the health hazard of noise-induced hearing loss. A quiet-by-design approach was used to reduce noise exposures of continuous mining machine operators by 3dB (A). The study showed the impact of successful acceptance and implementation at higher levels of an organisation directly impact on the acceptance and consistent usage of engineering controls at the employee level. One of the key factors in its success was getting upper management of the manufacturers of equipment to buy into the benefits of the downstream users which in turn benefit the manufacturers in the long-term. Although the Prevention through Design method was successful, the introduction and implementation of engineering controls in the workplace relied upon

---

---

consideration of the organisational issues that intersect across management, safety, training, and maintenance departments.

In an attempt to clarify the roles of design and construction professionals in site safety, a survey (Toole 2002) of design engineers, general contractors, and subcontractors in the United States of America indicated that there is not uniform agreement on the site safety responsibilities assumed by each of these groups. The work stated that site safety expectations must reflect the actual abilities of each company to prevent the root causes of accidents. The limited role the design engineers can typically play in site safety should be specifically acknowledged in the joint venture agreement.

Construction design organisations' interpretation of The Construction (Design and Management) Regulations in the UK has led to the development of in-house tools and procedures. Arup Project Management (APM) have proven (Duffy 2004) that the use of standard, but simple and flexible, tools and documents helps the systematic approach to health and safety during the design phase.

Details of the research mentioned in the above section including experimental design, manual handling subject and outline findings are presented in Table 3.

A safety through design model produced by (Christensen, Manuele 1999) is shown in Figure 2. This indicates that consideration of hazards and risks should be moved as far "upstream" as possible in the design process.

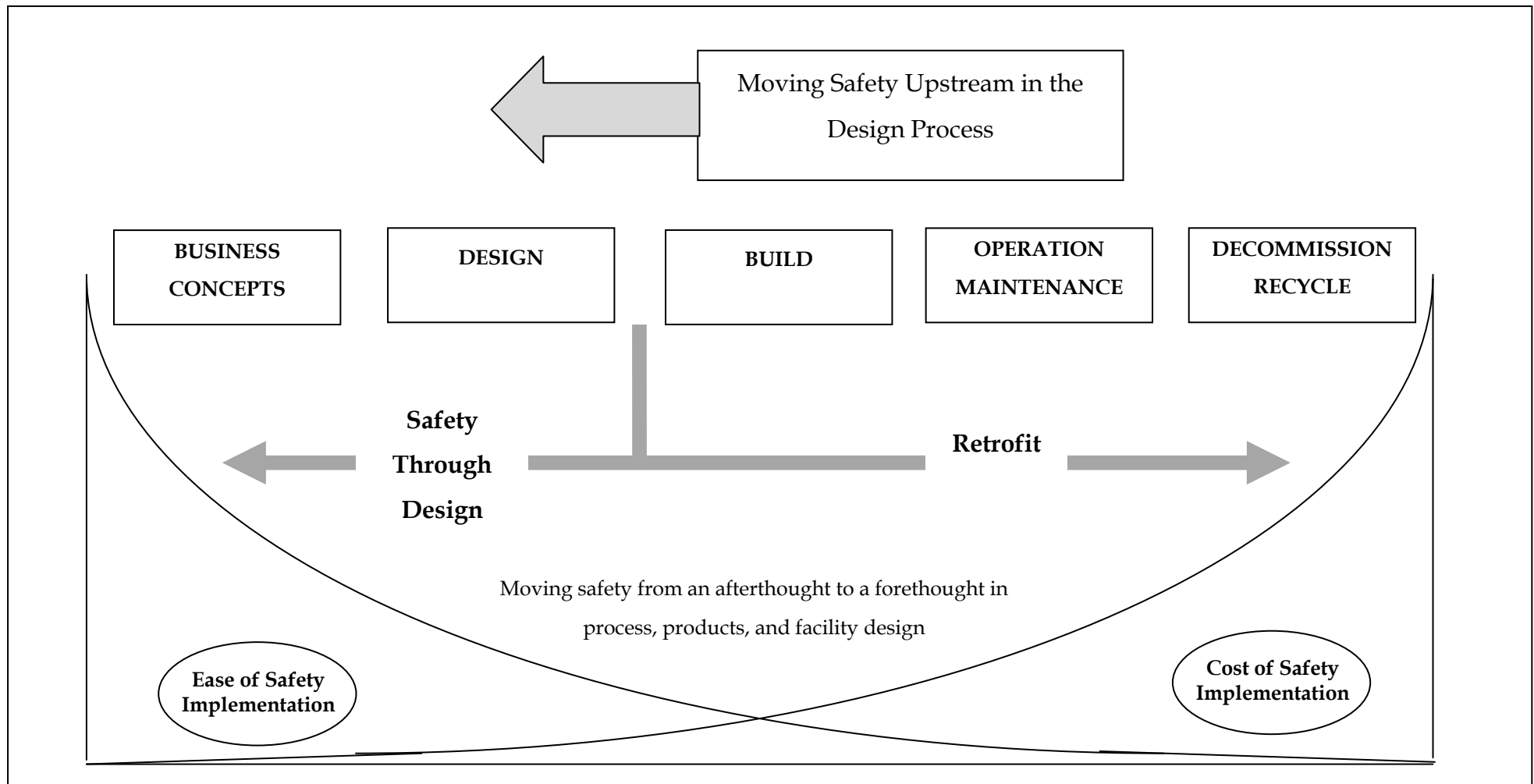


Figure 2 Model for Safety Through Design

Author and Year	Experimental Design	Safety in Design area	Findings
Aires et al (2010)	Review of existing data	EU members adaptation of Directive 92/57/EEC	Accident rate more than 10% lower in most member states but no evidence of specific success of the Directive
Baxendale and Jones (2000)	Review of existing data	Progress of CDM regulations	Disparity in format and content of risk assessments. Health and safety plans difficult for small and medium contractors. Overcome with use of planning supervisors.
Behm (2005)	Review of existing data	Fatalities and design for construction safety	The US should implement design for construction safety. Designers can participate in enhancing site safety. Investigations should consider if design linked to accident
Christensen and Manuele (1999)	Review of existing data	Definition of safety through design	Hazard analysis and risk assessment at design stage reduces injuries, illnesses and damage but also improves productivity, efficiency and avoids retrofitting
Gambatese (2008)	Workshop	Research issues in prevention through design	Seven topics identified. Occupational safety and health research conducted by independent organisations and researchers. Studies may overlap or leave knowledge gaps.
Gambatese and Hinze (1999)	Industry survey for best practice	Construction worker safety in the design phase	Workable software package developed to address project-specific hazards
Gibb et al (2003)	Case studies	Role of design in accident causality	Architects and engineers can make a difference at removing or reducing construction site risks.
Hadikusumo and Rowlinson (2002)	Development of design-for-safety-process tool	Integration of construction model and database	Mechanism provided to allow the user to do a walk-through in the virtually real project and identify safety hazards as well as precautions needed
Haslam et al (2003)	Case studies	Investigation of construction	A causal influence model is presented, derived from the research. It is argued that attention is needed to all levels in

		accidents	the influence hierarchy, if a sustained improvement in construction safety is to be achieved.
Hecker and Gambatese (2003)	Field study	Proactive approach to construction worker safety and health	Input of contractor personnel added value to the design process. More and better education tools needed. Dialogue between constructors and designers can offer benefits to both groups.
Howell et al (2002)	Review of existing data	New approach to construction safety	Organisational and individual pressures push people to work 'near the edge'. Adopting a new definition of hazard and applying better planning expands the zone of safety.
James (1994)	Review	The European influence	The Framework Directive is the most significant alterations to UK health and safety since the passage of the HSW Act.
Kovalchik et al (2008)	Field study with mining stakeholders	Prevention through design approach used to tackle excessive noise	Acceptance by management and machine manufacturers directly impacts on acceptance and usage of engineering controls at employee level
Marino Duffy (2004)	Case Studies	Techniques and procedures or effective communication of H&S information	The use of standard, but simple and flexible, tools and documents helps the systematic approach to health and safety during the design phase.
Toole (2002)	Questionnaire survey, 105 responses	Site safety roles	Under traditional project arrangements ability to influence root causes of safety varies from high to low depending on the role. Everyone involved in construction should be actively concerned with the safety of workers.

Table 3 Safety in Design research



---

---

## 2.4 Equipment

Mechanisation has always been an important factor in the technical advancement of construction with all the major industrialised countries having an industrial sector producing building machines. Heavy machinery for the construction industry, such as excavators and tower cranes, are manufactured by large companies like Caterpillar, Deere, Komatsu, Manitowoc, Liebherr, Schwing, Richier, Kato, Ruston-Bucyrus, Potain and Poclain. Some of these firms also produce large machines for agriculture and mining. Smaller electrical tools, such as power drills, are manufactured by firms that also produce general-purpose tools, e.g. Black & Decker and Bosch. Germany has been a leader in building mechanisation in Europe for some time and is the largest exporter of building machines, exceeding the output of even the USA and Japan (Sebestyén 1998).

In comparison to other sectors, construction is usually classified as a traditional or low technology sector with low levels of expenditure on activities associated with innovation such as research and development (Seaden, Manseau 2001a). Helander (Helander 1980) identified reasons for limited research in construction health and safety. Many construction companies are small and cannot support research and development programmes; ergonomic problems are considered to be long-term in nature and are overshadowed by more immediate concerns; individuals often spend less than six months on a site making ergonomic problems appear temporary and reducing the likelihood of complaints; the conservative nature of the construction industry reduces the likelihood of acceptance of novel, interdisciplinary methodologies.

The main drivers of technological change in the industry are seen to be new components introduced by suppliers to the industry (Reichstein,

---

---

Salter & Gann 2005). Although there is relatively little research in the building sector compared to other industrial areas, much of the progress in construction originates in the work of designers and manufacturers, so that the technical progress is not restricted to the result of formal building research (Sebestyén 1998).

Over the years considerable ergonomic advances have been made in the manufacturing industry with research in areas such as quality control, material handling, machine design, control of noise and illumination, shift work, operator training and workplace layout. The construction industry has no parallel experience (Helander 1980). Despite mechanical handling of materials over several decades, little research had been carried out into their effectiveness by the end of the last millennium. This research has usually been in the areas of organisation, stresses on the body and ergonomics of the tasks.

Research into construction organisation in the Netherlands found that financial barriers were the most important factor impeding the introduction of better tools. The Ministry of Social Affairs and Employment introduced a subsidy in 1986 so that every paving company could receive an allowance of 50% of the costs of new equipment. An evaluation of the effects of the subsidy scheme was carried out (Berndsen 1990) and found that, when introducing new appliances, special attention must be paid to avoiding health or safety effects such as the introduction of noise, mechanical vibrations and safety problems. The quality of the tool or machine is a determining factor for its regular use and therefore extensive testing is required before introduction. By taking away their financial barriers, the purchase of appliances was stimulated with even small companies investing in new equipment.

In one investigation into the physical effect on operators using mechanical devices, three classes of materials handling devices were considered

---

---

(Resnick, Chaffin 1997) comparing an articulated arm device with two types (overhead rail and fixed pivot) of hoist. The work concluded that more comprehensive studies were needed to develop guidelines specifying these devices and that the effects of handled load and movement distance on the forces and velocities provide insights into the mechanisms of whole-body exertions. The work highlighted the importance of using appropriate standards for complex whole-body exertions.

The effect on low-back stresses when learning to use a materials handling device was investigated in the United States (Chaffin et al. 1999). It was found that the materials handling devices were beneficial in reducing compressive forces in the lower back even when handling heavier loads than were experienced in the manual operation. The introduction of more complex operations, however, resulted in a slower learning process.

Detailed biomechanical analysis of materials handling manipulators (Nussbaum, Chaffin & Baker 1999) showed that overhead hoist machinery was better at reducing spine compression forces than an articulated arm device but imposed higher demands on coordination and stability at extreme heights (below the knee and at chest level) or with torso twisting motions. A continuation of this work (Nussbaum et al. 2000) showed the manipulators were effective at reducing hand forces but the articulated arm was less effective as the vertical travel distance increased. Hand forces are a key indicator that biomechanical and joints and muscle stresses may be occurring.

When considering the ergonomics of construction tasks, a manual handling operation consists of four components: (a) worker, (b) task, (c) tools and equipment and (d) environment (Ayoub 1992). The ergonomic approach to manual materials handling tasks focuses on three of these, necessitating a human-task-environment system. A generally accepted

---

---

means of minimising materials manual handling-related injuries is that of designing manual materials handling tasks so that the physical, physiological and mental demands of such tasks are within the physical, physiological and mental capacities of the workforce performing those tasks.

In a study looking at the use of ergonomics for reducing low-back stress of construction workers (Kaminskas, Kazlauskaite 2008) the analysis suggests that the risk of lower back injury may be reduced by using ergonomic devices to minimise tilting of the trunk during heavy lifting at work. Benefits of the ergonomic aids were shown when using manual lifting of heavy concrete road kerbs (up to 100 kg) and stone blocks. Positive effects were achieved due to the fact that the workers can perform the task with a straight back. Workers' participation was found to be necessary to assist in improving the quality of the innovative ergonomic devices.

Finnish research (Kaukiainen et al. 2002) looking at the use of equipment to lighten the load of construction workers examined four tasks; cutting mouldings; moving and cutting steel reinforcement; carrying carpet rolls; and fitting concrete drainpipes. Equipment was introduced to assist with all of these operations and it was found that the workload could be decreased with well-planned equipment, but more attention should be given to personal work methods and habits.

The adoption of mechanical aids without attention to the ergonomic factors involved has the potential of causing more problems than the device intends to solve. Research into the usability of manual handling aids for transporting materials (Mack, Haslegrave & Gray 1995) examined the use of trucks and trolleys used in industry to transport materials to find out why they were not always effective in reducing workload. Equipment was found to be difficult to use because it was often heavy to

---

---

operate and injuries such as finger trapping added to the lack of use. Use of the aids tended to be slower than simply moving the components by hand and there was an additional task of stowing the aid after use. It was stated that significant improvement in efficiency and reduction in accidents was achievable through more attention being paid to ergonomic design factors (design characteristics, load characteristics, environmental conditions, operational conditions and user characteristics) by manufacturers and purchases of aids.

Investigations into the use of power tools (Vedder, Carey 2005) identified that working postures in construction workers are determined by the work system design. The work system consists of the task itself, the available equipment, the power or hand tools employed, and the organisation and design process that influence each of these. This proposed multilevel approach provides an ergonomics framework for the refinement of tools, equipment and processes, giving attention to these considerations. Although this system is familiar to the ergonomics community, it is less familiar and widespread for designers, manufacturers and suppliers in the construction industry.

Details of the research mentioned in the above section including experimental design, lifting equipment subject and outline findings are presented in Table 4.

Author and Year	Experimental Design	Equipment Subject	Findings
Ayoub (1992)	Review of existing data	Determine comprehensive model to establish lifting limits	Comprehensive models rely on the accuracy of models for established biomechanical, physiological and psychophysical approaches
Berndsen (1990)	30 Semi structured questionnaire interviews in 27 companies	Use of appliances for paving work bought under incentive scheme	Appliances can reduce workload but need to avoid health and safety effects such as noise. Proper implementation is needed to encourage use.
Chaffin et al (1999)	Physiological experiments	Using materials handling devices	The devices had a beneficial effect on L4/L5 compression
Helander (1980)	Review of existing data	Safety challenges in construction	Considerable ergonomic advances have been made in the manufacturing industry with research in manual handling, machine design and control of noise. The construction industry has no parallel experience
Kaminskas and Kazlauskaite (2002)	Field observations and analysis of eight construction operatives	Reduction of low back stress for construction workers	Ergonomic devices do not reduce the weight of lifted elements, but the positive effect is achieved due to workers performing task with a straight back
Kaukiainen et al (2002)	Workplace equipment evaluation, 39 subjects	Mechanical handling devices	Equipment for moving and cutting reinforcement improved back posture and use of strength. Workload can be decreased with ergonomic equipment and work methods
Mack et al (1995)	Field study, 90 interviews	Usability of manual handling aids	Significant improvement and injury reduction possible with more attention to ergonomic design factors
Nussbaum et al (1999)	Physiological experiments	Using mechanical	Assisted lifting better in reducing spine compression forces but

		manipulators	imposes demands on stability and coordination
Nussbaum et al (2000)	Laboratory, controlled experiments, 10 subjects	Comparison of materials handling manipulators	Both devices reduced hand forces. Manipulators with high intrinsic inertia less effective.
Reichstein et al (2005)	An analysis of existing data	Comparison of innovation in construction, services and manufacturing in the UK	Construction is separated from other industries by liabilities of immobility and unanticipated demand
Resnick and Chaffin (1997)	Laboratory study, 10 subjects	Evaluation of three classes of materials handling device	Comprehensive study is needed to develop guidelines for the specification of devices in the workplace.
Seaden And Manseau 2001	International task group	International comparison of innovation in construction for policy development	Construction perceived as being "in trouble". It is slow to adopt new knowledge. It is very complex and the role of governments has not been adequately addressed. Small specialised construction firms dominate national markets. An organisation must exist to represent innovation interests of the industry.
Vedder and Carey (2005)	Case study examples to illustrate new approach	Holistic approach for development of tools, equipment, and work for construction	Total system philosophy not well known by designers, manufacturers and suppliers in the construction industry. This approach could make progress in this respect.

Table 4 Construction and lifting equipment research

---

---

## 2.5 Training

In the United Kingdom employers are required, under the Health and Safety at Work Act, to provide their employees with health and safety information and training. This should be supplemented as necessary with more specific information and training on manual handling injury risks and prevention. Lifting training is based upon the implicit assumption that back injuries are characteristically caused by faulty lifting technique and that they may therefore be prevented by teaching people the correct way to lift. In reality, there is relatively little direct evidence in support of either of these beliefs, and a certain amount of evidence to the contrary (Pheasant 1991).

Despite widespread understanding of safe-lift principles (maintain a straight back, use leg muscles, keep the load as close to the body as possible, use smooth body motion, avoid jerking, and turn the feet rather than twisting the torso) amongst industrial workers, the number of manual materials handling related injuries has not decreased significantly (Sanders, McCormick 1993).

A review was carried out into personnel training for safer material handling (Kroemer 1992) and found that the issue of training for prevention of back injuries in manual materials handling was confused at best. Companies have a legal responsibility to provide the training and continue to do this to limit their liability. Initial improvements following training are always likely due to the Hawthorne effect but the long-term results were often disappointing as people tended to refer to previous habits and customs because better practices are not reinforced and refreshed.

The three main strategies proposed by Pheasant (Pheasant 1991) for dealing with the risks associated with lifting and handling tasks are



---

---

selection, training and work design (ergonomics). All three approaches proceed on the assumption that lifting and handling injuries result from a mismatch between the demands of the task and the capacities of the person. Selection and training are aimed at solving the problem by fitting the person to the job while work design is aimed at fitting the job to the person.

Of the three strategies training is the most difficult to manage. Work design requires an understanding of the risks inherent in the task and then changing the operations to reduce or remove them. Selection requires an understanding of the demands of the work and recruiting workers capable of meeting those demands. Training, however, begins with understanding the risks; providing appropriate training; monitoring the work to see if the training has been successful; carrying out evaluations from the results of the monitoring; and making any necessary revisions to the training.

An examination of proposed manual handling international and European standards (Dickinson 1995) noted that, when assessing manual handling operations, if it was determined that the load was found to be unacceptable "the provision of information and training alone" was unlikely to ensure safe manual handling.

Research into manual handling training has looked at physical aspects, techniques used and how training fits into organisations. The physical aspects include benefits of physical training and shortfalls of using abdominal belt supports. Much training revolves around conditioning workers to adopt a squat lift rather than using a stoop lift when manually handling. In a review examining the empirical and theoretical basis for these lifting techniques (Burgess-Limerick 2003) it was stated that there is unlikely to be a single "best" technique which is appropriate in all situations. Training should instead provide education in general lifting

---

---

guidelines and assist lifters to discover individually appropriate postures and patterns of movement.

Despite the effectiveness of training manual handling techniques being in question, there would appear to be some benefit from flexibility and strength training for workers. The Health and Safety Executive review (Haslam et al. 2007) referred to work carried out to reduce patient handling injuries (Gundewall, Liljeqvist & Hansson 1993) and that flexibility and strengthening training for the lower back had showed promise as a measure to reduce these injuries. Other investigations (Holmström, Ahlborg 2005) of morning warming up exercises to increase and maintain joint and muscle flexibility and muscle endurance for workers showed indications of being beneficial.

In a review looking at task-specific and generalised physical training for improving manual material handling capability (Knapik, Sharp 1998) it was reported that, as well as advantages from regular physical activity (increased worker health, longevity, productivity and reduced medical costs), both task specific and general fitness training programmes can improve manual materials handling capability and each type of training has its place, depending on the nature of the occupational task.

The use of back support belts for prevention of back pain and injury is widespread. Research in the United States of America (Wassell et al. 2000) between 1996 and 1998 using a sample of 13,873 material handling employees found that neither frequent back belt use nor a store policy that required belt use was associated with reduced incidence of back injury claims or on low-back pain.

Repetitive lifting tasks were carried out under experimental conditions to evaluate lifting techniques and abdominal belt usage (Rabinowitz, Bridger & Lambert 1998) as it was thought that these two modalities improved the safety of industrial manual handling operations. From the results the

---

---

squat lift was perceived as being the safest method of lifting but 60% of participants regarded this as the least preferred method. A similar situation occurred with belt usage: all participants perceived using the belt as the safest method while 50% rated the belt as their least preferred lifting condition. The findings cast doubt on the efficacy and acceptability of both abdominal belts and the practice of training workers in safe lifting techniques.

Research into techniques used in manual handling training has commented on hazard recognition and shortfalls of training with lifting equipment. Hazard recognition is an essential element for safety motivation and it has been found that inexperienced construction workers generally underestimate the hazards and need training in hazard recognition (Helander 1991). Therefore, it is important to investigate the motivational issues in safety training to understand what aspect should be emphasised to change the behaviour of construction workers. In a review of the effect of training and lifting equipment for preventing back pain in lifting and handling (Martimo et al. 2008), no evidence was found to support the use of advice or training in working techniques with or without lifting equipment for preventing back pain or consequent disability.

Looking at organisational issues there has been research into differences in international systems, the need for multi-dimensional ergonomic interventions and making training more specific to workers needs.

Investigations into occupational safety and health and training in the construction sector in the European Union indicate that, according to European Community figures (EC 1993), less than a quarter of the European Union construction workers receive any training in occupational safety and health. Training for construction workers in Europe has been divided between the dual system concept

---

---

(apprenticeship) in the German-speaking countries and the British National Vocational Qualifications, NVQs (Laukkanen 1999). In construction, automation does not seem to have reduced the physical loading of construction work and typically new practices commence quite slowly on sites. It is therefore important to provide continuous support and safety motivation and commitment of all parties. Laukkanen concluded that the training most needed is safety instruction, teaching first aid skills, and accident prevention. Skill training is important combined with ergonomic instruction, and the need for further on-the-job training arises more frequently than in other sectors; usually a majority of the construction workers have had no training.

A comparative study between Danish and Swedish construction workers (Spangenberg et al. 2003) compared lost time injury (LTI) rates and injury risk factors. The LTI-rate of the Danish construction workers was approximately fourfold that of the Swedish construction workers. The difference was partly explained by differences in training and education. In Denmark, professional training consists of practical on-site experiences whilst Swedish workers were educated through schooling and apprenticeships which were based more on health and safety rules and regulations.

Investigations into manual handling risks and controls within an industrial setting (Wright, Haslam 1999) used interviews, postural analysis, the revised NIOSH equation, document analysis and an evaluation of training. Although the training was acceptable in some respects it was recommended that it should be modified to be more specific to the workers needs, providing principles that could be used in more situations. It also stated that training should be considered a secondary control for manual handling activities, in place to ensure that where risks remain, workers are fully informed and educated in ways they can reduce the risks.

---

---

An in-depth review funded by the UK's Health and Safety Executive (Haslam et al. 2007) was carried out in order to develop guidelines for effective manual handling training. The research included a systematic literature review, a telephone survey of representatives from a broad range of industrial sectors and expert panels to validate results and generate guiding principles. Little evidence was found to support the effectiveness of technique and educational based manual handling training: the techniques were not found to transfer into the workplace. There was strong evidence that multi-dimensional ergonomic interventions which involved participation by workers and managers and tailoring training to suit specific work practices were more effective in reducing manual handling injuries. The telephone survey respondents felt the manual handling training was more effective if tailored to specific industry and task demands, whilst the expert panels considered the focus of manual handling training should be on promoting the right culture to achieve safer working practices.

The Health and Safety Executive's review provided a list of 16 principal guidelines which included "management support is crucial to success", "training should be viewed as an ongoing process", and "evaluate the process and the outcome of training". It also stated that the core content of manual handling training should cover: why manual handling matters; statutory requirements; anatomy of physiology; care of the back; handling principles; hands-on experience; risk assessing situations; and dealing with problems. It was suggested that the broad principles serve as a basis for further discussion and future research.

Details of the research mentioned in the above section including experimental design, training research subject and outline findings are presented in Table 5.

Author and Year	Experimental Design	Training Subject	Findings
Burgess-Limerick (2003)	Review of the existing literature	Review of recommendations regarding lifting technique	Lifting training is generally ineffective. Education in general lifting guidelines preferable. Lifters need assistance to discover appropriate postures and patterns of movement.
Dickinson (1995)	Review of proposed standards	International and European manual handling standards	Designers, employers, employees and others involved in work, job and product design targeted. Provision of information and training alone is unlikely to ensure safe manual handling.
Haslam (2007)	Systematic literature review, telephone survey, expert panels	Investigation of current practices and development of guidelines	Considerable evidence that principles learnt during training not transferred to work environment. Manual handling training more effective if tailored to specific industry and task demands. Management commitment crucial to successful training.
Helander (1991)	Analyse existing data	Safety hazards from accident statistics	Inexperienced construction workers generally underestimate hazards and need training. Need to understand motivational issues for safety training.
Holmstrom and Ahlborg (2005)	Field experiment, 30 participants	Assess effect of warming-up exercises	Warming up exercises could be beneficial in increasing and maintaining joint and muscle flexibility and muscle endurance for workers exposed to MMH.
Knapik and Sharp (1998)	Review of existing data	Training for improving manual handling capability	Task specific and general fitness training programmes can improve MMH capability and each type of training has its place.
Kroemer (1992)	Review of existing data	Identify research issues in personnel training	Generally accepted that training and improving awareness and attitude is required but content and media to use not determined

Laukkanen (1999)	Review of existing data	Construction work and education	Automation does not seem to have reduced the physical loading of construction work. New practices commence quite slowly on sites. Skill training is important combined with ergonomic instruction.
Martimo et al (2007)	Review of existing data	Effect of training and lifting equipment for preventing back pain	No evidence to support use of advice or training in working techniques with or without lifting equipment for preventing back pain or consequent disability
Rabinowitz et al 1998	Laboratory experiment, 10 subjects	Lifting technique and abdominal belt usage	Efficacy and acceptability of belt usage and safe lifting techniques in doubt. Individual characteristics and preferences need to be considered.
Spangenberg et al (2003)	Case Study	Comparison of lost time injury rates between Swedish and Danish construction workers	Significant difference in LTI-rates explained by differences in education and experience, training and learning, and attitude.
Wassell et al (2000)	Prospective cohort study, 160 participants	Back belt use for prevention of back pain and injury	Back belt use not associated with reduced incidence of back injury claims or low-back pain.
Wright and Haslam (1999)	Field study, 53 participants, observations and Semi structured interviews	Manual handling in distribution centres	Significant manual handling risks and reported musculoskeletal disorders in company believed to be proactive in health and safety

Table 5 Manual handling training research

---

---

## 2.6 Ergonomics in the Construction Industry

“Despite countless health and safety initiatives and campaigns, the industry remains dangerous. What is even worse is that almost all of the deaths and injuries that occur are foreseeable and preventable. We have known for years how to prevent them, but they still happen – often in the same old ways. Perversely, this leads some people to think that they can’t improve, because the good are already good and the bad will never improve.” – Revitalising Health and Safety in Construction, Health and Safety Executive 2002.

The demanding nature of construction activities has been well documented over many years. In *The Principles of Scientific Management* by Frederick Winslow Taylor reference is made to work carried out by fellow member of the American Society of Mechanical Engineers, Frank Bunker Gilbreth. In the book Gilbreth observed “Think of the waste of effort that has gone on through all these years, with each brick layer lowering his body, weighing, say, 150 pounds, down two feet and raising it up again every time a brick (weighing about 5 pounds) is laid in the wall! And this each brick layer did about one thousand times a day (Taylor 1911).

As recently as the late 1990s the construction industry was characterised as most conservative (AP Koningsveld 1997). Work in the industry was physically straining and work organisation and working methods were traditional. The use of specialised trades to improve performance had resulted in a division of work with jobs tending to be both monotonous and repetitive. The introduction of mechanisation had reduced some of the physical strain but at the same time reducing the variety of the tasks making repetitive strain injuries a more likely hazard. Work was often



---

---

carried out with workers being exposed to the elements with detrimental consequences for their musculoskeletal and respiratory systems. Poor management of walkways on construction sites also meant that with exposure to rain they turned to mud making work more difficult.

With the cost of labour forming a large percentage of the cost of most buildings, cost-cutting companies look to the workforce to increase productivity. This adds to the pressure on workers of what is already “a dirty, demanding and dangerous” occupation. Many workers report that they continue to work whilst hurt and subsequently a great many construction workers are unable to carry out any form of work after they reach 55 years of age (Labourers’ Health & Safety Fund of North America 2010). Construction workers are less likely than workers in other industries to encourage young people to enter the industry. Young people are also put off by the demands of the industry. This has led to skills shortages in construction and subsequent efforts by the industry to improve conditions in order to attract young people and enable older workers to work longer.

The relatively new discipline of ergonomics emerged just over 60 years ago. The Ergonomics Research Society formed in 1949 with the intention to facilitate the exchange of ideas and expertise between the many disciplines which had made a contribution to the increased effectiveness of human performance during the Second World War (Singleton 1982). An early definition of ergonomics states that “A man and his machine may be regarded as the functional unit of industry, and the aim of ergonomics is the perfection of this unit so as to promote accuracy and speed of operation, and at the same time to ensure minimum fatigue and thereby maximum efficiency” (Le Gros Clark 1976).

Problems highlighted by ergonomists in the construction industry include working in the same position for long periods of time; the lifting and

---

---

carrying of heavy loads; working below knee level and above shoulder height; awkward bending and twisting of the back and tasks which require repetitive motions (Smallwood, Wheeler & Venter 2000). These problems are further exacerbated by the environment in which they are carried out. Poor housekeeping on construction sites increases the risk of slips and trips. Noise is a serious threat with many older workers suffering from hearing loss. The materials and equipment used also tend to create dust which can lead to a variety of health complications, and as buildings rise out of the ground there is always a risk that workers may fall from a height or will be struck by falling objects.

It is suggested (Stubbs, Nicholson 1979) that large numbers of back injuries occur amongst workers at an age when the general physique and musculature of the back are in optimal condition, so research should concentrate on faulty work performance rather than the physical condition of the workers. They also referred to the considerable loss of efficiency due to back injuries arising from bad manual handling and difficulty in gauging the extent of the problem due to an estimated underreporting of accidents in the construction industry believed to be in the order of 50%. In a review of existing manual handling guidelines (Buckle et al. 1992) the research showed that there was difficulty applying the guidelines in industrial settings and that, in any systematic evaluation of manual handling systems, a task analysis is a key tool in both system evaluation and system design.

Workers who are attracted to the construction industry derive some satisfaction from being part of the construction process. Work stress has not been reported as a severe problem in most construction trades although site managers are an exception (AP Koningsveld 1997). A very small percentage of workers will admit to enjoying working outside in the wind, rain and cold but many construction workers do like to work outside, and over the past decade progress has been made in the

---

---

assessment of construction risks and in measures to reduce or eliminate them which has made working in the construction industry considerably less arduous.

Good ergonomics in the construction industry can be achieved with simple inexpensive solutions (Laborers' Health & Safety Fund of North America 2010). Planning of work to minimise manual handling, the storing of materials more accessibly and ensuring that walkways are kept clear are good examples. The choice of equipment to include ergonomically designed tools, the use of carts and hoists to move materials instead of manual handling, using handles when carrying loads and kneepads to reduce contact stresses of kneeling at work can also make a difference. Add to this cooperation amongst workers so that they ask for help when lifting heavy loads, the specification of lighter loads and training workers and foremen to identify ergonomic risk factors and you can see why many companies are beginning to look at ergonomic problems and work solutions as a business case: making work easier for workers; getting them to work smarter and not harder and ending up with a more productive job.

Despite conditions in the construction industry, it is surprising that the attention of ergonomists and health and safety specialists has been poor compared to other industries. In most other industries, there is a general acceptance of research as an activity essential to growth and survival. The construction industry has been characterised as a notable exception. Undoubtedly, the fragmentation of the industry has inhibited co-ordinated research and development (Helander 1980).

Where organisations have decided to adopt systematic ergonomics approaches to solve problems in the construction industry, major improvements have been possible. Using a participatory approach, involving experienced construction workers in the development of

---

---

ergonomic solutions should lead to effective change within the industry. But care must be taken when introducing new methods and technology to reduce traditional hazards that new hazards do not appear.

Major construction companies today, on the whole, have effective management for safety. This tends to decrease as the size of the organisation decreases. The management of occupational health has tended to lag behind that of safety. Initiatives such as “Constructing Better Health” have had a positive impact on the construction industry’s approach to occupational health. Standards for occupational health providers wishing to work in the construction industry have been set which is hoped will reduce the number of providers attracted to the industry who understand the management of occupational health but do not understand the construction industry.

The construction industry still has proportionally more fatalities, accidents and ill health than other industries. However, changes in society mean that it is no longer acceptable that large numbers of construction workers drop out of the system at a relatively young age. This is not only socially unacceptable, but the costs to industry are extremely high and the return on investment in vocational training is poor (AP Koningsveld 1997). It is hoped that, like in many projects around the world, ergonomists can work as a catalyst for change.

Details of the research mentioned in the above section including experimental design, ergonomics in construction subject and outline findings are presented in Table 6Table 3.

Author and Year	Experimental Design	Ergonomics Subject	Findings
Buckle et al (1992)	Review and three case studies	Limitations in applying guidelines	Difficulty in applying existing guidelines in the industrial settings. Task analysis a key tool in systematic evaluation of manual handling. Task behaviour varies greatly between individuals and is affected by experience
Helander (1980)	Review of existing data	Safety challenges in construction	Considerable ergonomic advances have been made in the manufacturing industry with research in manual handling, machine design and control of noise. The construction industry has no parallel experience
Koningsveld and van der Molen (1997)	Research overview	Ergonomics in building and construction	Changes in working methods and technology resulted in less traditional hazards, but new hazards appeared.
Le Gros Clark (1954)	Definition	Ergonomics	"A man and his machine may be regarded as the functional unit of industry, and the aim of ergonomics is the perfection of this unit so as to promote accuracy and speed of operation, and at the same time to ensure minimum fatigue and thereby maximum efficiency"
Stubbs and Nicholson (1979)	Analyse existing data	Review of 821 extra reports from two large building in construction companies	Back injuries are the result of either an acute gross injury or cumulative effect of small excessive strains. High incidence of handling accidents in younger population
Taylor (1911)	Case studies	Using scientific principles to affect the way managers organise their workforce	Every act of the workmen to be preceded by preparatory acts by the management enabling him to do his work better and quicker. Each man to receive help daily by those over him rather than being coerced or left unaided.

Table 6 Construction ergonomics research

---

---

## **2.7 Methods**

Extensive studies of construction workers and the tasks they carry out are rare. The Hamburg Construction Worker Study (Latzka, Pfahlberg & Gefeller 2002) was a longitudinal study initiated to identify risk factors of musculoskeletal disorders in the German construction industry with a focus on bricklayers. The longitudinal study was carried out with 488 construction workers taking part in the investigation of chronic low-back pain. Methods used included interviews, measurement (size and weight) of masonry used in tasks, measurement of psychosocial work factors and anthropometric measurements.

### **2.7.1 Postural analysis**

Many studies that examined the health of construction workers have used postural analysis methods to assess risks within the operations being carried out. Postural analysis of work activities provides useful information to determine whether those activities pose significant risks to the workers. The National Institute for Occupational Safety and Health (NIOSH) carried out a review of over 600 epidemiologic studies (Bernard 1997) and reported that there was strong evidence for causal relationships between awkward postures and neck/shoulder disorders.

Postural load using the Ovako Working-Posture Analysis System (OWAS) was used to investigate the prevalence of back pain in workers working in a precast concrete manufacturing company (Burdorf, Govaert & Elders 1991). Although the system could record 84 different postures, only fifteen, of importance for the occupational strain on the back, were taken into account. Bending and twisting along with whole body vibration (use of vibrotables) were identified as risk factors by using OWAS.

A portable computer system for the OWAS method was used to analyse construction jobs and to provide suggestions for work redesign measures

---

---

(Kivi, Mattila 1991). The method proved to be well suited for analysing work postures and it was possible to classify the jobs and tasks clearly, and according to the severity and generality of poor postures. The method was found to offer a powerful and reliable basis of teamwork aimed at developing corrective measures.

The PATH (posture, activities, tools, and handling) tool was developed specifically for construction work as it was noted that little had been done to provide quantitative information regarding the high prevalence of musculoskeletal disorders in the construction industry (Buchholz et al. 1996). The PATH method is able to identify non-repetitive work tasks posing a risk to workers and allows the user to be mobile to follow workers around.

Experiments were carried out to examine the validity of PATH and a simplified version of PATH using six designed construction job tasks, comparing the real-time observational approaches with video recordings and an electronic postural assessment system (Paquet, Punnett & Buchholz 2001). The fixed-interval observations made in real-time provided frequency estimates of shoulder, trunk and some leg posture categories closely approximated measurements obtained with electronic instruments or with video analysis but it was felt that more evaluation was needed.

The postural classification tools RULA (rapid upper limb assessment) (McAtamney, Nigel Corlett 1993) and REBA (rapid entire body assessment) (Hignett, McAtamney 2000) were developed for use with display screen equipment users and patient handling respectively. REBA was developed to meet a need for the sensitivity to the type of unpredictable working posture found in healthcare. After recording observed postures for the trunk, neck, legs, upper arms, lower arms and wrists, details of the load and activity of the task were included and

---

---

through a series of matrices a score would result. The score was then used in a table providing risks levels and action requirements.

An alternative to observational postural classification schemes (OWAS, PATH, RULA) is the instrument-based technique for postural loading on the upper body assessment (LUBA). This method was developed to overcome shortfalls of the observational methods (Kee, Karwowski 2001) such as not being based on experimental data; being developed only to specific application purposes; and dealing with only a few representative joint motions. The limitations of LUBA were that postures were held for short periods (approximately 60 seconds); it only investigated static joint motions and joint postures; and motions were only expressed using a single degree of freedom.

## **2.7.2 Task analysis**

In an examination of three types of task analysis (Drury 1983) it was stated that task analysis is one of the basic tools used by ergonomists in investigating design tasks. It provides a formal comparison between the demands which the task places on the human operator and the capabilities the human operator possesses to deal with these demands. The purpose of task analysis is to make a step-by-step comparison of the operation being carried out. There are two stages of analysis, usually termed 'Description' and 'Analysis'. Task analysis goes the next step beyond task description.

When investigating the role of task analysis in training design, it was stated (Annett, Duncan 1967) that at a time when powerful new training techniques are evolving, it is important that equally powerful methods of determining training requirements developed. It was thought that the major problem in task analysis for industrial training was to determine



---

---

what are described in what level of detail. It will often be apparent during task analysis that the same performance may be achieved in different ways.

### **2.7.3 Multilevel system approaches**

Research and practice in the field of work organisation had demonstrated that considering only a small number of work factors can be misleading and inefficient in solving job design problems (Carayon, Smith 2000). Theories of organisation and job design have primarily focused on methods to direct worker behaviour to improve performance. The Balance Theory Model proposed a model for job stress that integrated the psychological and biological theories within an ergonomic framework (Smith, Sainfort 1989). Essentially, when balance cannot be achieved through changing the negative elements of the job, it can be improved by enhancing the positive elements of the job. Balance theory emphasises a systems approach in which all elements of the work systems should be considered in order to improve performance, and health and safety.

In an investigation of contributing factors in construction accidents (Haslam et al. 2003) a model was proposed from the findings suggesting a hierarchy of causal influences. It was felt that this model was best suited to dealing with the highly adaptive socio-technical systems found in construction rather than the deterministic, causal accident models. The intention of the model was to indicate the pathways through which originating organisational, managerial and design influences shape the circumstances on site, giving rise to the conditions in which accidents occur.

When looking at the development of tools, equipment and work processes for the construction industry (Vedder, Carey 2005) a multilevel systems approach was used. This was to deal with considerations required for

safety, health, physical workload, and productivity in the development process. It was felt that as each of the elements of the work system interact they should be designed with the complete work system in mind. Although this total-system approach is familiar to the ergonomics community, it is less widespread for designers, manufacturers and suppliers in the construction industry, where there is a need to facilitate progress among these key influences.

A summary of the three different methods described above comparing the different elements used in each of the methods is shown in Table 7. It can be seen that there are similarities between the different methods, although the approaches used in each instance need careful consideration.

<b>Job design for stress reduction</b>	<b>Accident causality</b>	<b>Development of tools, equipment and work</b>
Carayon and Smith, 2000	Haslam et al, 2005	Vedder and Carey, 2005
Individual	Immediate accident circumstances	Occupational safety design
Technology	Materials/equipment factors	Basic ergonomics design
Task	Worker factors	Detailed ergonomics task design
Environment	Site factors	Application context analysis and optimisation
Organisational factors	Originating influences	Process optimisation: design for construction

Table 7 Holistic or multilevel approach elements

Author and Year	Experimental Design	Manual Handling Subject	Findings
Annett and Duncan (1967)	Review of existing data	Task analysis and training design	Same performance may be achieved in different ways. Procedures are easier to train them principles. Task analysis cannot be undertaken in isolation.
Buchholz et al (1996)	Pilot field study, observations of six construction labourers	Ergonomic job analysis of construction work	The PATH method effective in collecting ergonomic data for many construction operations and tasks
Burdorf et al (1991)	Field study, 114 subjects, observed postures and questionnaire	Postural load and back pain concrete element manufacture	Average time spent working with a bent and/or twisted position of the back contributed to the prevalence of back pain
Carayon and Smith (2000)	Analysis of model	Impact of sociotechnical and business trends on work organisation and ergonomics	Work and organisations are multidimensional, can have multiple (positive and negative) impacts on people, and can be redesigned to accommodate both human and organisational needs.
Drury (1983)	Review of different methods	Task analysis methods in industry	No one analysis method will solve ergonomic problems but task analysis is a uniquely useful method for highlighting the problems so that ergonomics solution techniques can be used.
Haslam et al (2005)	Analysis of existing data and expert panels	Analysis of accident records	Accident studies illustrate how upstream influences manifest themselves in contemporary construction operations
Hignett and McAtamney (2000)	Technical note	Postural analysis tool	Initial development of REBA shows promise as a useful postural analysis tool, further validation needs to be carried out.
Kee and Karwowski	Laboratory, controlled	Assess method of measuring	The postural classification scheme can be used to assess

(2001)	experiments using 20 subjects	perceived joint discomforts	postural stresses and prevent posture related disorders.
Kivi and Mattila (1991)	Field study, 6457 postures observed	Improvement work postures in the building industry	The OWAS method proved to be well suited for analysing work postures in building construction
Latza (2002)	Longitudinal study using structured interviews, 488 participants	Impact of manual materials handling of low back pain among construction workers	Repetitive work involving bent positions and handling heavy stone suggests increase in risk of future chronic low-back pain
McAtamney and Corlett (1993)	Description of ergonomic tool development	Postural analysis to investigate work-related upper limb disorders	RULA provides a method for screening large numbers of operatives quickly and its scoring system provides an indication of the level of action required
Paquet et al (2001)	Field observations compared to electronic measurement and video analysis of five participants	Postural assessment in construction work	Fixed interval observations closely approximated electronic measurements and video analysis
Smith and Sainfort (1989)	Conceptualising model	Balance theory of job design	Interventions that look at total systems are more successful. Balance achieved by changing negative elements or enhancing positive ones. Offers a clear direction for method of job design
Vedder and Carey (2005)	Case study examples to illustrate new approach	Holistic approach for development of tools, equipment and work for construction	Total system philosophy not well known by designers, manufacturers and suppliers in the construction industry. This approach could make progress in this respect.

Table 8 Research methods research

---

---

## 2.8 Culture

### 2.8.1 Introduction

"Exercise is bunk. If you are healthy, you don't need it: if you are sick, you shouldn't take it." - Henry Ford.

If an organisation understands the importance of safety culture the likelihood is that their management of health and safety is sufficient to produce a good safety culture. However, if they have many health and safety failings an examination of their health and safety culture is not the correct action to be taking.

"What has been will be again, what has been done will be done again; there is nothing new under the sun." - Ecclesiastes 1:9

In *The Principles of Scientific Management* (Taylor 1911) reference is made to the education and development of the workforce and to the intimate friendly co-operation between the management and the men which could be substituted for training and worker participation following examinations of health and safety culture in an organisation today. Taylor went on to say that "It will doubtless be claimed that in all that has been said no new fact has been brought to light that was not known to someone in the past. Very likely this is true. Scientific management does not necessarily involve any great invention, nor the discovery of new or startling facts."

Researchers trying to categorise the culture of the construction industry have a difficult task. Large construction companies on the whole are involved with large construction projects in a project management capacity using a group of engineers and managers to administer packages of work being carried out by several layers of subcontractors. Medium-sized construction companies are more likely to be involved with the

---

---

building of small offices and factories or extensions to large buildings and the refurbishment of medium size structures in a more hands-on fashion working closely with a number of small construction specialists. At the lower end of the scale (small builders, individuals, "cowboys" etc) individuals are likely to be doing most of their work on weekends; one man bands acting as specialist subcontractors; the smaller outfits frequently working beyond their capabilities. A number of reports and research papers have put forward descriptions of the construction industry culture but with so many different subcultures, which are likely to differ between organisations, how can the descriptions be representative? The following sections describe the progress researchers have made in this area.

## **2.8.2 Industry culture**

In 1996 the International Council for research and innovation in building and construction set up a task group in response to growing interest in the nature of culture within construction projects in construction firms (Fox 2007). In their paper on the pluralistic facets of culture and its impact on construction, Barthorpe et al (Barthorpe, Duncan & Miller 2000) describe some specific cultural perspectives of the construction industry including employee profile; the confrontational nature of contracting; the image of the industry; cultural diversity and the subcultures of the industry without providing a concrete definition. In other work, an investigation on women in non-traditional occupations (Gale 1994), a section on the culture of the construction industry opens with the statement that the construction industry can be broken into several sub industry cultures and goes on to talk about these cultures. This aspect of research into culture in the construction industry which generally looks at project and company culture was identified by Fox (Fox 2007). He argued that the environment

---

---

within the construction industry possessed its own distinct nature and that people who belonged to the construction industry in whatever employment capacity may share the same cultural characteristics. He said that if we cannot define the industry, we cannot define its culture.

Following an argument for using a holistic definition of the construction industry Fox (Fox 2007) considered three cultural factors in the industry:

- human skills and cultural transparency;
- a self-reliant construction culture; and,
- industry based better practice and culture.

These were studied together with a further three dimensions relating to future industry development:

- thinking the best and behaving the best (a better practice culture);
- long-term vision and policy for the industry; and,
- a learning culture.

He stated that, as well as using these dimensions in any vision seeking to change the culture, the culture still needed to be further explored and articulated.

### **2.8.3 Organisational culture**

According to Shipley (Shipley 1995) there are two sides to an organisation: its tasks side and its relationship side. Changes intended to improve or change the task requirements may disrupt relationships. The people within organisations often rely on support from each other. This informal side to organisations, not visible in the organisational chart, can be a powerful block to any suggested changes. Relationships which have been built up around the use of an existing technology may seem threatened by the introduction of a new technology.

In the period of economic expansion between the end of the Second World War and the oil crisis in the mid-1970s companies did not find it necessary

---

---

to understanding how they functioned. The 1980s saw companies working in more difficult commercial environments and they began to look at their operations to help explain why some companies were more successful than others which led to research into organisational culture (Hofstede 2001) (Schein 1980). Hofstede carried out an extensive questionnaire survey of IBM employees in many international offices and identified four cultural dimensions (power distance, uncertainty avoidance, masculinity/femininity and individualism/collectivism). While Schein suggested that there are three levels of culture:

- Artefacts such as buildings, documents and policies;
- Values such as what people agree should be the case, e.g., that safety and welfare should take precedence over profit and efficiency; and
- Basic assumptions, the often unquestioned guesses and hunches about how things work and how problem should be dealt with.

According to (Guldenmund 2000) at the level of espoused values we find attitudes which are equated with safety climate while the basic assumptions form the core of the culture. Safety climate tools may indicate levels of safety performance but the assessment of an organization's basic assumptions should lead to an explanation of its attitudes.

## **2.8.4 Safety Culture**

The term safety culture has become associated with safety critical disasters over the last 25 years beginning with the Chernobyl nuclear disaster and continuing with King's Cross and Piper Alpha where it was raised as a substantive issue in official inquiry reports.

The Human Factors Working Group of the Advisory Committee on Safety in Nuclear Installations (ACSNI) defined safety culture as 'the product of individual and group values, attitudes, perceptions, competencies, and patterns of behaviour that determine a commitment to, and the style and



---

---

proficiency of, an organisation's health and safety management' (HSC 1993).

A review of literature on safety culture (Choudhry, Fang & Mohamed 2007) found eight definitions for safety culture and said that most of the definitions were relatively similar, focusing on the way people think and/or behave in relation to safety. It went on to say that the definitions reflected the view that safety culture is something an organization 'is' rather than something an organization 'has'.

A model of construction safety culture has been developed (Chinda, Mohamed 2008) and used to examine interactions and causal relationships between five enablers (Leadership, Policy and strategy, People, Partnerships and resources and Processes). The study found that leadership strongly influenced people and policy and strategy and recommended that leaders become role models and promoting safe work behaviour, ensuring that workers accept their safety responsibilities, and said realistic safety policies and communicate these policies throughout their organisations. They stated that leadership is the main driver to effective safety culture, and a strong commitment of leaders is crucial in promoting safety culture.

### **2.8.5 Safety Climate**

The term safety climate has often been interchanged with safety culture. The term organisational climate appears to have been developed in social psychology literature from the 1930s. Climate researchers tended to focus on workforce perceptions of the social and managerial aspects of the work environment where climate was a descriptive variable in the study of organisational effectiveness. The term culture was originally used in anthropology before its application to organisational analysis in the 1950s (Cox 1998).

---

---

In 'Perspectives on safety culture', (Glendon, Stanton 2000) state that the prime research method for investigating safety climate is the questionnaire, which is used to identify dimensions that represent the safety climate of an organization. There is also reference to a summary of six safety climate studies which identified the following safety climate dimensions: management attitudes; training; procedures; risk perception; work pace; and workers involvement.

### **2.8.6 Safety systems**

Virtually every work activity puts the worker at risk of some degree of injury. In inherently hazardous industries such as construction and mining a great number of hazards can be eliminated by physically removing workers from the operation and using machinery instead or, where possible, doing the work remote from the hazard (e.g. by using offsite solutions). Risks associated with any remaining hazards need to be minimised. In order to do this the risks need to be assessed and appropriate safe systems of work put in place.

For some short duration tasks a safe system may only require verbal instruction from a supervisor or manager. It is not a safe system if workers have been left to devise their own method of work. For all safe systems, there are five basic steps necessary in producing them (Holt 2002):

- Assessment of the task.
- Hazard identification on risk assessment.
- Identification of safe methods.
- Implementing the system.
- Monitoring the system.

This approach is outlined in BS OHSAS 18001:2007 as Plan-Do-Check-Act and shown in Figure 3 below.

---

---

According to BS OHSAS 18001:2007 the success of the system depends on commitment from all levels and functions of the organization, and especially from top management. A system of this kind enables an organization to develop an OH&S policy, establish objectives and processes to achieve the policy commitments, take action as needed to improve its performance and demonstrate the conformity of the system to the requirements of this OHSAS Standard.

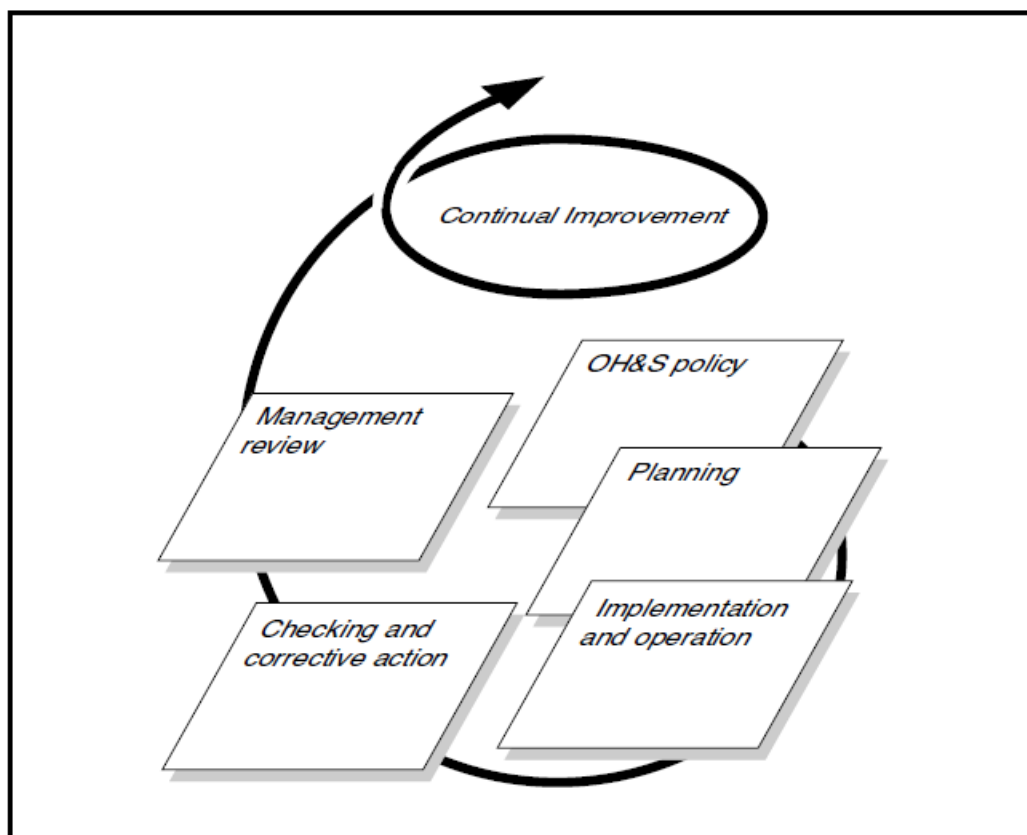


Figure 3 From BS OHSAS 18001:2007

The use of health and safety climate questionnaire tools to determine workers attitude to health and safety would constitute part of the 'check' part of the Plan-Do-Check-Act approach outlined in BS OHSAS 18001:2007.

---

---

## 2.8.7 Summary

The construction industry has moved from having organisations with strong cultures, with large workforces being trained in-house and communications existing between the management and the workers. Towards smaller, project management style companies working with layers of sub-contractors, having no or little shared culture who now approach health and safety consultants to measure the behaviour and attitudes of the workers on large construction projects in order to understand measures needed to manage occupational health and safety.

The implementation of a good health and safety system is possible with commitment throughout an organisation. However, the short duration of construction projects and the fragmented nature of the workforce make this extremely difficult to do within the construction industry.

The relationship between an organisation and its culture and climate has been compared to a tree (the organisation: systems etc), its roots (the culture: assumptions, beliefs & values) and the weather (the climate: behaviours, attitudes and feelings) as depicted in Figure 4 below.

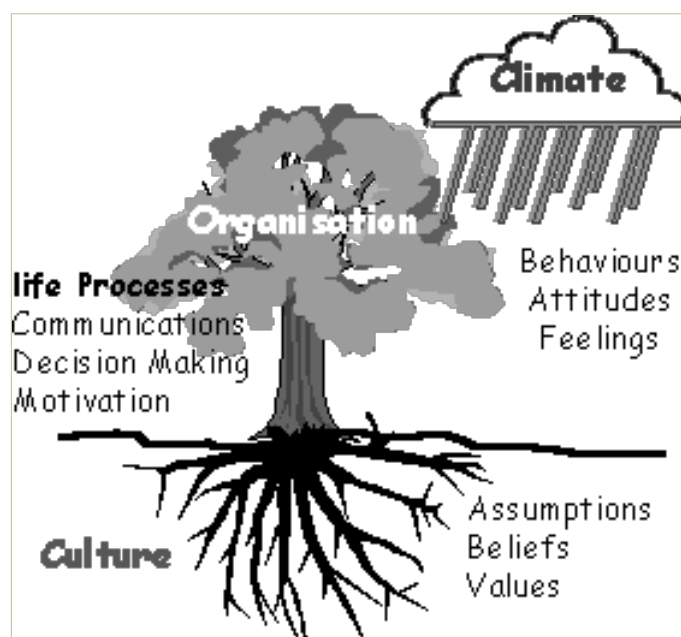


Figure 4 From - <http://www.m1creativity.co.uk/innovationclimate.htm>

---

---

Details of the research mentioned in the above section including experimental design, culture subject and outline findings are presented in

Table 9.

Author and Year	Experimental Design	Culture area	Findings
Barthorpe et al (2000)	Overview of literature published on the subject of culture	General	Culture is an evolving, pluralistic concept, having many definitions and interpretations and there is an increasing tendency to use "culture" in many diverse applications.
Chinda and Mohamed (2007)	Empirical examination of interactions and causal relationships between enablers	Construction safety culture	Leadership enable directly influences implementation of policy and strategy and indirectly partnerships and resources. Partnerships and resources indirectly affect processes through policy and strategy.
Choudhry (2007)	Literature review	Safety culture	Safety culture thought to influence employees' attitudes and behaviour in relation to an organisation's ongoing health and safety performance.
Cox (1998)	Positioning paper	Safety culture	There is much to be gained from a rigorous and controlled focus on organisational safety culture. Safety climate appears to be the preferred metric.
Fox (2007)	Industry Survey (unpublished PhD Thesis, 2003))	Conceptualisation of construction industry developmental model	Identification of 3 current industry development factors and 3 future industry development factors related to the construction industry culture.
Gale (1994)	Questionnaire survey (N=55) semistructured interviews (N=8)	Industry culture	Education system promotes the existing construction culture with women entering into the industry accepting it. If the industry culture was improved it would attract both men and women.
Glendon and Stanton (2000)	An overview of the existing literature and safety case study	Safety culture	It is appropriate to maintain the distinction between the overlapping concepts of safety culture and safety climate. The measurement of safety culture depends on how it is defined.

Guldenmund (2000)	Literature review	Safety culture and safety climate	Safety climate might be considered an alternative safety performance indicator. Assessments of organisations assumptions are important since they can explain its attitudes.
Hofstede (1984)	extensive questionnaire survey	Organizational culture	Identified for cultural dimensions (power distance, uncertainty avoidance, masculinity/femininity and individualism/collectivism).
Schein (1985)	Development of theoretical model	Organizational culture	Suggested that there are three levels of culture; artefacts; values; and basic assumptions.
Taylor (1911)	Case studies	Using scientific principles to affect the way managers organise their workforce	Every act of the work meant to be preceded by preparatory acts by the management enabling him to do his work better and quicker. Each man to receive help daily by those over him rather than being coerced or left unheeded.

Table 9 Culture research

---

---

## 2.9 Innovation

### 2.9.1 Introduction

Discussions regarding innovation are usually concerned with the positive aspects of innovations so introducing innovative equipment, practices or techniques into an industry is usually considered to be a good thing. However, because of the financial implications of investing in the equipment, practices or techniques there can also be an association with the risk of failure. According to (Tomala, Sénéchal 2004) introducing an innovation is a risky business with only 14% of innovations having significant success. Succeed or fail, the introduction process generally produces a chain reaction through a company affecting production systems, logistics, administration, information flow, sales departments, accounting and financial services.

Research into innovation in the construction industry usually begins by stating some negative perception such as: the industry is known for having many barriers and resistance to innovations (Park, Nepal & Dulaimi 2004); the industry is not generally innovative (Blayse, Manley 2004); the industry is widely perceived as being slow to innovate (Veshosky 1998); and the construction industry views innovation as a rare occurrence. However, Winch (Winch 2003) questioned the characterization of the industry as being backward and failing to innovate in comparison to other sectors and broke down the elements of comparison methods to argue that the comparisons, usually with the motor industry, were flawed and that the construction industry is no worse or better than any other sector. The construction industry's ability to innovate looks poor if considered as a form of manufacturing but it needs to be understood that it has its own dynamic and industrial development (Gann 2000).



---

---

## 2.9.2 Types of innovation

There is a description of innovation in the Oslo Manual, produced by the Organisation for Economic Cooperation and Development, which refers to it as being either 'technical' or 'organisational'. According to Anderson and Manseau (Manseau, Shields 2005), a technical innovation involves either 'product' or 'process' innovation, whereas organisational innovation includes changes to organisational structure, introduction of advanced management techniques, and implementation of new corporate strategic orientations

In examining innovation in construction in the context of a sociology of technical approach, Harty (Harty 2005) states that innovation can be either 'bounded' or 'unbounded'. The distinction being that 'bounded' innovations are relatively contained in their effects and consequences within a single organisation while 'unbounded' innovations have widely felt inter-organisational repercussions.

Research by Slaughter (Slaughter 1998) presents a set of models that respond to the nature of the construction industry and the activities of specific construction companies. The five different types (incremental, modular, architectural, system and radical) can be ordered by their degree of required change from the current state-of-the-art or practice.

## 2.9.3 Types of innovators

Clients and manufacturers can hold the key to driving innovation in the construction industry. The role to be played by clients in promoting innovation is so well accepted by academics and policymakers that UK policy identifies a client as the main institutional leader in stimulating construction innovation.

Manufacturers indirectly affect innovation in the construction industry by producing innovative components and building products. They are able

---

---

to do this because they operate in a more stable and standardised market which enables them to maintain research and development programmes (Blayse, Manley 2004). Innovation by manufacturers can depend on how much of the market for their products is in construction. Bricks and cement are almost exclusively produced for the construction industry and therefore technical developments are likely to focus on improvements related to construction applications (Gann 2000).

Rather than following the recognized model of innovation where the need for the innovation is identified, research is carried out and the solution is developed, builders tend to innovate during the building process, directly in the workplace solving specific problems as they occur (García 2005).

Builders have been shown capable of developing useful, effective, and low-cost innovations, particularly from the purpose of successfully connecting different building systems (Slaughter 1993). Builders have access to knowledge and detailed information that is unavailable to manufacturers which combines with their significant experience and expertise enables them to be innovative.

In synthesis of literature on small construction firms (Sexton, Barrett 2003b) reference is made to innovation 'champions'. These are people who envision and motivate others to adopt new ideas or allow new ideas a smooth passage. Introducing innovations is a tricky business and the 'champions' will be the people who are prepared to absorb the risks and help to drive the innovations through (Ling 2003).

There is some research to suggest that those who innovate are more likely to be information seekers. A study of home builders in the United States (Toole 1998) examined the adoption of technological innovations by small- and medium-sized home building firms and found that builders who are more apt to adopt non-diffused innovations are those who reduce uncertainty by gathering and processing information about innovations.

---

---

## 2.9.4 Management of innovation

A British standard (BS 7000-1 - Design management systems: guide to managing innovation) was introduced in 1989 and republished in 1999 which gives advice on the development of innovative products to satisfy customer's needs.

New technologies have been adopted by the construction industry either when they become cheaper or when they were perceived to offer clear technical advantages over traditional materials (Gann 2000). To realise the benefits of innovation (improved quality, reduced costs and faster construction) it is necessary to manage and control significant factors (level of interest of project team members; working environment; formation of task groups; and the capabilities of the people involved in the innovation) that affect innovation success (Ling 2003).

The development of an innovation assessment tool (Gesey, Glass & Bouchlaghem 2006) identified six innovation performance parameters which can be seen in Figure 5 below. When discussing the management parameter they referred to innovation as being extremely complex and involving the effective management of a variety of different activities and said that management must believe in innovative practices and take such strategic measures sufficient to save its adoption.

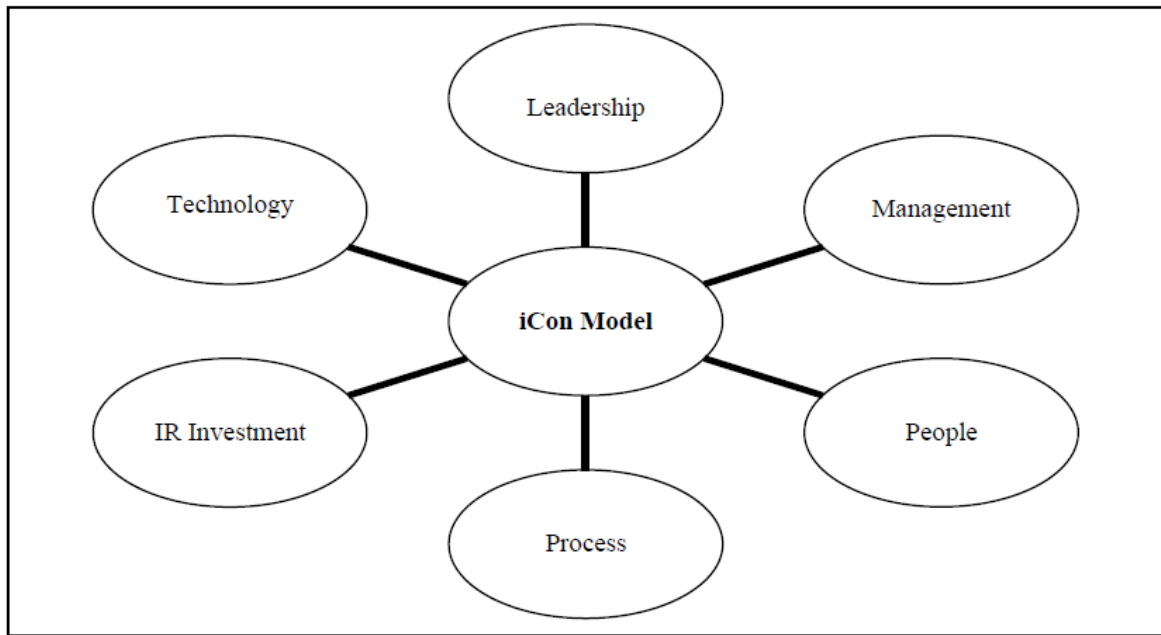


Figure 5 A proposed model for innovative construction (iCon)

### 2.9.5 Supporting innovation

In the UK, the Centre for Construction Innovation (CCI) was established in response to two government reports: The Latham Report (Latham 1994) and the Egan Report entitled 'Rethinking Construction' (Egan 1998b). Following the second report three organisations were set up to enable companies to adopt and share new and best practice: the Construction Best Practice Programme; the Movement for Innovation (M4I) and Rethinking Construction. Over time the three organisations have merged to become Constructing Excellence. Government regulatory and procurement policies continue to have a strong influence on demand for construction products and play an important part in shaping the direction of technological change (Gann 2000).

The goal of the CCI is to supply business support for the Construction Industry generally and to promote and foster the 'Rethinking

---

---

Construction' agenda and help implement Accelerating Change (Egan 2002b) in the UK region of the North West (Abbott, Allen 2005). The centre acts as an innovation broker managing knowledge transfer between universities and industry. Tools used by the centre include training, seminars, workshops and in-company events.

Internationally the approaches to innovation that countries adopt are relatively similar even though the political and social structures of those countries may be radically different. Research looking into public policy and construction innovation in fifteen different countries (Seaden, Manseau 2001b) found that most of the available instruments supporting innovation had not been of great use to the construction industry. Support that was of use included programmes with greater local presence, focussed on access to technology, promoting collaborative arrangements along with institutions that were available to evaluate new products or processes before market launch.

Details of the research mentioned in the above section including experimental design, innovation subject and outline findings are presented in Table 10.

Author and Year	Experimental Design	Innovation area	Findings
Abbott and Allen (2005)	Case study	Innovation support	Rethinking Construction in the Construction Best Practice Programme provides an excellent resource and knowledge base that universities can draw from and contribute to.
Blayse and Manley (2003)	Literature review	Key influences	Six primary influences: clients and manufacturers; the structure of production; relationships between individuals and firms; procurement systems; regulations/standards; and the nature and quality of organisational resources.
Garcia (2005)	Case studies	Methods of innovation	Main innovations have been made in the fields of materials and machinery, and most of them could be considered as a technology transfer from other sectors.
Harty (2005)	Case study	Innovation approaches	Proposed approach focuses on the actual processes by which existing positions and expectations interacts with novel technologies and new ways of working.
Gesey et al. (2006)	Comparison of existing tools/models	Innovation assessment tool	The tool allows companies to measure themselves against key determinants of leadership, management, people, processes, IR investment and technology.
Ling (2003)	Questionnaire survey from 58 construction projects	Managing innovation	Four categories identified that effect extent to which innovation benefits projects.
Park (2004)	Use of causal loop diagrams to develop innovation model	Modelling of construction innovation	Project manager driven motivation facilitated by organisational climate for innovation shown to influence the innovation mechanism.
Seaden and Manseau (2001)	Review of reports on innovation	Examination of innovation policies across a range of countries	Programmes with greater local presence, focused on access to technology, promoting collaborative arrangements, seem to be more successful.

Sexton and Barrett (2003)	Synthesis of previous work	Innovation in small construction firms	Gaps in literature compared to innovation model.
Slaughter (1993)	Field based study with 100 interviews	Roles within the innovation	The builder has access to knowledge and detailed information is unavailable to the manufacturers.
Slaughter (1998)	Modification of existing models	Modelling of construction innovation	Five models based upon current theories in management and economics provide companies with a means through which to reduce the perceived risks of using innovations.
Tomala and Senechal (2004)	Synthesis of previous work	Managing innovation	Methods identified which improve the visibility of the consequences of introducing innovation, thus limiting the risks of non-performance over the whole life cycle.
Toole (1998)	Empirical investigation interviewing 100 homebuilders	Adoption of innovation	Uncertainty reduction plays a key role in the adoption of the technological innovations in residential construction.
Veshosky (1998)	Project managers (134) interviewed from sample of top engineering and construction firms (14)	Managing innovation	Engineering and construction firms can improve the effectiveness of innovation information management systems already in place.
Winch (2003)	Analysis of existing research	Perception of construction innovation	Cross-sector comparisons of the performance of the construction industry are inherently flawed.

Table 10 Innovation research

---

---

## **2.10 Culture and Innovation**

### **2.10.1 Introduction**

As organisational cultures emerge from interaction and learning of individuals within organisations (Schein 1990) (Jassawalla, Sashittal 2002) it can play a critical role in motivating innovative behaviour enabling individuals to believe in innovation as organisational value (Hartmann 2006).

The construction industry can benefit with effectively managed innovation but in order to do this requires a move from the current adversarial and blame cultures in the industry to a more sharing culture. There are no guidelines or best strategy examples for managing innovation. However, any meaningful innovation strategy should have unequivocal pull support from the top (Egbu 2004).

### **2.10.2 Research**

In order for individuals to innovate and organisation should support them by providing a tolerance of failure, encouraging their ideas and not punishing their risk-taking. Research investigating creativity (Farid, El-Sharkawy & Austin 1993) states that the act of creativity is forming something from nothing and that innovation shapes that something into products and services. An organisation that seeks the benefits from innovation must therefore attempt to establish a culture conducive to creating and testing new ideas.

Research examining the motivational influence of culture on innovation in construction (Hartmann 2006) highlighted the need to overcome the effects of project constraints and regional separation on an innovation-supportive culture by the following actions:

- Introducing a comprehensive reward and incentive system.
- Allowing for autonomous work and task identity.
- Providing professional qualifications and training.
- Giving general and immediate feedback.
- Providing communication channels for implicit knowledge and



- 
- 
- Initiating innovation projects

### **2.10.3 Health and safety**

It is wrong to believe that you can improve the health and safety performance of organisations by improving the organisational culture alone. Organisations should have adequate occupational health and safety management systems and engineering controls in place before steps were taken to improve workplace culture (Vecchio-Sadus, Griffiths 2004). Once physical improvements and management systems are in place the promotion of those improvements can then begin to improve the safety culture.

### **2.10.4 Developments**

The development of a model to measure the innovativeness of construction companies (Seaden et al. 2003) found a strong association between advanced technology practices and business practices: or that an innovative firm is generally innovative in technology and in business at the same time suggesting innovativeness may be a culture that permeates all the activities of the firm.

In the UK, a raft of government and institutionally driven initiatives to promote the benefits of innovation and stimulate innovation capability within and between construction firms was introduced in an effort to bring in a new 'should innovate, can innovate, want to innovate' construction industry culture (Sexton, Barrett 2003b). An investigation of innovation in small construction firms (Sexton, Barrett 2003a) conducted workshops to find out, amongst other things, how improvements in the construction firms could be integrated into the strategies and cultures of the firms. One of the findings from the research was that policies that are appropriate for large construction firms are not necessarily appropriate for small construction firms, and vice versa.

---

---

Hofstede (Hofstede 2001) produced one of the most comprehensive studies to date of how values in the workplace are influenced by culture. This surveyed IBM employees between 1967 and 1973 in their international offices covering more than 70 countries. The work found that: cultures, especially national cultures are extremely stable over time; change usually comes from outside but can also come from inside; and that culture affects the likelihood that the members accept new ideas and innovations.

A study investigating the diffusion of innovations examined individual and cultural factors (Tolba, Mourad 2011) offering a conceptual model incorporating both individual and cultural factors. Individual factors referred to the involvement of lead users and opinion leaders whilst cultural factors referred to Hofstede's uncertainty avoidance and individualism factors. They concluded that it was important that the best use of lead users and opinion leaders were considered as well as cultural factors in maximising innovation diffusion.

The results of the IBM survey were used to infer and compare dominant national culture traits. From the original analysis four traits were found (Power Distance, Uncertainty Avoidance, Individualism/Collectivism and Masculinity/Femininity. The definition for Individualism says that it 'stands for a society in which the ties between individuals are loose: Everyone is expected to look after him/herself and her/his immediate family only.' Whereas Collectivism 'stands for a society in which people from birth onwards are integrated into strong, cohesive in-groups, which throughout people's lifetime continue to protect them in exchange for unquestioning loyalty.'

In his book *Culture's Consequences*, Hofstede (Hofstede 2001) examined organisational culture through a follow-up project from the IBM survey and explored why individuals within organisations differed in their perceptions of the same organisational reality. Demographic characteristics such as age, education, and gender were found to play a role, but so did personality.

---

---

A theoretical perspective looking at organisational culture in the management of technological change (Jackson, Philip 2005) highlights organisational culture as a major obstacle to managing change. The work refers to weaknesses with existing cultural models and approaches which assume countries are static over time. The theoretical framework put forward is derived from grid and group cultural theory (Douglas 1970) as a more coherent and interpretive research framework. The framework includes four cultural types: fatalist; hierarchist; individualist; and egalitarian, and states that the latter three are the best enabling characteristics for the management of technological change.

Research combining innovation and culture and offering a conceptual and practical framework (Miller, Brankovic 2010) shows how a cultural infrastructure that orientates actors in the practices of creativity and improvisation combine with individual meaning making processes to simultaneously generate innovation and an innovation culture across organisation. In this work they look at the individual cultural processes involved and conceptualise the use by extending Hatch's cultural dynamics framework to innovation (Hatch 1993) which Hatch expanded from Schein's model of organisational culture (Schein 1990).

Schein (Schein 1980) refers to the organisation not as an abstract entity; rather, it acts through the individual behaviour of certain key members in crucial or leadership roles. He said that an organisation is a complex social system which must be studied if individual behaviour is to be truly understood and that it changes and evolves in response to internal and external forces. This move towards an organisational psychology perspective and away from individual orientated industrial psychology approaches is possible due to advances in systems dynamics and developmental psychology.

It is hard to understand human nature, leadership/influence and group dynamics individually let alone how they all interact with each other. Schein (Schein 1980) said that, for an individual, an organisation as a whole exists as a psychological entity to

---

---

which he or she reacts. It is therefore necessary to investigate the individual within a group, that group within an organisation and that organisation as a system and how that system copes with external adaptation and internal integration when faced with innovations.

An in-depth case study investigating the innovation activities of a construction firm (Hartmann 2006) looked at the role of organisational culture in motivating individuals' innovative behaviour. The research looked at mechanisms mobilised by managerial actions that foster innovative behaviours in industry and reports on a case study that examined how organisational culture affects the generation of innovative ideas. The case study showed that individuals require a comprehensive reward and incentive system, allowance for autonomous work and task identity, provision of professional qualifications and training, given general and immediate feedback and provide them with communication channels for implicit knowledge to create a culture that motivates individual's innovative behaviour.

Details of the research mentioned in the above section including experimental design, culture and innovation subject and outline findings are presented in Table 11.

Author and Year	Experimental Design	Innovation & Culture area	Findings
Douglas (1970)	Development of theoretical model	Classification of people's values	Provides a means of classifying and assessing cultures with a two dimensional model of Grid (regulation) and Group (general boundary around a community)
Egbu (2004)	Three empirical studies	Managing innovation	If the construction industry to build core competencies, maintain capability and benefit from innovation, it has to change from an adversarial and blame cultures to a sharing culture
Farid et al (1993)	Synthesis of previous work	Managing innovation	An organisational culture conducive to the development and testing of creative ideas is essential for stimulating creativity.
Hartmann (2006)	In depth case study with 1500 employees	Organisational culture and innovation	Within construction firms managerial actions have to take the effects of project constraints and regional separation in the development of an innovation supportive culture into account.
Hatch (1993)	Development of theoretical model	Cultural dynamics perspective	Reformulates Schein's model of organisational culture by making a place for symbols alongside assumptions, values and artefacts.
Hofstede (2001)	Survey of 20 organisations in Denmark and the Netherlands	Organisational culture	Individuals within organisations differ in their perceptions of the same organisational reality due to demographic characteristics such as age, education and gender.
Jackson and Philip (2005)	Development of theoretical model	Organisational culture and management of technological change	To manage technological change effectively, organisations should have a mix of enabling qualities of three cosmologies (hierarchal, individualist and egalitarian).
Miller and Brankovic (2010)	Development of theoretical model	Organisational culture and creativity	Combines an organisational-level cultural framework with Hatch's individual cultural processes framework.

Schein (1990)	Development of theoretical model	Organisational culture	Suggested that there are three levels of culture; artefacts; values; and basic assumptions.
Seaden et al (2002)	Using existing survey to test model	Measuring innovativeness of companies	Smaller firms more risk averse, with low intensity of use of innovative practices and negative correlation with innovativeness to profitability when prepared to larger firms
Sexton and Barrett (2003)	Synthesis of previous work	Innovation in small construction firms	Gaps in literature compared to innovation model.
Sexton and Barrett (2003)	Case study	Innovation and small construction firms	Small construction firms have their own distinctive characteristics, which are profoundly different from those of large construction firms
Tolba and Mourad (2010)	Development of theoretical model	Cultural factors and diffusion of innovation	Companies should consider the best use of lead users and opinion leaders, while considering cultural factors, in a way in a way that maximized innovation diffusion.
Vecchio-Sadus and Griffiths (2003)	Case Study	Enhancing safety culture	Organisations with sound occupational health and safety (OHS) management systems it is easier to promote and publicise management commitment to OHS.

Table 11 Culture and innovation research

---

---

## 2.10.5 Summary

This review of the research literature has confirmed that manual handling of concrete products in the construction industry represents a risk of injury to the workers. Three approaches have been identified to tackle manual handling of materials: the selection of the workforce; training of the workforce; and the design of the work activity. With regard to the work activity, designers were seen to be in a position to help reduce risks. Of the three approaches, training was said to be the most difficult and was found to be poor in most industries. Where manual handling had been investigated in construction, this was usually confined to trades with more consistent work patterns such as bricklaying. Even though research had investigated bricklaying a hundred years ago, recent research was recommending similar changes.

Even though many designers are required under legislation to consider the health and safety of workers installing their designs, research increasingly linked design with accidents, fatalities and injuries in construction. Costs and culture are cited as reasons for designers not complying with legislation. Research has shown that communication between designers and contractors added value to projects and that moving safety upstream, towards the design process, saved money.

The introduction of new equipment into the construction industry tended to be driven by suppliers. The research shows that there have been advances into the ergonomic design of equipment in manufacturing but there were no parallel advances in the construction industry. However, research into the use of mechanical materials handling devices in manufacturing stated that guidelines were needed and that lack of finance was shown to be a barrier to the introduction of new equipment.

Although there has been an increase in the awareness of good lifting practices in industry, research has shown that reductions in manual

---

---

handling injuries have not followed. The provision of training and information was indicated as not being enough to compensate for the heavy loads being lifted and that workers should be trained to assess and manage the risk. A review of training practices recommended that training be targeted and worker participation was required.

An examination of literature investigating construction industry culture revealed an emphasis on definition but little evidence of practical improvements. It was however possible to look at organisational culture in which reference has been made to technical changes being resisted through organisational relationships being disrupted. Generally, organisational culture research related to economic performance while safety culture research related to accidents and the use of safety climate tools for measurement.

Introducing innovation in one department can have a chain reaction affecting many other departments of a company. The construction industry's ability to innovate is put into question in much research literature considering innovation in construction but some research shows that the industry has a similar innovation record to most other industries. Research investigating types of innovation referred to the consideration of either technical or organisational innovation. Clients have been shown to be important in driving innovation in industry, builders are generally seen to be good innovators and champions are needed to drive innovations. Where innovation is to be supported, this needs to have a local presence and assistance with product evaluation.

The construction industry was seen to have an adversarial and blame culture which is not conducive to innovation. Research recommended a need to establish a culture conducive to creating and testing new ideas. It was said that investigating an organisation's safety culture was not appropriate unless all other health and safety management procedures were in place. The promotion of innovation within an organisation was



---

---

shown to be a good thing because innovativeness can permeate all activities of a firm.

## **2.10.6 Research Questions**

The research questions addressed in this research are related to four issues, namely the introduction of technical and organisational innovations related to the provision of highway kerbs, the role of the designer and whether the design of the tasks could reduced risk of injury to the workers, the methods used to train workers involved with the installation of highway kerbs and the cultural relationships between the key players in the supply chain regarding resistance to change or championing innovation.

### **2.10.6.1 Research Question I**

*What are the key functions and considerations of the training of workers in the installation of highway kerbs?*

This question tests to see if the provision of training is a key element of skills preparation and consequently has significant implications for the health and safety of workers.

### **2.10.6.2 Research Question II**

*Do alternatives to the manual handling of concrete highway kerbs pose any risks?*

This question aims to find out if the use of innovative mechanical methods of kerb installation and/or installation of alternative kerb types increase or decrease the level of risk of injury to the workers.

### **2.10.6.3 Research Question III**

*How could the design for safety concept improve the installation of highway kerbs?*

---

---

This question provides insights on the impact of regarding safety in the design of road infrastructure and what is required to design healthy kerb installation processes.

#### 2.10.6.4 Research Question IV

*How is the risk of injury to the workers affected by the organisation of the work?*

This question seeks to investigate the importance of the health and safety of the workers in the organisation of the kerb installation work.

#### 2.10.6.5 Research Question V

*In what way can the culture of those in the supply chain affect the introduction of technical innovations?*

This question investigates the extent to which effective introduction of new innovations depends on the culture of the supply chain organisations, the resisting or championing by individuals and how they feel, behave and relate to the change.

---

---

## 3 METHODOLOGY

### 3.1 Introduction

This chapter outlines the research design and methodology for the study. The purpose of this study is to increase the understanding of the reasons behind the continued use of manual handling for the installation of concrete highway kerbs in the construction industry. The research was not building upon existing research in this area but was taking a detailed look at a single aspect of manual handling across the whole of the construction industry. Considering these qualifications, a qualitative study approach was adopted. This enables the flexibility required to adapt the research methods as key findings emerge.

In order for the knowledge obtained from the research to contribute to scholarly learning, the design has to be underpinned by existing and preferably current philosophical thinking. Methods used in the research must then be compatible with that thinking in order to have a consistent logic within the recognized system of methods and principles of research methodology. It is also important that the research methods selected are appropriate to the environment that the research is being carried out. The methodology was chosen as relevant to the tasks of carrying out field observations, individual interviews and focus groups.

The literature review was useful in identifying research projects that investigated the manual handling of materials in various industries; health and safety and ergonomics in the construction industry; and to a lesser extent the manual handling of materials in the construction industry. This research clarified why the adopted methods used were appropriate for these studies and listed any shortfalls.

---

---

Within the adopted research method, it is important to understand what tools are available for data acquisition. The data produced has then to be analysed in such a way that the quality of the results can be shown to be valid. With this understanding, it is possible then to apply these tools to the research in hand in such a way that the results enable a full theoretical discussion to be produced as well as final conclusions to be made.

This chapter outlines the logical sequence that connects data acquisition to the initial research objectives through its analysis to final conclusions. Details of all of the adopted techniques and methods used to design, plan and implement this study can be seen in the following sections: Section 3.2 Research Methodology; Section 3.5 Research Methods; Section 3.6 Data Collection; Section 3.7 Data Analysis; Section 3.8 Quality Criteria; and Section 3.9 Adopted Research Methodology.

## **3.2 Research methodology**

"Organic life, we are told, has developed gradually from the protozoon to the philosopher, and this development, we are assured, is indubitably an advance. Unfortunately it is the philosopher, not the protozoon, who gives us this assurance."

- Bertrand Russell.

"Philosophy is not a theory but an activity."

- Ludwig Wittgenstein.

Russell and Wittgenstein were two of the great philosophers of the 20th century. Their work was very influential to the members of the Vienna Circle and in the formation of Logical Positivism. This school of philosophy linked truth to meaning in a way that allowed no pathway to

---

---

genuine knowledge other than that of science. It included the verification principle that no statement is meaningful unless it is capable of being verified. This line of thought excluded metaphysics, ethics, aesthetics and religion from purview of genuine philosophy (Crotty 1998). The Logical Positivism movement was a great influence in the 1930s and 1940s, especially in casting doubt on the value of speculative metaphysics. But by the mid-1950s very few philosophers accepted it except in radically modified form.

It is important, when carrying out research, that its design is informed by a theoretical perspective based on an epistemology such as Objectivism, Constructionism, and Subjectivism. It is obvious from the above that any research must be viewed in relation to the accepted schools of philosophy of its time. Today, research is broadly covered by two theoretical perspectives termed positivism and interpretivism. Positivism, following Auguste Comte, asserted that only verifiable claims based directly on experience could be considered genuine knowledge (Patton 2002). It views knowledge as absolute and objective and its methods originate in the natural sciences. Interpretivism by contrast seeks to find new interpretations by viewing knowledge as being made up of multiple realities which are time and context dependent. It emerged in contradistinction to positivism in attempts to understand and explain human and social reality (Crotty 1998).

These two distinct paradigms hold contrasting views on the definition of knowledge and have been the subject of long-standing debate in science, with positivism aligning with quantitative methods and interpretivism aligning with qualitative methods (Denzin, Lincoln 2000). A quantitative approach employs strategies of enquiry such as experiments and surveys, and collects data on predetermined instruments that yield statistical data while a qualitative approach collects open-ended, emerging data with the primary intent of developing themes from the data (Creswell 2003). The

two approaches still aim to do the same thing only in a different way: qualitative research stresses the socially constructed nature of reality, the intimate relationship between the researcher and what is studied, and the situational constraints that shape enquiry; quantitative studies emphasise relationships between variables not processes (Denzin, Lincoln 2000).

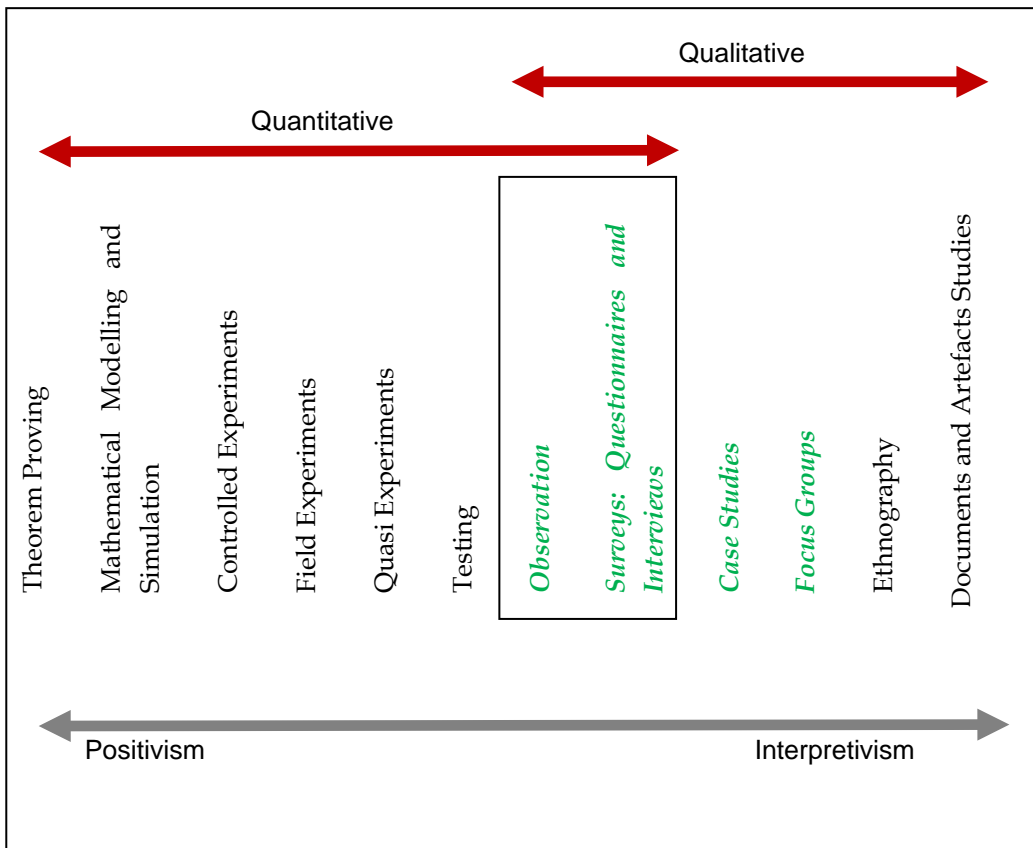


Figure 6 Research Methods and Strategies. Source: (De Villiers 2005)

### 3.3 Research Design

Research design is about turning research questions into the research project (Robson 2002). It means that in order to answer research questions, the appropriate strategies, methods and techniques should be chosen. Yin (Yin 1994) proposes that the types of research questions determine the

---

---

most suitable strategy. The research questions in this study focus mainly on “What” and “How” questions.

Fellows and Liu (Fellows, Liu 2008) describe several types of research, e.g. instrumental, descriptive, exploratory, explanatory and interpretive. The research presented in this thesis is of an interpretive type. Interpretive research aims at soliciting people's accounts of how they find the world, together with the structure and processes within it.

In order to account for the short duration of the project and a need to begin to collect data at the earliest opportunity, a flexible approach was required. A qualitative interpretive approach to the research allowed room to consider many forms of data, to find out what factors were in play and include the perspectives, biases and insights of the researcher. This approach to what was a relatively new topic meant that the possibility that there are new questions to be asked was not ignored.

Qualitative research methods chosen included:

- Dual moderators focus groups - one moderator ensures that the focus group runs smoothly while the other make sure all the topics are covered.
- In-depth interviews - collecting an individual's perspectives and experiences.
- Observation - collecting data on naturally occurring behaviours in their usual contexts

### **3.4 Sampling**

Sampling is the act, process, or technique of selecting a suitable sample, or a representative part of a population for the purpose of determining parameters or characteristics of the whole population (Mugo 2008). Purposeful sampling selects information rich cases for in-depth study. Size and specific cases depend on the study purpose. Qualitative research methods are not as dependent upon sample sizes as quantitative methods;

---

---

a case study, for example, can generate meaningful results with a small sample group.

In the UK about 4% of all kerbs are replaced each year therefore it was unrealistic to try and obtain a representative sample, on a 12 month research project, of the supply chain personnel involved. However, the task itself was very simple and the product uniform and basic and it was very unlikely that the operation, although some variations in installation methods were noted, would vary significantly across the UK.

In purposeful sampling, the sample should be judged on the basis of the purpose and rationale for each study and the sampling strategy used to achieve the studies purpose. The validity, meaningfulness, and insights generated from qualitative inquiry have more to do with the information-richness of the cases selected and the observational/analytical capabilities of the researcher than with sample size (Mugo 2008).

With regard to the quality of the sample, the HSE inspectors and contractors interviewed oversaw kerb laying activities for very large areas of the country. In addition there was only one person in charge of the kerb specification at the Highways Agency and he attended the second of the three focus groups.

In this study opportunistic sampling, a type of purposeful sampling, was used which involves following new leads during field work, taking advantage of the unexpected flexibility. Throughout the project new contacts were being made which in turn led to further contacts. Therefore, there was some theoretical sampling (i.e., the selection of participants according to the needs of your emerging analysis (Morse, Richards 2002).

There was a certain amount of balance achieved with the sample of people involved in the research. The researcher felt that those people attending the focus groups were on the whole proactive and keen that changes should be made from the existing manual handling operations. Whereas, a large proportion of the attendees at the kerbs forums were on the whole



---

---

reactive to the HSE's imposed deadlines to move away from manual handling of kerbs.

Researchers have to be aware of the interviewer effect (no two interviewers are alike and the same person may provide different answers to different interviewers) and the respondent effect (respondents might also give incorrect answers to impress the interviewer). In the case of this study there was only one interviewer so details of the research should have been presented to the interviewees consistently.

### **3.5 Research methods**

Rather than looking at reasons for using either a quantitative approach or a qualitative approach, Tashakkori and Teddlie (Tashakkori, Teddlie 1998) thought it more productive to consider them in continua. They saw purely quantitative studies to be at one end of a continuum and the purely qualitative studies at the other end, with a wide variety of designs between.

This preference for a continuum reflects the importance of looking at research design issues as shades of grey rather than as black or white. The two research approaches do not appear to be that different as they both seek to answer 'how' and 'why' questions. The range of approaches and the quantitative /qualitative overlap in the studies can be seen in Figure 6.

Quantitative research has traditionally concentrated on isolating cause and effect but rapid social change and the resulting diversification of life worlds forces researchers to make use of inductive strategies (Denzin, Lincoln 2000). It is very likely that the factors affecting the installation of concrete highway kerbs, even considering a widely-recognized conservative construction industry, will have changed during the course of these investigations and the investigations themselves, because of their

---

---

nature (close contact with many actors close to the operations under investigation), will have contributed to that change. It was therefore felt that the qualitative approach was best suited to this study.

According to Patton (Patton 2002), qualitative findings grow out of three kinds of data collection: (1) in-depth, open-ended interviews; (2) direct observation; and (3) written documents. Interviews yield direct quotations from people about their experiences, opinions, feelings, and knowledge. The data from observations consist of detailed descriptions of people's activities, behaviours, actions, and the full range of interpersonal interactions and organisational processes that are part of the observation of all human experience. Document analysis includes studying excerpts, quotations, or entire passages from organisational, clinical, or program records; memoranda and correspondence; official publications and reports; personal diaries; and open-ended written responses to questionnaires and surveys.

Qualitative research is a situated activity that locates the observer in the world. A set of interpretive, material practices make the world visible. They transform the world and turn it into a series of representations, including field notes, interviews, observations, photographs, recordings, and memos to self (Denzin, Lincoln 2000). It involves an interpretive, naturalistic approach to the world. Researchers study things in their natural settings, attempting to make sense of, or to interpret, phenomena in terms of the meanings people bring to them.

Qualitative research uses multiple methods that are interactive and humanistic. The methods of data collection are growing, and they increasingly involve active participation and sensitivity to the participants in the study. The data collected involve text (or word) data and image (or picture) data (Creswell 2003). Qualitative research is emergent as research questions may change, data collection refined as the theory or general

---

---

pattern of understanding emerges. The qualitative researcher uses a broad holistic approach, reflect on their own biases, values and interests and how these affect the research and use an iterative approach moving from data collection and analysis to problem reformation and back.

Any divide, objectivist research being associated with quantitative methods against constructionist research being associated with qualitative methods, is far from justified. We should accept that, whatever research we engage in, it is possible to use either qualitative methods or quantitative methods, or both, to serve our purposes. Our research can be qualitative or quantitative, or both qualitative and quantitative, without this being in any way problematic. What would seem to be a problematic is any attempt to be at once objectivist and constructionist (Crotty 1998).

## **3.6 Data collection**

### **3.6.1 Literature review**

Literature reviews help researchers limit the scope of their inquiry, and they convey the importance of studying a topic to readers. In a quantitative study the literature is used deductively as a basis for advancing research questions or hypotheses. In a qualitative study, the literature is used sparingly in the beginning in order to convey an inductive design, unless the qualitative strategy type requires a substantial literature orientation at the outset (Creswell 2003).

A literature review enables the researcher to gain a fuller understanding of the area being investigated. It should reveal work carried out by other researchers on the same or similar topics. This will prevent duplication of research and promote the extension of research already carried out. Not only will the review inform the researcher of the topic under investigation

---

---

it should also provide details of the research strategies and methods that have been used.

### **3.6.2 Case studies**

At the early stages of any research it is possible that a situation presents itself whereby all the elements of the research under investigation are present in a single case. Concentrating on a single case study can provide all the information needed to answer formulated research questions. A frequent criticism of case study methodology is that its dependence on a single case renders it incapable of providing a generalising conclusion (Tellis 1997). The goal of the study should establish the parameters, and then should be applied to all research. In this way, even a single case could be considered acceptable, provided it met the established objective. Case study can be seen to satisfy the three tenants of the qualitative method: describing, understanding, and explaining.

### **3.6.3 Observation**

All research requires some form of observation. This could be in the form of witnessing a laboratory experiment, watching the behaviour of people in a naturalistic setting or being aware of a person's body language when conducting an individual interview. Observing activities, interactions, what people say, what they do, and the nature of physical setting is important in a comprehensive approach to fieldwork (Patton 2002).

There is no pure, objective, detached observation as all observation involves the observer's participation in the world being studied (Denzin, Lincoln 2000). Therefore it is important to take into consideration the observer's effect on that which is being studied. Whether it is the presence of the observer in a given situation or the questions presented to

---

---

interviewees, the relationship between researcher and participant needs to be discussed in any analysis.

### **3.6.4 Task breakdown/analysis**

The observation of people engaged in work is a central feature of ergonomics. Systematic observation of tasks, with some specific purpose in mind, has become a central part of the human resource disciplines developed in the 20th century. The development of task analysis methods is inextricably tied up with the development of ergonomics (Shepherd, Stammers 1995).

Hierarchical task analysis (HTA) breaks down the task under analysis into a hierarchy of goals, operations and plans. The task is described by a task statement, which states the overall goal of the task. This forms the top level of the hierarchy, which is then decomposed into sub-goals. Sub-goals can be decomposed further until an appropriate stopping point is reached (Stanton, Young 1999). They are easily implemented and provide user satisfaction as good progress is made in little time. However, they provide more descriptive information than analytical information and do not handle cognitive components of tasks, only observable elements.

### **3.6.5 Postural analysis**

The discomfort which results from a poor working posture may distract the subject from the task at hand, reduce his work output and predispose the worker to errors and accidents. Many authorities would accept that long-term postural stress is an important causative factor in a variety of chronic disorders of the musculoskeletal system (Singleton 1982).

---

---

Methods for direct measurement of the effort involved in holding a posture, as well as its effects, are less common than for dynamic work. Measurement of muscular activity using electromyographic (EMG) readings, discomfort recordings and a wide range of interpretive methods are used. Amongst the interpretive methods, the use of posture recordings such as OWAS, NIOSH, posture targeting, RULA and REBA are increasingly being used.

### **3.6.6 Interviews**

The main advantage of an interview is in its familiarity to the respondent as a technique and this, combined with the face-to-face nature, is likely to elicit more information, and probably more accurate information (Stanton, Young 1999). It is a flexible method and structured interviews offer consistency and thoroughness. The analysis, however, can be time-consuming.

In conventional approaches, subjects are seen as repositories of facts and the related details of experience. The information is viewed, in principle, as held uncontaminated by the subjects. The interviewer's task is to formulate questions and provide an atmosphere conducive to open and undistorted communication between the interviewer and the respondent. They must be wary of how they ask questions, lest their manner of enquiry bias what lies within the subject (Holstein, Gubrium 1995).

However, interviews can be seen to be interpretively active, implicating meaning-making practices on the part of both interviewers and respondents. It is contended that if interview data are unavoidably collaborative (Alasuutari 1995, Holstein, Staples 1992), attempts to strip interviews of their interactional ingredients will be futile. Researchers need to acknowledge interviewers' and respondents' constitutive

---

---

contributions and consciously and conscientiously incorporate them into the production and analysis of interview data. All interviews are reality-constructing, meaning-making occasions, whether recognised or not (Holstein, Gubrium 1995).

### **3.6.7 Focus groups**

A focus group, or expert panel, is a carefully planned discussion, designed to obtain the perceptions of the group members on a defined area of interest. Typically there are between five and 12 participants, the discussion being guided and facilitated by a moderator. The group members are selected on the basis of their individual characteristics as related to the topic of the session. The group based nature of the discussions enables the participants to build on the responses and ideas of others, thus increasing the richness of the information gained (Langford, McDonagh 2003).

Within the boundaries of the above definition, the focus group allows the researcher to explore the topic under consideration using a predetermined set of questions together with persuasive prompts should discussions falter. Questions can be delivered with either one or two facilitators who are free to direct conversations as they progress and introduce new areas for discussion when needed. Although seen as a qualitative tool, focus groups members can be asked to fill out questionnaires at some stage of the meeting to provide quantitative information.

---

---

## **3.7 Data Analysis**

### **3.7.1 Task observation**

Observing the different methods used for the installation of highway kerbs enabled a better understanding to be gained of the roles played by all of the surrounding factors that impacted on the work. It was also beneficial when viewing video, taken during the site visits, for the purpose of carrying out task and postural analysis of the various methods.

### **3.7.2 Task and postural analysis**

These quantitative elements of the data gathering were not recorded in sufficient quantity to allow meaningful statistical analysis to be performed. Rather, they were used to indicate, in the case of the task analysis, the distinct elements of the working methods under consideration and, for the postural analysis, which of the distinct elements posed a risk to the workers. In addition the postural analysis enabled a quantification of any changes made to the methods in regard to the risks posed.

### **3.7.3 Analysis of text (safety meetings, focus groups, interviews)**

The attendance at safety meetings, the organising of focus groups and conducting of telephone interviews provided sufficient textual data for content analysis. Classical content analysis comprises techniques for reducing the texts to a unit by variable matrix. The researcher can produce a matrix by applying a set of codes to a set of qualitative data (Denzin, Lincoln 2000). Raw field notes and verbatim transcripts



---

---

constitute the undigested complexity of reality. Simplifying and making sense out of that complexity constitutes the challenge of the content analysis. Without classification there is chaos and confusion (Patton 2002). Developing some manageable classification or coding scheme is the first step of analysis. This essentially means analysing the core content of interviews and observations to determine what is significant.

Transcriptions of the three focus groups together with notes from site visits, safety meetings, telephone interviews and kerb forums provided seven sets of text data. A coding system was developed incorporating three separate characteristics: stakeholder; topic; and whether the point raised was either conservative (negative) or innovative (positive). Hard copies of all of the datasets were read through to identify all salient points and the points were colour-coded depending on the relevant topic. The next stage was to reduce the points to a single line of text and tabulate them highlighting stakeholder, topic and whether they were conservative or innovative.

Once the points are reduced to a single line of text any further analysis relies on the researcher's ability to put the line of text in the context of the event (focus group, phone interview etc) that the text was drawn from. On completion of a table for each of the seven datasets the tables were pasted together to form a single document to allow sorting of all of the data. Coding also allowed each of the seven datasets to be identified within the final table thus enabling themes across various datasets to be identified and used to validate their impact on the study. The final table, once sorted, allowed a visual examination of patterns produced by markings of the three characteristics.

The analysis allowed meaning to be given to any first impressions from data acquisition; meaning to the final compilation of data; interpretation of single instances and an aggregation of instances to draw conclusions as a

---

---

class. Results of the analysis of the text datasets can be seen in chapter 5 whilst details of the findings from the site visits (task observation, task analysis, and postural analysis) recorded in chapter 4.

### **3.8 Quality Criteria**

In quantitative research the following questions have to be asked: Are the findings valid? Can they be generalised and can they be replicated? In qualitative research this is not necessarily the case. Validity in qualitative research has to do with description and explanation and whether or not the explanation fits the description. In other words, is the explanation credible? In addition, qualitative researchers do not claim that there is only one way of interpreting an event. There is no one "correct" interpretation (Denzin, Lincoln 2000). For questions of meaning and interpretation in individual cases found in qualitative research, generalisability falls short. The traditional view of generalisability limits the ability to reconceptualise the role of social science in education and human services. When looking to see if the research can be replicated the traditional sense of replicability is pointless here; taking, for instance, the use of case studies in qualitative research: the value of the case study is its uniqueness.

What constructionism drives home unambiguously is that there is no true or valid interpretation. There are useful interpretations, to be sure, and these stand against interpretations that appear to serve no useful purpose (Crotty 1998). There are liberating forms of interpretation too; they contrast sharply with interpretations that prove oppressive. There are even interpretations that may be judged fulfilling and rewarding -- in contradistinction to interpretations that impoverish human existence and

---

---

stunt human growth. 'Useful', 'liberating', 'fulfilling', 'rewarding' interpretations, yes. 'True' or 'valid' interpretations, no.

Given that a construct is not directly observable, determining the validity of observations or the results of measurement (including the "human instrument" of qualitative research) is, at best, difficult (Tashakkori, Teddlie 1998). There are two general strategies that can be followed: *judgemental validation* can be used for determining the validity of an instrument that measures a specific and well defined attribute; *empirical validation* requires two types of information a) the degree to which the measurement outcome representing a construct related to the measures of other constructs and b) the degree to which the measurement outcome is unrelated to measures of other constructs. If the result of a measurement is valid, it should be consistent with measures of related constructs or other measures of the same construct and it should be unrelated to the measures of unrelated constructs.

A procedural perspective recommended by Creswell (Creswell 2003) is to identify and discuss one or more strategies available to check the accuracy of the findings. He goes on to list eight primary strategies, organised from those most frequently used and easy to implement to those occasionally used and difficult to implement:

- *Triangulate* different data sources to build a coherent justification for themes.
- Use *member checking* taking findings back to participants to see if they agree.
- Use *rich, thick description* to convey the findings.
- Clarify the researcher's *bias*.
- Present *negative or discrepant information* that runs counter to the themes to convey different perspectives.
- Spend *prolonged time* in the field to gain an in-depth understanding of the phenomenon under study.
- Use *peer debriefing* to enhance the accuracy of the account.
- Use an *external auditor* to review the entire project.

---

---

## **3.9 Adopted Research Methodology**

The adopted research methodology was based around the interaction of data collected from site visits with that collected from interviews and focus groups. The site visits were used to carry out observation of working practices providing video and photographic records from which tasks could be broken down and postural analysis of the tasks carried out, while the attendance at various safety association meetings, discussions with construction industry contacts and the publicising of the research project were used to find experts with the appropriate experience to be used in interviews and focus groups. The way that the methods used covered the main research areas can be seen in Figure 7.

### **3.9.1 Literature review**

A systematic search was carried out of internet research databases to find any related publications. Combinations of keywords (kerbs, kerb laying, manual handling, construction, construction management etc) were used to identify research papers and the Refworks online referencing facility was used for sorting, keeping, and working with the references. In addition various libraries were visited to search older journals that were not available on the Internet.

All related legislation, British Standards and Highways Agency documents and specifications were identified and copies obtained. Internet searches were also used to find details of alternative kerb materials and kerb laying methods. As the use of concrete highway kerbs appeared to extend across Western Europe, translations for 'kerb' were identified and used in further internet searches.

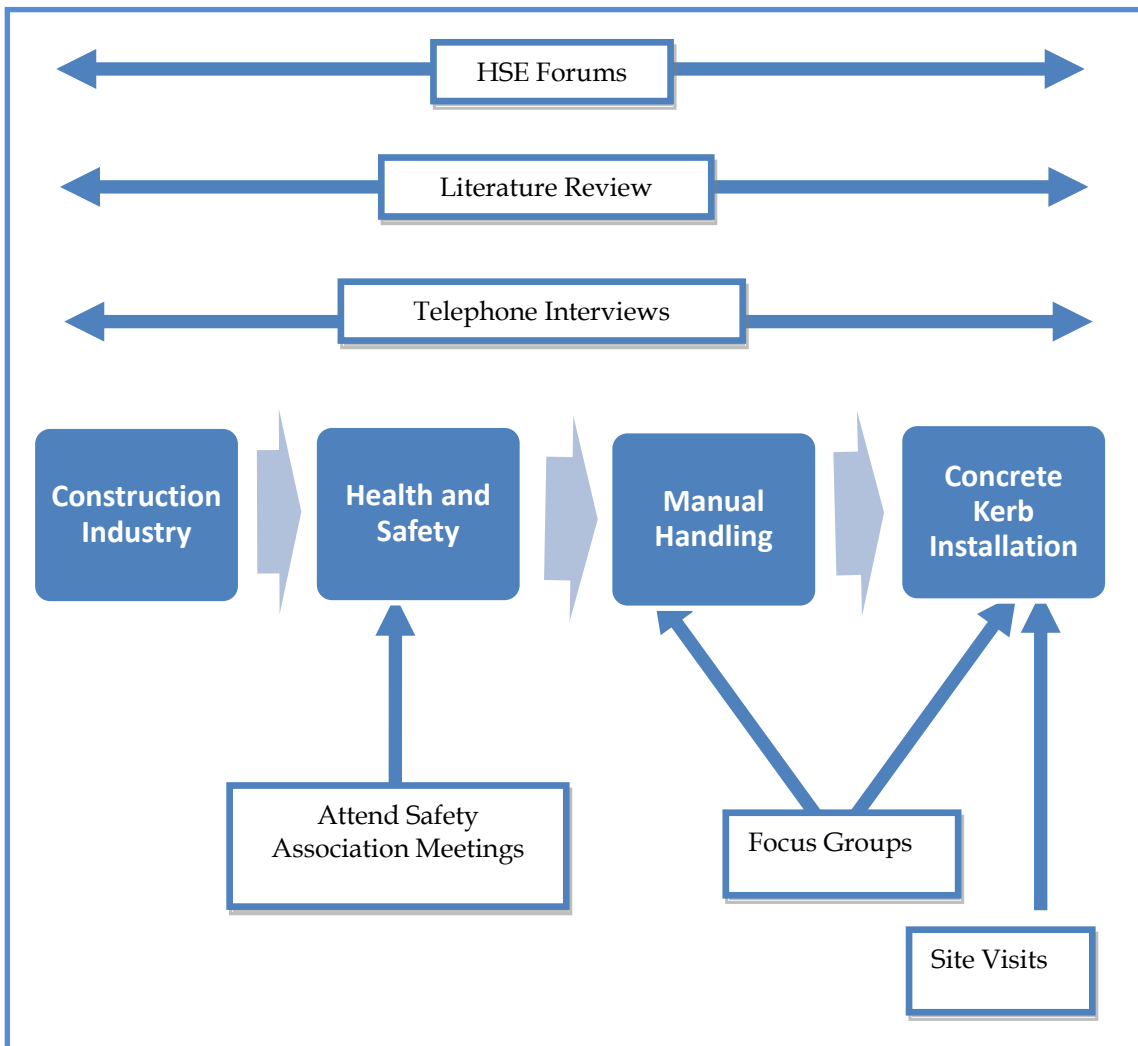


Figure 7 Key Topics and Methods Used

### 3.9.2 Case studies

For this research, a case study in its true sense would for instance be a local authority looking to introduce new methods of installing highway kerbs on their road projects. The research could have then identified the existing methods being used, the range of new methods under review and

---

---

talk to all parties involved. However, as this opportunity did not arise at the beginning of this project, by investigating the practice of manually handling highway kerbs and alternative options, it could be said that this was an example, rather than a case study, of a manual handling operation within the construction industry.

### **3.9.3 Observation**

During the early stages of the research, efforts were concentrated on making contact with contractors, health and safety associations and local authorities to publicise the research, identify active kerb laying operations and obtain permission to carry out site visits. Several months into the project, having given a number of presentations and providing material for construction press articles and following up contacts made at safety association meetings, a network of industry contacts was established.

The selection of sites to visit was very much on an opportunistic basis and because the manual handling method of installing highway kerbs was widely used by contractors most of the visits looked at these operations. As more methods of installation became apparent, such as the use of a kerb-race, sites where this type of work was being carried out were sought to visit. An attempt was also made to visit a variety of settings (city centre, housing estate, rural road, car park etc).

Before attending any of the sites, permission was sought to record the kerb installation methods using video and photographic methods. A list of the sites visited indicating the date of the visits and the type of activity observed during the site visit is shown in Table 12.

---

---

### 3.9.4 Task breakdown/analysis

A task analysis was carried out following site visits taking elements which describe the path required to complete the operation. All of the tasks required to carry out the operation were first identified.

Related tasks were grouped together and given group names which were placed in operational order. Each task was then given an identification number so that the tasks could be tabulated.

Date	Location	Activity
January 16	Concrete product manufacturer	Kerb manufacture
January 22	University campus	Manual kerb laying
January 27	Local authority depot	Kerb storage
January 27	Access road	Speak to kerb layers
February 6	Concrete product manufacturer	Kerb manufacture
February 18	Vacuum lifter manufacturer	Technical discussion
February 24	Channel Tunnel rail link	Discussed kerb laying
March 12	University campus	Arrange visit
March 21	Road works	Arrange visit
March 24	University campus	Arrange visit
March 25	Road works	Manual kerb laying
April 9	Athletic Stadium car park	Manual kerb laying
April 29	Construction equipment exhibition	Vacuum lifter demonstrations
June 6	Public house car park	Vacuum lifter set up
August 6	City centre	Manual kerb laying
August 15	Footpath widening	Use of scissor clamps
August 22	Road resurfacing	Discuss kerb/drains

---



---

September 18	Housing estate	Use of scissor clamps
September 25	Various county council sites	Manual kerb laying
October 1	Motorway Dublin	Slip forming
October 29	Housing estate	Kerb race installation
November 4	Rural Road	Vacuum lifter operation
November 19	Contractors safety meeting	Equipment demonstrations

Table 12 Site visits

Once tabulated, tasks where risks to health were present were identified and appropriate controls listed beside them. This is similar to carrying out a risk assessment of the work. The task analysis sheets can be seen in Appendix C.

### 3.9.5 Postural analysis

Video recordings of the various methods used to install kerbs, obtained from the site visits, were used to carry out postural analysis of the workers involved. This was to quantify the risks associated with all of the operations. It was also helpful to assess any improvements that were being made to existing operations.

The key postures in the kerb laying operations, see Table 13, were scored using the REBA (Rapid Entire Body Assessment) tool from observing the work. The scores were then developed into action levels ranging from no action necessary to immediate action required. The use of this tool for evaluating postural loading on the body is a widely accepted method (Hignett, McAtamney 2000).



---



---

1.	The back with its natural “S-Curve” intact
2.	The neck in its proper alignment
3.	The elbows held naturally at the sides of the body and the shoulders relaxed
4.	The wrists in line with the forearm
(MacLeod 2000)	

Table 13 Key postures of practical relevance in the workplace

The REBA tool assists the observer in producing a score for the posture of various parts of the body. A score of 1 would indicate that the body part was in a neutral position and the scores increase to between 2 and 4 as the body part moves away from the neutral position. The scores of the trunk, neck and legs are combined, using a matrix, to give the first score, which is then adjusted to account for any loads being considered in that particular task or operation. The scores for the upper and lower arms and wrists are combined, using a matrix, to give the second score and this is adjusted to account for the individuals coupling with the load. The first and second scores are then combined, using a matrix, and adjusted for the activity of the operation to achieve a REBA score as indicated in Figure 8 which can then be used to obtain a risk level and appropriate level of action required.

The postures measured represented the *worst* adopted during the work cycle for the task assessed. The impact from repetitive work, static muscle work and the demands of rapid changes in posture are included in the score, along with the postural loading that is occurring on the body. REBA was developed to measure the impact from different task types. REBA provides a risk rating of 1 (low) to 15 (high) see Table 14. It measures the posture, force and movement in dynamic tasks where manual handling may also occur.

---



---

<b>REBA SCORE</b>	<b>RISK LEVEL</b>	<b>ACTION</b>
1	Negligible	None Necessary
2-3	Low	May be Necessary
4-7	Medium	Necessary
8-10	High	Necessary Soon
11-15	Very high	Necessary Now

Table 14 Risk ratings used in the REBA postural analysis tool

# REBA Employee Assessment Worksheet

based on Technical note: Rapid Entire Body Assessment (REBA), Hignett, McAtamney, Applied Ergonomics 31 (2000) 201-205

### A. Neck, Trunk and Leg Analysis

**Step 1: Locate Neck Position**  
  
 Step 1a: Adjust...  
 If neck is twisted: +1  
 If neck is side bending: +1  
 Neck Score:

**Step 2: Locate Trunk Position**  
  
 Step 2a: Adjust...  
 If trunk is twisted: +1  
 If trunk is side bending: +1  
 Trunk Score:

**Step 3: Legs**  
  
 Adjust: 30-60° (+1), 60° (+2)  
 Leg Score:

**Step 4: Look-up Posture Score in Table A**  
 Using values from steps 1-3 above, locate score in Table A  
 Posture Score A:

**Step 5: Add Force/Load Score**  
 If load < 11 lbs: +0  
 If load 11 to 22 lbs: +1  
 If load > 22 lbs: +2  
 Adjust: If shock or rapid build up of force: add +1  
 Force/load Score:

**Step 6: Score A, Find Row in Table C**  
 Add values from steps 4 & 5 to obtain Score A.  
 Find Row in Table C.  
 Score A:

**Scoring:**  
 1 = negligible risk  
 2 or 3 = low risk, change may be needed  
 4 to 7 = medium risk, further investigation, change soon  
 8 to 10 = high risk, investigate and implement change  
 11+ = very high risk, implement change

### B. Arm and Wrist Analysis

**Step 7: Locate Upper Arm Position:**  
  
 Step 7a: Adjust...  
 If shoulder is raised: +1  
 If upper arm is abducted: +1  
 If arm is supported or person is leaning: -1  
 Upper Arm Score:

**Step 8: Locate Lower Arm Position:**  
  
 Lower Arm Score:

**Step 9: Locate Wrist Position:**  
  
 Step 9a: Adjust...  
 If wrist is bent from midline or twisted: Add +1  
 Wrist Score:

**Step 10: Look-up Posture Score in Table B**  
 Using values from steps 7-9 above, locate score in Table B  
 Posture Score B:

**Step 11: Add Coupling Score**  
 Well fitting Handle and mid range power grip: good: +0  
 Acceptable but not ideal hand hold or coupling: acceptable with another body part, fair: +1  
 Hand hold not acceptable but possible, poor: +2  
 No handles, awkward, unsafe with any body part, Unacceptable: +3  
 Coupling Score:

**Step 12: Score B, Find Column in Table C**  
 Add values from steps 10 & 11 to obtain Score B. Find column in Table C and match with Score A in row from step 6 to obtain Table C Score.  
 Score B:

**Step 13: Activity Score**  
 +1 1 or more body parts are held for longer than 1 minute (static)  
 +1 Repeated small range actions (more than 4x per minute)  
 +1 Action causes rapid large range changes in postures or unstable base

Table A		Neck											
		1				2				3			
Trunk Posture Score	Legs	1	2	3	4	1	2	3	4	1	2	3	4
	1	1	2	3	4	1	2	3	4	3	3	5	6
	2	2	3	4	5	3	4	5	6	4	5	6	7
	3	2	4	5	6	4	5	6	7	5	6	7	8
	4	3	5	6	7	5	6	7	8	6	7	8	9
5	4	6	7	8	6	7	8	9	7	8	9	9	

Table B		Lower Arm						
		1			2			
Upper Arm Score	Wrist	1	2	3	1	2	3	
	1	1	1	2	2	1	2	3
	2	1	2	3	2	3	4	
	3	3	4	5	4	5	5	
	4	4	5	5	5	6	7	
	5	6	7	8	7	8	8	
6	7	8	8	8	9	9		

Table C		Score B, (table B value + coupling score)											
Score A (score from table A + load/force score)	1	1	1	1	2	3	3	4	5	6	7	7	7
	2	1	2	2	3	4	4	5	6	6	7	7	8
	3	2	3	3	3	4	5	6	7	7	8	8	8
	4	3	4	4	4	5	6	7	8	8	9	9	9
	5	4	4	4	5	6	7	8	8	9	9	9	9
	6	6	6	6	7	8	8	9	9	10	10	10	10
	7	7	7	7	8	9	9	9	10	10	11	11	11
	8	8	8	8	9	10	10	10	10	10	11	11	11
	9	9	9	9	10	10	10	10	11	11	11	12	12
	10	10	10	10	11	11	11	11	12	12	12	12	12
	11	11	11	11	11	12	12	12	12	12	12	12	12
	12	12	12	12	12	12	12	12	12	12	12	12	12

Table C Score

+

Activity Score

Final REBA Score

Figure 8 REBA Postural Analysis Tool

Task name: \_\_\_\_\_ Reviewer: \_\_\_\_\_ Date: \_\_\_\_\_/\_\_\_\_\_/\_\_\_\_\_

This tool is provided without warranty. The author has provided this tool as a simple means for applying the concepts provided in REBA.

© 2004 Human Consulting, Inc.

provided by Practical Ergonomics

rbarker@ergosmart.com (816) 444-1667

---

---

### **3.9.6 Interviews**

The main advantage of an interview is in its familiarity to the respondent as a technique and this, combined with the face-to-face nature, is likely to elicit more information, and probably more accurate information (Stanton, Young 1999). It is a flexible method and structured interviews offer consistency and thoroughness. The analysis, however, can be time-consuming.

### **3.9.7 Focus groups**

Focus groups can be linked with other techniques to triangulate data or add insight into a research problem (Bruseberg, McDonagh-Philp 2002). In this study, focus groups were used to explore issues surrounding the manual handling of kerbs, accompanied by individual interviews, site observations and equipment assessments.

Three focus group meetings with a number of industry professionals (total  $n = 24$ ), were held to discuss topics associated with kerb installation work, the details of which are shown in Table 15. Five or six questions were developed for each of the areas covered: kerb manufacture and lifting equipment (Table 16); design issues (Table 17); and training (Table 18), prior to each meeting to assist in guiding discussion within the group.

As recommended (Christie, Scane & Collyer 1995), the group numbers were between 5 and 10 members. Also, as ergonomists and designers have extended the usefulness of the basic focus group methodology by integrating activity elements to aid generation of new ideas (Langford, McDonagh 2003), an exercise was used at each group meeting to act as a break from the round table discussion. The groups were split into two

with each half working to consider a particular problem. Meetings were recorded for later transcription.

	Topic	Exercise	No. in group	Date	Attendees included
1	Manufacture of concrete kerbs/lifting equipment	Lifting equipment	8	30/04/03	HSE inspectors, Ergonomists, Manufacturers, Safety Supervisors
2	Design issues	Finding alternative design situations	10	21/08/03	HSE inspector, Highways Agency Engineer, Plastic Kerb Manufacturer, Local Authority Designers and Contractors
3	Training issues	Effectiveness of training for different parties	6	23/09/03	Training instructors, Contractors and Safety Supervisors

Table 15 Breakdown of focus group participants

Question	Questions prepared for focus group meeting on manufacturing and lifting equipment.
1	How have we arrived at using kerbs?
2	Can we change kerbs?
3	Is there an alternative to concrete kerbs?
4	Is lifting equipment the answer?
5	How should guidance be structured?

Table 16 Questions used in focus group one

Question	Questions prepared for focus group meeting on design issues.
1	How do you feel design affects health and safety on site?
2	Does existing documentation restrict the design of highways?
3	What do you think about the state of communication between parties in the construction process?
4	Can the construction industry adopt alternatives where practices have been used for tens of years?
5	What should drive changes in construction to improve health and safety?
6	Would input from all parties concerned improve introduction of safer working practices?

Table 17 Questions used in focus group two

Question	Questions prepared for focus group meeting on training issues.
1	How much health awareness instruction is required in the training of kerb installation?
2	How big is the divide between training and practice?
3	Do we need to train construction workers differently?
4	With the increase in the use of mechanical lifters, do we need less training?
5	Assuming that in five years time mechanical lifters are accepted, who should provide the training?

Table 18 Questions used in focus group three

### 3.10 Summary

This chapter has outlined the reasons for the adopted research design. An examination has been carried out of the theoretical perspectives and the appropriateness of interpretivism and the use of qualitative methods bearing in mind the qualifications that the research was subject to.

Details of the data collection tools and approaches have been included: observation of the tasks and the use of video recording to facilitate task and postural analysis; the use of active interviewing techniques; and the benefits of using focus groups. Analysis of the data has been discussed most of which has required analysis of text with subsequent coding of material and interpretation.

In addition details of how the methods and tools were applied within the construction industry setting are shown: kerb installation as a kind of case study of manual handling within construction; task analysis used for risk

---

---

identification; postural analysis used to quantify level of risk and effectiveness of changes.

The appropriateness of the choice of methods can be seen in the results from the study. Chapter 4 contains details of the findings from the site visits with descriptions of kerb installation methods observed, together with details of the task analysis/breakdown of the operations and the postural analysis results of the posture is used for the various installation methods. Chapter 5 contains the results from the various interviews and the focus groups that were carried out with experienced industry professionals.

Discussion of the results together with their interpretation in context of the methodological approach can be found in chapter 6. Final conclusions drawn from the results and discussion chapters have been included in chapter 8.



---

---

## 4 RESULTS (SITE VISITS)

### 4.1 Introduction

This chapter presents the results obtained from the field observations which formed part of the kerb installation site visits. Establishing the site visits was an ongoing process that continued for the full length of the project and relied upon contacts made in the industry before and during the research project. Observation of the kerb installation operations was essential in providing the researcher with first-hand experience of the activities and, wherever possible, an opportunity to record the activities for more considered investigation and analysis.

In the following sections a full description of each of the kerb installation operations is provided together with a photograph of the installation work being carried out. The photograph shows details of the work environment, the operatives and the equipment that was being used. Photographic and video records enabled observation of the activities to continue after the site visits and were used for the task and postural analysis. Discussions with the supervisors and workers are detailed in the text results which can be found in chapter five.

The task analysis or task breakdown was used to provide a detailed breakdown of the work including all of its sub tasks. The full details of these can be seen in appendix 10.1. Investigation of the task analysis/breakdown aimed to identify those sub tasks that posed the greatest risk to the kerb laying operatives. The severity of the risk in these sub tasks was then assessed with the postural analysis work.

The postural analysis results are shown for three of the sub tasks for each kerb installation operation. These were established using the rapid entire body analysis (REBA) tool (Hignett, McAtamney 2000). The REBA tool

---

---

results provided a numerical score for each of the sub tasks. The scoring system depended on the postures that the individuals adopted during the work, the load characteristics and the repetition of the work. The scores indicate which response category the sub tasks fall into. Details of the REBA calculations are shown besides photographs of the sub tasks and the severity of the responses indicated.

During the research it was possible to attend a number of equipment demonstrations in various parts of the UK where kerb installation equipment was on display. As these demonstrations were providing the manufacturers with opportunities to promote their equipment to the construction industry, the latest developments of the equipment were usually on display. Descriptions of the equipment observed during these visits are included at the end of this chapter.

## **4.2 Manual Kerb Laying - University Campus**

At an early stage of the research an opportunity arose as work was being carried out on the university campus. The workers were approached and some exploratory questions were used to elicit details of working operations. They said that the kerbs had been delivered to the point of installation using a forklift machine. Manual handling of the kerbs was the method of installation. The kerbs were laid 1 inch higher so that they could be knocked down to the correct level. Some smaller kerbs were being used to enable radius sections to be formed. As this was an opportunistic visit no photographic or video recording of the operations was made and therefore no postural analysis.

The main installer preferred to lay the kerbs alone because he found it easier to do. He said that he would prefer the kerbs to be 1 1/2 metres long and made out of hardened rubber as he felt that that would enable

---

---

him to lay more kerbs. He was not interested in using equipment to lift kerbs because he felt that this would slow him down and cost him money. He said that he needed to get in “close and personal” with the kerbs because of the intricacies of laying them. When he was not laying kerbs his other tasks involved installing drainage and being involved with ground works (concrete footings, slabs). He understood the problems with regard to the weight of the kerbs and gave as an example the reduction in the weight of cement bags and also mentioned that contractors were worried about legal compensation claims.


### **4.3 Manual Kerb Laying – Road Works**

On arriving at this site the string setting out line had already been set up and the first delivery of concrete bedding had been made. Photographs and video records of the work were taken and then, as they waited for the next delivery, the two men were interviewed. They said that they were allowed a set period of time (approximately 12 minutes) for installing each kerb. This included putting up the string line, laying the concrete bed, laying the kerbs and tidying the bed. The kerbs were lifted off a loader shovel excavator the previous day and walked (manoeuvred in an upright position with one end on the floor) into place. Although they had been given kerb clamps for lifting the kerbs they preferred not to use them. In this instance the kerbs, due to the road alterations being carried out, were higher than ground level with the result that the men did not have to lean over so much. However, on some occasions they have had to lay the kerbs below ground level as the roads were being altered. The lead installer used knee pads and tended to kneel down when he could because he was affected by back pain. He had visited his doctor who advised him not to do this type of work. He continued because he was finding it difficult to

find alternative work (that he would be physically able to do) that paid as well. This job also required him to do lots of shovelling work, use a pneumatic hammer for breaking out the existing road surface and the previous week he had been laying block paving. He was also working seven days a week.

### 4.3.1 Task analysis


The task analysis identified six sub tasks which were broken down into a further 21 tasks (for the full analysis see appendix 10.1).

Operation – Manual handling of highway kerbs																																					
Task	REBA Rating																																				
Lifting kerbs into position																																					
	<table border="0"> <tr> <td>4</td> <td></td> <td></td> <td>3</td> </tr> <tr> <td>2</td> <td>6</td> <td>5</td> <td>2</td> </tr> <tr> <td>1+1</td> <td>2</td> <td>2</td> <td>1+1</td> </tr> <tr> <td></td> <td>8</td> <td>7</td> <td></td> </tr> <tr> <td></td> <td></td> <td>10</td> <td></td> </tr> <tr> <td></td> <td></td> <td>0</td> <td></td> </tr> <tr> <td>REBA Score</td> <td></td> <td>10</td> <td></td> </tr> <tr> <td colspan="4">Risk Level = High</td> </tr> <tr> <td colspan="4"><i>Action – Necessary Soon</i></td> </tr> </table>	4			3	2	6	5	2	1+1	2	2	1+1		8	7				10				0		REBA Score		10		Risk Level = High				<i>Action – Necessary Soon</i>			
4			3																																		
2	6	5	2																																		
1+1	2	2	1+1																																		
	8	7																																			
		10																																			
		0																																			
REBA Score		10																																			
Risk Level = High																																					
<i>Action – Necessary Soon</i>																																					


Within those 21 tasks, the risks identified included the hammering of steel pins and hammering down of the kerb; shovelling of wet concrete; kerbs falling on to feet; posture when crouching down to carry out the work; and manual handling of the concrete kerbs.

### 4.3.2 Postural analysis

Using the task analysis together with video and photographic records of the work the manual handling of the kerb, tapping a kerb down into place and shovelling of concrete operations were selected for postural analysis.

Hammering kerbs down to level				
	4 2 1+2	7 0 7	4 1 5	3 1 1+1
			9 0 9	
			REBA Score	
			Risk Level = High	
			<i>Action - Necessary Soon</i>	

The manual handling operation score was 10, the hammering and shovelling operations both scored nine which meant that, using the REBA action criteria, for all three operations, remedial action was 'necessary soon'.

Levelling concrete bed to receive kerbs				
	3 1+1 2	5 1 6	5 1 6	3 2 2+1
			8 1 9	
			REBA Score	
			Risk Level = High	
			<i>Action - Necessary Soon</i>	

---


---

## **4.4 Manual Kerb Laying - Car Park**

This work formed part of a car park to a new athletics complex. On the day of the visit the kerb installation operations were delayed due to the late delivery of bedding concrete. Final excavation for the area to be kerbed was being done while waiting for the concrete. Following excavation, some stone was placed and compacted. When it arrived, the bedding concrete was laid onto the stone. Lines were placed along steel pins to enable the kerb to be installed in line and to level. A pallet of kerbs was positioned close to where the work was to be carried out. Two men took the kerbs from the pallets to position on the bedding in line with the string line. One of the men then stayed to hammer the kerb into place and down to level. The concrete bedding material was tidied up as the work progressed. A disc cutter was used to cut any kerbs that were required to be shorter in length. This produced a considerable amount of dust as no dust suppression equipment was used. A loader shovel excavator was used to place concrete along the string line. The men said that they generally were involved in ground work operations (kerbs, drains, footings and slabs).


### **4.4.1 Task analysis**

The task analysis identified six sub tasks which were broken down into a further 21 tasks (for the full analysis see appendix 10.1). Within those 21 tasks, the risks identified included the hammering of steel pins and hammering down of the kerb; shovelling of wet concrete; dust inhalation; kerbs falling on to feet; posture when crouching down to carry out the work; and manual handling of the concrete kerbs.

Operation – kerbs laid for car park																																					
Task	REBA Rating																																				
Shovelling concrete for kerb bed																																					
	<table border="0"> <tr> <td>4</td> <td></td> <td></td> <td>2</td> </tr> <tr> <td>1</td> <td>5</td> <td>3</td> <td>2</td> </tr> <tr> <td>1+1</td> <td>1</td> <td>1</td> <td>1+1</td> </tr> <tr> <td></td> <td>6</td> <td>4</td> <td></td> </tr> <tr> <td></td> <td></td> <td>7</td> <td></td> </tr> <tr> <td></td> <td></td> <td>0</td> <td></td> </tr> <tr> <td>REBA Score</td> <td></td> <td>7</td> <td></td> </tr> <tr> <td colspan="4">Risk Level = Medium</td> </tr> <tr> <td colspan="4"><i>Action – Necessary</i></td> </tr> </table>	4			2	1	5	3	2	1+1	1	1	1+1		6	4				7				0		REBA Score		7		Risk Level = Medium				<i>Action – Necessary</i>			
4			2																																		
1	5	3	2																																		
1+1	1	1	1+1																																		
	6	4																																			
		7																																			
		0																																			
REBA Score		7																																			
Risk Level = Medium																																					
<i>Action – Necessary</i>																																					


#### 4.4.2 Postural analysis

Using the task analysis together with video and photographic records of the work the manual handling of the kerb, tapping a kerb down into place and shovelling of concrete operations were selected for postural analysis.

Task	REBA Rating																																				
Lifting kerb into place																																					
	<table border="0"> <tr> <td>4+1</td> <td></td> <td></td> <td>2</td> </tr> <tr> <td>2</td> <td>8</td> <td>2</td> <td>2</td> </tr> <tr> <td>2+1</td> <td>2</td> <td>2</td> <td>1</td> </tr> <tr> <td></td> <td>10</td> <td>4</td> <td></td> </tr> <tr> <td></td> <td></td> <td>11</td> <td></td> </tr> <tr> <td></td> <td></td> <td>1</td> <td></td> </tr> <tr> <td>REBA Score</td> <td></td> <td>12</td> <td></td> </tr> <tr> <td colspan="4">Risk Level = Very High</td> </tr> <tr> <td colspan="4"><i>Action – Necessary Now</i></td> </tr> </table>	4+1			2	2	8	2	2	2+1	2	2	1		10	4				11				1		REBA Score		12		Risk Level = Very High				<i>Action – Necessary Now</i>			
4+1			2																																		
2	8	2	2																																		
2+1	2	2	1																																		
	10	4																																			
		11																																			
		1																																			
REBA Score		12																																			
Risk Level = Very High																																					
<i>Action – Necessary Now</i>																																					

The manual handling operation score was 12, the hammering and shovelling operations both scored seven which meant that, using the

REBA action criteria, for the manual handling operation, action was 'necessary now' and for the other two operations, action was 'necessary'.

Tapping kerb to level																																					
	<table border="0"> <tr> <td>4</td> <td></td> <td></td> <td>2</td> </tr> <tr> <td>2</td> <td>7</td> <td>2</td> <td>1</td> </tr> <tr> <td>2+1</td> <td>0</td> <td>1</td> <td>1+1</td> </tr> <tr> <td></td> <td>7</td> <td>3</td> <td></td> </tr> <tr> <td></td> <td></td> <td>7</td> <td></td> </tr> <tr> <td></td> <td></td> <td>0</td> <td></td> </tr> <tr> <td>REBA Score</td> <td></td> <td>7</td> <td></td> </tr> <tr> <td colspan="4">Risk Level = Medium</td> </tr> <tr> <td colspan="4"><i>Action - Necessary</i></td> </tr> </table>	4			2	2	7	2	1	2+1	0	1	1+1		7	3				7				0		REBA Score		7		Risk Level = Medium				<i>Action - Necessary</i>			
	4			2																																	
2	7	2	1																																		
2+1	0	1	1+1																																		
	7	3																																			
		7																																			
		0																																			
REBA Score		7																																			
Risk Level = Medium																																					
<i>Action - Necessary</i>																																					


#### 4.5 Vacuum Lifter Set Up - Public House Car Park

It was intended to inspect the kerb laying operations during this site visit. Unfortunately, overnight rain filled the trench where the work was to be carried out thus delaying the work. However, as the equipment was on site, it was possible to demonstrate how the vacuum lifting equipment was prepared ready for use. The Al-Vac vacuum lifter had been delivered on a lorry to the car park. The first operation required the machine to be lifted off the lorry and onto the forks of a loader shovel excavator. The machine was then lowered down to ground level where the two operatives could adjust the supporting framework/swinging arm and handlebars in order for the equipment to be ready to pick up kerbs. This work included the pumping up of a small hydraulic device attached to the supporting framework and lifting of the vacuum plate to fix it to the framework. Once ready, all that was required was for the excavator to pick up a pallet of kerbs to sit just in front of the equipment making it ready to lay the kerbs into position.



## 4.5.1 Task analysis

A task analysis identified risks that included manual pumping of the hydraulic system with raised arms; lifting the metal vacuum plate whilst fixing it into position; and securing the metal clamps to the vacuum tube with raised arms.


Operation – Vacuum lifter set-up																													
Task	REBA Rating																												
Pumping hydraulic system																													
	<table border="0"> <tr> <td>0</td> <td></td> <td></td> <td>3</td> </tr> <tr> <td>1</td> <td>2</td> <td>8</td> <td>2</td> </tr> <tr> <td>1</td> <td>1</td> <td>0</td> <td>2+1</td> </tr> <tr> <td></td> <td>3</td> <td>8</td> <td></td> </tr> <tr> <td></td> <td></td> <td>7</td> <td></td> </tr> <tr> <td></td> <td></td> <td>1</td> <td></td> </tr> <tr> <td>REBA Score</td> <td></td> <td>8</td> <td></td> </tr> </table> <p><b>Risk Level = High</b></p> <p><i>Action – Necessary Soon</i></p>	0			3	1	2	8	2	1	1	0	2+1		3	8				7				1		REBA Score		8	
0			3																										
1	2	8	2																										
1	1	0	2+1																										
	3	8																											
		7																											
		1																											
REBA Score		8																											

## 4.5.2 Postural analysis

Using the task analysis together with video and photographic records of the work the pumping operation, lifting vacuum plate and securing clamps operation were selected for postural analysis. These operations would only be carried out once to make the equipment ready for use.

The lifting operation score was 10, the pumping and securing clamps operations both scored eight which meant that, using the REBA action criteria, for all three operations, action was ‘necessary soon’.

Lifting vacuum plate into place																																					
	<table border="0"> <tr> <td>2+1</td> <td></td> <td></td> <td>1</td> </tr> <tr> <td>2+1</td> <td>8</td> <td>5</td> <td>2</td> </tr> <tr> <td>2</td> <td>1</td> <td>1</td> <td>1+1</td> </tr> <tr> <td></td> <td>9</td> <td>6</td> <td></td> </tr> <tr> <td></td> <td></td> <td>10</td> <td></td> </tr> <tr> <td></td> <td></td> <td>0</td> <td></td> </tr> <tr> <td>REBA Score</td> <td></td> <td>10</td> <td></td> </tr> <tr> <td colspan="4">Risk Level = Very High</td> </tr> <tr> <td colspan="4"><i>Action – Necessary Soon</i></td> </tr> </table>	2+1			1	2+1	8	5	2	2	1	1	1+1		9	6				10				0		REBA Score		10		Risk Level = Very High				<i>Action – Necessary Soon</i>			
2+1			1																																		
2+1	8	5	2																																		
2	1	1	1+1																																		
	9	6																																			
		10																																			
		0																																			
REBA Score		10																																			
Risk Level = Very High																																					
<i>Action – Necessary Soon</i>																																					

Securing clamps to vacuum tube																																					
	<table border="0"> <tr> <td>1</td> <td></td> <td></td> <td>4</td> </tr> <tr> <td>1</td> <td>4</td> <td>7</td> <td>1</td> </tr> <tr> <td>2</td> <td>0</td> <td>1</td> <td>1+1</td> </tr> <tr> <td></td> <td>4</td> <td>8</td> <td></td> </tr> <tr> <td></td> <td></td> <td>8</td> <td></td> </tr> <tr> <td></td> <td></td> <td>0</td> <td></td> </tr> <tr> <td>REBA Score</td> <td></td> <td>8</td> <td></td> </tr> <tr> <td colspan="4">Risk Level = High</td> </tr> <tr> <td colspan="4"><i>Action – Necessary Soon</i></td> </tr> </table>	1			4	1	4	7	1	2	0	1	1+1		4	8				8				0		REBA Score		8		Risk Level = High				<i>Action – Necessary Soon</i>			
1			4																																		
1	4	7	1																																		
2	0	1	1+1																																		
	4	8																																			
		8																																			
		0																																			
REBA Score		8																																			
Risk Level = High																																					
<i>Action – Necessary Soon</i>																																					


## 4.6 Manual Kerb Laying – City Centre

For this site visit the operations were being carried out on a road bridge deck, over a railway line, in a busy city centre. All of the work was being carried out manually with no scissor clamps or vacuum lifters being used. The men were required to work bent over for longer than usual because it was on top of a bridge deck, and steel pins to hold the setting out line could not be used. Therefore the workers needed to spend more time in a bent position making sure the kerbs were correctly positioned both

horizontally and vertically. The work was being carried out in fairly high summer temperatures which required an early start. The temperature also affected the length of time available to install the kerbs before the concrete bedding material hardened. This put pressure on the workers to install the kerbs before this happened. The main installer said that part of the work required the installation of large bus stop kerbs. They had tried to install these by hand (because the rates applied for installation were attractive) but eventually succumbed to the weight of the materials and used mechanical means for installation. They also said that they were aware of a kerb lifter with wheels that had been developed by a fellow worker.

### 4.6.1 Task Analysis


A task analysis identified six sub tasks which were broken down into a further 21 tasks. Within those 21 tasks, the risks identified included the hammering down of the kerb; shovelling of wet concrete; dust inhalation;

Operation – Manual kerb laying																																					
Task	REBA Rating																																				
Lifting kerb into place																																					
	<table style="margin-left: auto; margin-right: auto;"> <tr> <td style="background-color: cyan;">2</td> <td></td> <td></td> <td style="background-color: cyan;">1</td> </tr> <tr> <td style="background-color: cyan;">4+1</td> <td style="background-color: cyan;">9</td> <td style="background-color: cyan;">5</td> <td style="background-color: cyan;">2</td> </tr> <tr> <td style="background-color: cyan;">2</td> <td style="background-color: yellow;">2</td> <td style="background-color: yellow;">3</td> <td style="background-color: cyan;">1+1</td> </tr> <tr> <td></td> <td style="background-color: green;">11</td> <td style="background-color: green;">8</td> <td></td> </tr> <tr> <td></td> <td></td> <td style="background-color: green;">12</td> <td></td> </tr> <tr> <td></td> <td></td> <td style="background-color: yellow;">1</td> <td></td> </tr> <tr> <td><b>REBA Score</b></td> <td colspan="2" style="background-color: blue;">13</td> <td></td> </tr> <tr> <td colspan="4"><b>Risk Level = Very High</b></td> </tr> <tr> <td colspan="4"><i>Action – Necessary Now</i></td> </tr> </table>	2			1	4+1	9	5	2	2	2	3	1+1		11	8				12				1		<b>REBA Score</b>	13			<b>Risk Level = Very High</b>				<i>Action – Necessary Now</i>			
2			1																																		
4+1	9	5	2																																		
2	2	3	1+1																																		
	11	8																																			
		12																																			
		1																																			
<b>REBA Score</b>	13																																				
<b>Risk Level = Very High</b>																																					
<i>Action – Necessary Now</i>																																					


kerbs falling on to feet; posture when crouching down to carry out the work; and manual handling of the concrete kerbs.

## 4.6.2 Postural analysis

Using the task analysis together with video and photographic records of the work, the manual handling of the kerb, tapping a kerb down into place and shovelling of concrete operations were selected for postural analysis.

Hammering kerb to level																																					
	<table border="0"> <tr> <td>2+1</td> <td></td> <td></td> <td>2</td> </tr> <tr> <td>4</td> <td>9</td> <td>6</td> <td>2</td> </tr> <tr> <td>1+1</td> <td>1</td> <td>0</td> <td>2</td> </tr> <tr> <td></td> <td>1</td> <td>6</td> <td></td> </tr> <tr> <td></td> <td>0</td> <td>11</td> <td></td> </tr> <tr> <td></td> <td></td> <td>1</td> <td></td> </tr> <tr> <td>REBA Score</td> <td></td> <td>12</td> <td></td> </tr> <tr> <td colspan="4">Risk Level = Very High</td> </tr> <tr> <td colspan="4"><i>Action – Necessary Now</i></td> </tr> </table>	2+1			2	4	9	6	2	1+1	1	0	2		1	6			0	11				1		REBA Score		12		Risk Level = Very High				<i>Action – Necessary Now</i>			
	2+1			2																																	
4	9	6	2																																		
1+1	1	0	2																																		
	1	6																																			
	0	11																																			
		1																																			
REBA Score		12																																			
Risk Level = Very High																																					
<i>Action – Necessary Now</i>																																					

The manual handling operation score was 13, the hammering and shovelling operations both scored 12 which meant that, using the REBA action criteria, for the all three operations, action was 'necessary now'.

Shovelling concrete bed																																					
	<table border="0"> <tr> <td>2+1</td> <td></td> <td></td> <td>1+1</td> </tr> <tr> <td>4</td> <td>9</td> <td>4</td> <td>1</td> </tr> <tr> <td>1+1</td> <td>1</td> <td>0</td> <td>1</td> </tr> <tr> <td></td> <td>10</td> <td>4</td> <td></td> </tr> <tr> <td></td> <td></td> <td>11</td> <td></td> </tr> <tr> <td></td> <td></td> <td>1</td> <td></td> </tr> <tr> <td>REBA Score</td> <td></td> <td>12</td> <td></td> </tr> <tr> <td colspan="4">Risk Level = Very High</td> </tr> <tr> <td colspan="4"><i>Action – Necessary Now</i></td> </tr> </table>	2+1			1+1	4	9	4	1	1+1	1	0	1		10	4				11				1		REBA Score		12		Risk Level = Very High				<i>Action – Necessary Now</i>			
	2+1			1+1																																	
4	9	4	1																																		
1+1	1	0	1																																		
	10	4																																			
		11																																			
		1																																			
REBA Score		12																																			
Risk Level = Very High																																					
<i>Action – Necessary Now</i>																																					

---

---

## **4.7 Manual Handling of Kerbs - Footpath Widening**


These works were required for widening of the footpath along a rural road. The kerbs were lined up ready for installation on arrival of the researcher and the men said that they had done this with the use of a kerb lifter, taking the kerbs from stacks laid out along the line by a machine. They proceeded to demonstrate this operation with a kerb lifter held by both of the men which attached to the ends of the kerb. The kerb lifter had been made in-house. A concrete lorry arrived and the bedding concrete was placed. The kerbs were being installed in a trench by the side of the road surface and so the men straddled the kerb and lowered it down to the finished position. The main installer said that he found it easier laying the kerbs to laying the back edges of the footpath. He said that he would kneel in front of the kerb to hammer it into position and use kneepads to protect his knees while doing this. He also complained that the batch of kerbs being used were warped making it difficult to butt the kerbs up against each other. The men said that they "pretty much just do kerbs".


### **4.7.1 Task analysis**

The task analysis identified six sub tasks which were broken down into a further 20 tasks (for the full analysis see appendix 10.1). Within those 20 tasks, the risks identified included the hammering of steel pins and hammering down of the kerb; shovelling of wet concrete; kerbs falling on to feet; posture when crouching down to carry out the work; and manual handling of the concrete kerbs.

## 4.7.2 Postural analysis


Using the task analysis together with video and photographic records of the work, the manual handling of the kerb, tapping a kerb down into place and shovelling of concrete operations were selected for postural analysis.

Operation - Increase footpath width																																					
Task	REBA Rating																																				
Shovelling concrete for haunching																																					
	<table border="0"> <tr> <td>4</td> <td></td> <td></td> <td>3</td> </tr> <tr> <td>2</td> <td>5</td> <td>5</td> <td>2</td> </tr> <tr> <td>1</td> <td>0</td> <td>1</td> <td>1+1</td> </tr> <tr> <td></td> <td>5</td> <td>6</td> <td></td> </tr> <tr> <td></td> <td></td> <td>7</td> <td></td> </tr> <tr> <td></td> <td></td> <td>0</td> <td></td> </tr> <tr> <td>REBA Score</td> <td></td> <td>7</td> <td></td> </tr> <tr> <td colspan="4">Risk Level = Medium</td> </tr> <tr> <td colspan="4"><i>Action - Necessary</i></td> </tr> </table>	4			3	2	5	5	2	1	0	1	1+1		5	6				7				0		REBA Score		7		Risk Level = Medium				<i>Action - Necessary</i>			
4			3																																		
2	5	5	2																																		
1	0	1	1+1																																		
	5	6																																			
		7																																			
		0																																			
REBA Score		7																																			
Risk Level = Medium																																					
<i>Action - Necessary</i>																																					

Lifting kerb into place																																					
	<table border="0"> <tr> <td>4</td> <td></td> <td></td> <td>3</td> </tr> <tr> <td>1</td> <td>6</td> <td>4</td> <td>2</td> </tr> <tr> <td>2+1</td> <td>2</td> <td>2</td> <td>1</td> </tr> <tr> <td></td> <td>8</td> <td>6</td> <td></td> </tr> <tr> <td></td> <td></td> <td>10</td> <td></td> </tr> <tr> <td></td> <td></td> <td>0</td> <td></td> </tr> <tr> <td>REBA Score</td> <td></td> <td>10</td> <td></td> </tr> <tr> <td colspan="4">Risk Level = High</td> </tr> <tr> <td colspan="4"><i>Action - Necessary Soon</i></td> </tr> </table>	4			3	1	6	4	2	2+1	2	2	1		8	6				10				0		REBA Score		10		Risk Level = High				<i>Action - Necessary Soon</i>			
4			3																																		
1	6	4	2																																		
2+1	2	2	1																																		
	8	6																																			
		10																																			
		0																																			
REBA Score		10																																			
Risk Level = High																																					
<i>Action - Necessary Soon</i>																																					

The manual handling operation score was 10, the hammering and shovelling operations scored five and seven respectively which meant that, using the REBA action criteria, for the manual handling operation,

remedial action was 'necessary soon' and for the other two operations, action was 'necessary'.

Tapping kerb to level																													
	<table border="0"> <tr> <td style="background-color: cyan;">3</td> <td></td> <td></td> <td style="background-color: cyan;">2</td> </tr> <tr> <td style="background-color: cyan;">1</td> <td style="background-color: cyan;">5</td> <td style="background-color: cyan;">2</td> <td style="background-color: cyan;">1</td> </tr> <tr> <td style="background-color: cyan;">1+2</td> <td style="background-color: yellow;">0</td> <td style="background-color: yellow;">1</td> <td style="background-color: cyan;">1+1</td> </tr> <tr> <td></td> <td style="background-color: green;">5</td> <td style="background-color: green;">3</td> <td></td> </tr> <tr> <td></td> <td></td> <td style="background-color: green;">4</td> <td></td> </tr> <tr> <td></td> <td></td> <td style="background-color: yellow;">1</td> <td></td> </tr> <tr> <td></td> <td></td> <td style="background-color: blue;">5</td> <td></td> </tr> </table> <p>REBA Score</p> <p>Risk Level = Medium</p> <p><i>Action – Necessary</i></p>	3			2	1	5	2	1	1+2	0	1	1+1		5	3				4				1				5	
3			2																										
1	5	2	1																										
1+2	0	1	1+1																										
	5	3																											
		4																											
		1																											
		5																											

#### 4.8 Use of Scissor Clamps – Housing Estate

A housing estate was visited where kerbs were being installed using pairs of scissor clamps. In this case, the concrete kerbs were not being laid on to wet concrete but, instead, a dropped ledge had been cast on to the edge of the concrete road slab onto which a layer of dry sand-cement mix was placed and the kerbs were placed on to this. However, the kerbs had previously been laid out by hand along the line ready to be installed. Once in place, the kerbs were tapped down slightly with the head of a pickaxe to achieve the correct level. A string line was used to achieve this level but the line was supported on spare kerbs rather than the usual steel pins. Kerb installation was the predominant occupation of the two men. As a team, they performed the task well aided by the fact that they were of similar height. As both of the men were short in stature, this meant they were not required to bend over as much when installing the kerbs.




## 4.8.1 Task analysis


The task analysis identified five sub tasks which were broken down into a further 24 tasks. Within those 24 tasks, the risks identified included the hammering of steel pins and hammering down of the kerb; shovelling of dry mix concrete; kerbs falling on to feet; and manual handling of the concrete kerbs.


## 4.8.2 Postural analysis

Using the task analysis together with video and photographic records of the work, the lifting of the kerb, tapping a kerb down into place and shovelling of concrete operations were selected for postural analysis. The lifting operation score was six, the hammering and shovelling operations scored seven and four respectively which meant that, using the REBA action criteria, for the lifting, shovelling and tapping down a kerb into place, remedial action was 'necessary'.

Operation - kerbs laid on housing estate																																					
Task	REBA Rating																																				
Shovelling sand / cement bed																																					
	<table border="0"> <tr> <td>2</td> <td></td> <td></td> <td>2</td> </tr> <tr> <td>1</td> <td>3</td> <td>4</td> <td>2</td> </tr> <tr> <td>1+1</td> <td>0</td> <td>1</td> <td>2+1</td> </tr> <tr> <td></td> <td>3</td> <td>5</td> <td></td> </tr> <tr> <td></td> <td></td> <td>4</td> <td></td> </tr> <tr> <td></td> <td></td> <td>0</td> <td></td> </tr> <tr> <td>REBA Score</td> <td></td> <td>4</td> <td></td> </tr> <tr> <td colspan="4">Risk Level = Medium</td> </tr> <tr> <td colspan="4"><i>Action - Necessary</i></td> </tr> </table>	2			2	1	3	4	2	1+1	0	1	2+1		3	5				4				0		REBA Score		4		Risk Level = Medium				<i>Action - Necessary</i>			
2			2																																		
1	3	4	2																																		
1+1	0	1	2+1																																		
	3	5																																			
		4																																			
		0																																			
REBA Score		4																																			
Risk Level = Medium																																					
<i>Action - Necessary</i>																																					



Lifting kerb into place																													
	<table border="0"> <tr> <td>3</td> <td></td> <td></td> <td>1+1</td> </tr> <tr> <td>1</td> <td>4</td> <td>1</td> <td>1</td> </tr> <tr> <td>2</td> <td>2</td> <td>0</td> <td>1</td> </tr> <tr> <td></td> <td>6</td> <td>1</td> <td></td> </tr> <tr> <td></td> <td>6</td> <td></td> <td></td> </tr> <tr> <td></td> <td>0</td> <td></td> <td></td> </tr> <tr> <td>REBA Score</td> <td>6</td> <td></td> <td></td> </tr> </table> <p>Risk Level = Medium</p> <p>Action - Necessary</p>	3			1+1	1	4	1	1	2	2	0	1		6	1			6				0			REBA Score	6		
	3			1+1																									
1	4	1	1																										
2	2	0	1																										
	6	1																											
	6																												
	0																												
REBA Score	6																												


Tapping kerb to level																													
	<table border="0"> <tr> <td>1+1</td> <td></td> <td></td> <td>1</td> </tr> <tr> <td>3+1</td> <td>6</td> <td>1</td> <td>2</td> </tr> <tr> <td>2</td> <td>1</td> <td>0</td> <td>1</td> </tr> <tr> <td></td> <td>7</td> <td>1</td> <td></td> </tr> <tr> <td></td> <td>7</td> <td></td> <td></td> </tr> <tr> <td></td> <td>0</td> <td></td> <td></td> </tr> <tr> <td>REBA Score</td> <td>7</td> <td></td> <td></td> </tr> </table> <p>Risk Level = Negligible</p> <p>Action - Necessary</p>	1+1			1	3+1	6	1	2	2	1	0	1		7	1			7				0			REBA Score	7		
	1+1			1																									
3+1	6	1	2																										
2	1	0	1																										
	7	1																											
	7																												
	0																												
REBA Score	7																												

## 4.9 Slip Forming - Motorway Dublin

At the time of the research it was not possible to find any slip forming of kerbs in the United Kingdom. The nearest work of this type that could be found was in Dublin, Ireland. A site visit was organised to observe slip forming of concrete kerb on a road linking to the M50 motorway just outside of Dublin. During the visit, a 65m length of kerb was laid 300mm high and 200mm wide. The work was carried out by a gang of three men with one of the men operating the slip forming machine, one of the men regulating the concrete going into the machine and a third man checking

the finished surface of the slip formed kerb. They said that it was possible to do 300m of kerb in a single day and, if necessary, 700m of kerb a day with a gang of seven men. The cold joint had to be formed at the beginning of a run and another formed at the end of the run. Expansion joints were cut into the slip formed kerb on the day after casting.

The engineer puts steel pins along the side of the road every 10m which were levelled to allow a guide wire to be attached. Hydraulic rams and tracts react to the senses touching the guide wire to enable the kerb to be cast correctly. The levelling plate on the machine was vibrated to achieve a smooth finish on the slip formed kerb. The plate had to be raised when the machine passed road gullies. The kerb was cast in one complete section with no additional haunching or bedding concrete necessary.

Operation – Slip forming machine support tasks																																					
Task	REBA Rating																																				
Clear hopper with shovel																																					
	<table border="0"> <tr> <td>1+1</td> <td></td> <td></td> <td>3</td> </tr> <tr> <td>1+1</td> <td>3</td> <td>4</td> <td>1</td> </tr> <tr> <td>1</td> <td>0</td> <td>1</td> <td>1+1</td> </tr> <tr> <td></td> <td>3</td> <td>5</td> <td></td> </tr> <tr> <td></td> <td></td> <td>4</td> <td></td> </tr> <tr> <td></td> <td></td> <td>0</td> <td></td> </tr> <tr> <td>REBA Score</td> <td>4</td> <td></td> <td></td> </tr> <tr> <td colspan="4">Risk Level = Medium</td> </tr> <tr> <td colspan="4"><i>Action – Necessary</i></td> </tr> </table>	1+1			3	1+1	3	4	1	1	0	1	1+1		3	5				4				0		REBA Score	4			Risk Level = Medium				<i>Action – Necessary</i>			
1+1			3																																		
1+1	3	4	1																																		
1	0	1	1+1																																		
	3	5																																			
		4																																			
		0																																			
REBA Score	4																																				
Risk Level = Medium																																					
<i>Action – Necessary</i>																																					


### 4.9.1 Task analysis


The task analysis identified five sub tasks which were broken down into a further 17 tasks (for the full analysis see appendix 10.1). Within those 17 tasks, the risks identified included the hammering of steel pins; shovelling

of concrete with arms raised; bent posture while trowelling kerbs; and manual handling the concrete chute.

### 4.9.2 Postural analysis

Using the task analysis together with video and photographic records of the work, the machine driving, finishing kerb profile and use of shovel operations were selected for postural analysis.

Operating machine																													
	<table border="0"> <tr> <td>1</td> <td></td> <td></td> <td>1</td> </tr> <tr> <td>2</td> <td>1</td> <td></td> <td>1</td> </tr> <tr> <td>1</td> <td>0</td> <td></td> <td>0</td> </tr> <tr> <td></td> <td>1</td> <td></td> <td>1</td> </tr> <tr> <td></td> <td></td> <td>1</td> <td></td> </tr> <tr> <td></td> <td></td> <td>1</td> <td></td> </tr> <tr> <td></td> <td></td> <td>2</td> <td></td> </tr> </table> <p>REBA Score</p> <p>Risk Level = Low</p> <p>Action – May Be Necessary</p>	1			1	2	1		1	1	0		0		1		1			1				1				2	
1			1																										
2	1		1																										
1	0		0																										
	1		1																										
		1																											
		1																											
		2																											


Finishing kerb profile																													
	<table border="0"> <tr> <td>4</td> <td></td> <td></td> <td>2</td> </tr> <tr> <td>2</td> <td>6</td> <td></td> <td>3</td> </tr> <tr> <td>1+1</td> <td>0</td> <td></td> <td>0</td> </tr> <tr> <td></td> <td>6</td> <td></td> <td>3</td> </tr> <tr> <td></td> <td></td> <td>6</td> <td></td> </tr> <tr> <td></td> <td></td> <td>0</td> <td></td> </tr> <tr> <td></td> <td></td> <td>6</td> <td></td> </tr> </table> <p>REBA Score</p> <p>Risk Level = Medium</p> <p>Action – Necessary</p>	4			2	2	6		3	1+1	0		0		6		3			6				0				6	
4			2																										
2	6		3																										
1+1	0		0																										
	6		3																										
		6																											
		0																											
		6																											

The finishing operation score was 6, the shovelling and driving operations scored four and two respectively which meant that, using the REBA action

criteria, for the finishing and shovelling operations, remedial action was 'necessary' and for the driving operation, action 'may be necessary'.

## 4.10 Kerb Race Installation - Housing Estate

A second housing estate was visited which used a different system to the previously visited estate. On the first housing estate the road was concrete with a step down at its edge left for the installation of a concrete kerb. On this estate the road was asphalt and a kerb-race was installed along the edge of the proposed road prior to asphaltting and used as a guide or shutter. The work being carried out during the site visit was the installation of steel pins and shutters to enable the kerb race to be cast. For the installation work, the shutters were positioned along the approximate line of the kerb race, adjusted to the correct position by hand, and then secured into place using steel pins hammered into the stone sub base of the road.


Operation - Kerb Race Installation																																														
Task	REBA Rating																																													
Hammering in steel pins																																														
	<table border="0"> <tr> <td>2+1</td> <td></td> <td></td> <td></td> <td>1</td> </tr> <tr> <td>4</td> <td>6</td> <td></td> <td>1</td> <td>2</td> </tr> <tr> <td>1</td> <td>1</td> <td></td> <td>0</td> <td>1</td> </tr> <tr> <td></td> <td>7</td> <td></td> <td>1</td> <td></td> </tr> <tr> <td></td> <td></td> <td>7</td> <td></td> <td></td> </tr> <tr> <td></td> <td></td> <td>1</td> <td></td> <td></td> </tr> <tr> <td>REBA Score</td> <td colspan="4">8</td> </tr> <tr> <td>Risk Level = High</td> <td colspan="4"></td> </tr> <tr> <td>Action - Necessary Soon</td> <td colspan="4"></td> </tr> </table>	2+1				1	4	6		1	2	1	1		0	1		7		1				7					1			REBA Score	8				Risk Level = High					Action - Necessary Soon				
2+1				1																																										
4	6		1	2																																										
1	1		0	1																																										
	7		1																																											
		7																																												
		1																																												
REBA Score	8																																													
Risk Level = High																																														
Action - Necessary Soon																																														

As the work was at ground level it required the men to spend most of their time in a bent position. Removal of the shutters following casting of

the kerb race was not observed but again this would require the men to be bent over for most of the operation.

### 4.10.1 Task analysis


A task analysis identified risks that included hammering steel pins to secure steel forms; positioning the steel forms by hand; and lifting the steel forms to the location where they were to be fixed (for the full analysis see appendix 10.1).

Positioning steel forms																																	
	<table border="1"> <tr> <td>2+1</td> <td></td> <td></td> <td>1</td> </tr> <tr> <td>4+1</td> <td>9</td> <td></td> <td>2</td> </tr> <tr> <td>1+2+</td> <td>1</td> <td></td> <td>1</td> </tr> <tr> <td>1</td> <td></td> <td></td> <td></td> </tr> <tr> <td></td> <td>10</td> <td></td> <td></td> </tr> <tr> <td></td> <td></td> <td>10</td> <td></td> </tr> <tr> <td></td> <td></td> <td>1</td> <td></td> </tr> <tr> <td>REBA Score</td> <td></td> <td>11</td> <td></td> </tr> </table>	2+1			1	4+1	9		2	1+2+	1		1	1					10					10				1		REBA Score		11	
	2+1			1																													
4+1	9		2																														
1+2+	1		1																														
1																																	
	10																																
		10																															
		1																															
REBA Score		11																															
	<p>Risk Level = High</p> <p><i>Action -Necessary Soon</i></p>																																

### 4.10.2 Postural analysis

Using the task analysis together with video and photographic records of the work, the positioning of the steel forms, and the lifting and hammering operations were selected for postural analysis. The positioning operation score was ten, and the hammering and lifting operations scored eight and seven respectively which meant that, using the REBA action criteria, for the positioning and hammering operations,

action was 'necessary soon' and for the lifting operation, action was 'necessary'.

Lifting steel forms				
	1+1			2+1
	2+1	5	3	1
2	1	1	1	1
	6	4		
		7		
		0		
		7		
	Risk Level = Medium			
	<i>Action – Necessary</i>			

#### 4.11 Vacuum Lifter Operation – Rural Road

This work was being carried out in a rural setting where the kerbs were being replaced on both sides of the existing road. The first operation was the delivery of stacks of kerbs, bound with nylon bands and wrapped in polythene, which were lifted off the lorry and onto timber pallets with a mechanical hiab grab attached to the lorry. The timber pallets were provided by the contractor and were essential so that the loader shovel excavator could carry the kerb lifter and a pallet of kerbs. The workers had to manually handle the timber pallets into place to receive the stacks of kerbs. One lane of the road was closed to enable the loader shovel excavator to move between the store of kerbs and the kerb laying activities. This was also required so that the bedding concrete could be laid into the trench adjacent to the edge of the road to receive the kerbs. Once the concrete had been laid and the height adjusted with a shovel in readiness for the kerbs to be laid, pallets of kerbs were placed at intervals

---

---

along the road as required. An element of work was removed from that day as it was possible to install the steel pins and string line the previous day. Normally, in a more populated area, this would have been carried out on the same day to prevent repeating the work due to vandalism.

The kerb installation was a three-man operation with one man driving the excavator, one man operating the vacuum lifter and the third man tapping down the kerbs to level. To begin the work the plastic wrapping was removed from the block of kerbs and the binding straps cut to free the kerbs. The vacuum pack was pushed onto the kerbs by the operator's foot to enable a secure connection. It was then lifted off the block and placed on to the concrete up to the line and then tapped down to level with a large rubber mallet.

The machine used to install the kerbs was an Al-Vac vacuum lifter and had been purchased by the council after reservations arising from trials had been dealt with and also because it had been difficult to get a rival Probst machine on hire for further trials. The Al-Vac machine had to be moved after the installation of every other kerb and was also difficult to use on inclined roads (the men said that they had to "fight against it to move the kerbs"). The men also preferred the Probst machine because the boom extended further. They knew of a kerb layer who had laid 700m of kerbs in a day but usually does 500m (at £1.70/m) whilst they usually do 200m a day when on a bonus.


Noise levels were measured by the Council during the site visit. This was because the machine was driven by a diesel engine whereas the previous one had a petrol engine. The noise levels were in excess of 90 dB. Readings were also taken by the side of the concrete lorry and the results were in excess of 100 dB. The council policy was to use protection when workers were exposed to levels over 90 dB for daily exposure.



The foam pad on the lifter vacuum head tended to wear quickly due to the vacuum connection having to be manually broken by the operator pulling it off the kerb. One pack of kerbs was the wrong way round on the forks because of a damaged pallet. At one point the string line broke because it had been caught by the vacuum lifting head several times. The operator of the vacuum lifters said that he used his foot to push the vacuum head on to the kerb to make sure the vacuum took. He also needed to pull the vacuum head off the kerbs once laid because the vacuum was still there. He found the controls on the vacuum lifter easy to use and said that he had no aches or pains at the end of the day when using it.

#### 4.11.1 Task analysis


The task analysis identified six sub tasks which were broken down into a further 25 tasks (for the full analysis see appendix 10.1). Within those 25 tasks, the risks identified included the hammering of steel pins and hammering down of the kerb; shovelling of wet concrete; and kerbs falling on to feet.


Operation – Kerb Installation With Vacuum Lifter																																					
Task	REBA Rating																																				
Shovelling concrete to level bed																																					
	<table style="border-collapse: collapse; margin-left: 20px;"> <tr> <td style="background-color: cyan; padding: 2px;">3</td> <td></td> <td></td> <td style="background-color: cyan; padding: 2px;">1+2</td> </tr> <tr> <td style="background-color: cyan; padding: 2px;">1+1</td> <td style="background-color: cyan; padding: 2px;">4</td> <td style="background-color: cyan; padding: 2px;">5</td> <td style="background-color: cyan; padding: 2px;">2</td> </tr> <tr> <td style="background-color: cyan; padding: 2px;">1</td> <td style="background-color: yellow; padding: 2px;">0</td> <td style="background-color: yellow; padding: 2px;">1</td> <td style="background-color: cyan; padding: 2px;">1+1</td> </tr> <tr> <td></td> <td style="background-color: green; padding: 2px;">4</td> <td style="background-color: green; padding: 2px;">6</td> <td></td> </tr> <tr> <td></td> <td></td> <td style="background-color: green; padding: 2px;">6</td> <td></td> </tr> <tr> <td></td> <td></td> <td style="background-color: yellow; padding: 2px;">1</td> <td></td> </tr> <tr> <td>REBA Score</td> <td colspan="3" style="background-color: lightblue; padding: 2px;">7</td> </tr> <tr> <td>Risk Level = Medium</td> <td colspan="3"></td> </tr> <tr> <td><i>Action – Necessary</i></td> <td colspan="3"></td> </tr> </table>	3			1+2	1+1	4	5	2	1	0	1	1+1		4	6				6				1		REBA Score	7			Risk Level = Medium				<i>Action – Necessary</i>			
3			1+2																																		
1+1	4	5	2																																		
1	0	1	1+1																																		
	4	6																																			
		6																																			
		1																																			
REBA Score	7																																				
Risk Level = Medium																																					
<i>Action – Necessary</i>																																					



## 4.11.2 Postural analysis

Using the task analysis together with video and photographic records of the work, the lifting of the kerb, tapping a kerb down into place, and shovelling of concrete operations were selected for postural analysis.

Lifting Kerb into place																																					
	<table border="0"> <tr> <td>1</td> <td></td> <td></td> <td>1</td> </tr> <tr> <td>1</td> <td>2</td> <td>1</td> <td>2</td> </tr> <tr> <td>2</td> <td>0</td> <td>0</td> <td>1</td> </tr> <tr> <td></td> <td>2</td> <td>1</td> <td></td> </tr> <tr> <td></td> <td></td> <td>1</td> <td></td> </tr> <tr> <td></td> <td></td> <td>0</td> <td></td> </tr> <tr> <td>REBA Score</td> <td></td> <td>1</td> <td></td> </tr> <tr> <td>Risk Level = Negligible</td> <td colspan="3"></td> </tr> <tr> <td>Action -None Necessary</td> <td colspan="3"></td> </tr> </table>	1			1	1	2	1	2	2	0	0	1		2	1				1				0		REBA Score		1		Risk Level = Negligible				Action -None Necessary			
1			1																																		
1	2	1	2																																		
2	0	0	1																																		
	2	1																																			
		1																																			
		0																																			
REBA Score		1																																			
Risk Level = Negligible																																					
Action -None Necessary																																					

Tapping kerb to level																																					
	<table border="0"> <tr> <td>3</td> <td></td> <td></td> <td>1</td> </tr> <tr> <td>1</td> <td>2</td> <td>3</td> <td>2</td> </tr> <tr> <td>1</td> <td>0</td> <td>1</td> <td>2+1</td> </tr> <tr> <td></td> <td>2</td> <td>4</td> <td></td> </tr> <tr> <td></td> <td></td> <td>3</td> <td></td> </tr> <tr> <td></td> <td></td> <td>0</td> <td></td> </tr> <tr> <td></td> <td></td> <td>3</td> <td></td> </tr> <tr> <td>Risk Level = Very Low</td> <td colspan="3"></td> </tr> <tr> <td>Action - May Be Necessary</td> <td colspan="3"></td> </tr> </table>	3			1	1	2	3	2	1	0	1	2+1		2	4				3				0				3		Risk Level = Very Low				Action - May Be Necessary			
3			1																																		
1	2	3	2																																		
1	0	1	2+1																																		
	2	4																																			
		3																																			
		0																																			
		3																																			
Risk Level = Very Low																																					
Action - May Be Necessary																																					

The shovelling operation score was seven, the tapping and lifting operations scored three and one respectively which meant that, using the

---

---

REBA action criteria, for the shovelling operation, action was 'necessary'; for the tapping operation, action may be necessary, and for the lifting operation, there was 'none necessary'.

## 4.12 Equipment Demonstrations

The annual Site Equipment Demonstrations (SED) national exhibition was attended in order to see what vacuum lifting equipment and other mechanical means of kerb installation was being promoted in the construction industry.



Figure 9 Probst Vacuum Lifter

There were live demonstrations for both of the main vacuum lifters (Probst from Germany, Figure 9 and Al-Vac from Denmark, Figure 10). The two manufacturers had several different lifting devices and, as they had a company colour (yellow for Probst and blue for Al-vac), it was easy to identify which companies' devices were being used when visiting construction sites. The designer of the Al-Vac equipment was present at

---

---

their live demonstration and available to answer questions. He said that he had developed the equipment for a contractor who had been asking for a solution to manual handling in his organisation. He also explained the basic details of how the vacuum equipment worked as it was being demonstrated.



Figure 10 Al-Vac Vacuum lifter

The Probst equipment was mounted on a tele-handler and demonstrated by an operative to lift kerbs from a pallet and place them in a line along the ground. The operative would then return the kerbs to the pallet and start the process once again. The operation appeared very easy and fluid during transit from the pallet to the line of kerbs along the ground. However, the handles of the equipment were very close to the vacuum head and which meant that the operator's hands would then be only about two to 300 mm from the ground. This meant that although the equipment took the weight of the kerb the operative still had to adopt an out-of-neutral posture to install every kerb in the line.

---

---

By comparison, the Al-Vac equipment was positioned on the ground, not on a machine, and the demonstration showed kerbs being lifted off a stack and placed around the area where the operator stood. This machine had a handlebar arrangement which was pivoted at the base of the vacuum tube allowing the kerb to be placed on the ground without the operator bending over.



Figure 11 Probst Vacuum lifter with extended tube

A smaller exhibition, although more specific to road works, was organised by the Civil Engineering Contractors Association in combination with a contractor working on a road construction project. In addition to equipment on show from the two vacuum lifter companies, there was an hydraulic clamp device, Figure 12, which could be attached to a mini digger to pick up and place concrete kerbs. There was a live demonstration of this equipment in order to show its versatility.



Figure 12 Hydraulic clamp kerb lifter

The Probst Company had a vacuum lifter on display and demonstrating its versatility in manoeuvring kerbs from pallet to ground. The vacuum lifter device now had an extended tube, Figure 11, installed between the vacuum head and the vacuum tube to enable kerbs to be placed onto the ground or lower without the operator having to bend over. They demonstrated a two-man manual vacuum lifter which could be used to pick up and move paving slabs. There was also an additional head for their mechanical vacuum lifter which was able to pick up curved concrete channels, Figure 13.

The Al-Vac company were demonstrating their latest arrangement of the vacuum lifting equipment. The equipment was located on an aluminium trailer rather than on the forks of a tele-handler or loader shovel excavator. They were demonstrating the use of an attachment that could pick up and move paving slabs, Figure 14.

---

---

The vacuum head had a pivot arrangement enabling slabs to be removed from a vertical position, as stored on the timber pallet, and placed onto the ground in a horizontal position.



Figure 13 Probst curved vacuum head



Figure 14 Al-Vac pivot head

---

---

## 4.13 Summary

This chapter has provided details of observation fieldwork carried out to investigate the kerb installation operations. The work detailed included the installation of British Standard concrete highway kerbs by hand, with the use of manually-handled scissor clamps, and with the aid of mechanical vacuum lifters supported on the forks of a tele-handler or loader shovel excavator. It was not possible within the timeframe of the research to observe installation of any alternative (lightweight/recycled materials) kerb units. Details have also been included of observations of slip formed concrete kerb installation and the installation of a kerb-race used to support the edge of asphalt housing estate roads.

For each of these operations detailed descriptions have been given together with the results of postural analysis of sub tasks of the operations most likely to present a risk of injury or ill-health to the operatives. Photographs of all the sub tasks analysed in this way have been included alongside the postural analysis calculations. Necessary response for each of the sub tasks was identified and stated.

The final section of this chapter presented details of the construction equipment demonstrations visited during the course of the research. This showed the range of equipment becoming available to the industry as well as some of the adaptations of the equipment to meet the needs of the users as the equipment becomes more widely used.

Details of results from the safety meetings, interviews, focus groups/expert panels and kerbs forums can be found in chapter five which cover the text analysis obtained from all of these events. Discussion of the results from this chapter and chapter five can be found in chapter six and the final conclusions are presented in chapter eight.

---

---

## **5 RESULTS (TEXT ANALYSIS)**

### **5.1 Introduction**

This chapter contains details of the analysis of text obtained from the safety meetings, interviews, focus groups and kerbs forums only. The results from the observation fieldwork carried out during the site visits can be found in chapter four. The text data was collected from the various interviews and focus groups etc over the full length of the research.

In the body of this chapter the results of the text analysis are displayed in graphical and text form. In both cases they are accompanied by examples of the actual comments made by the stakeholders during the research. Details of the methods used for the text analysis are included within this chapter at the beginning of the graphical presentation of the full text analysis.

The final section of this chapter provides details of the exercises that were conducted with the attendees of the three focus groups which concentrate on the three topics: the lifting equipment being used for kerb installation; the effect of design on the use of kerbs for roads; and the training of operatives involved with kerb installation work. The sections immediately following this introduction provide details of the safety meetings, interviews, focus groups and kerb forums; together with the way in which the data was obtained.

#### **5.1.1 Safety Meetings**

The researcher used health and safety contacts to obtain details of health and safety meetings in the local area. These meetings ranged from County Health and Safety Risk Management Groups to a health and safety group



---

---

covering five County Councils and a construction safety association covering the whole of the Midlands. Attendance at these meetings was used to publicise research, obtain details of other meetings, obtain contacts for interview, and gain invitations to visit other appropriate work sites.

The researcher attended these meetings as an invited guest and was able to present details about the research before taking part in open discussion related to the research. This enabled the researcher to collect the views of a number of safety professionals regarding kerb installation issues.

### **5.1.2 Interviews**

The building up of contacts was a progressive process over the course of the research. Existing industry contacts suggested health and safety meetings to attend at which further contacts were made and other safety meetings suggested. A number of interviews were conducted over the telephone either from the researcher making contact with an interviewee known to have specialist information or interviewees contacting the researcher following publicity of the research. In addition, hosts at sites visited would be questioned regarding the construction work and fellow attendees at safety meetings would elicit further information.

Notes taken from all of these interviews have been included in the text analysis.

### **5.1.3 Focus groups**

In order to obtain a larger pool of data for analysis three, focus groups were organised with three separate themes: manufacture, design, and training. For each of these focus groups, the relevant industry professionals/experts were contacted to partake in the discussion which

---

---

was led by the researcher asking prepared questions. Audio recordings were taken of the three focus groups and the researcher transcribed the recordings after the meetings.

### **5.1.4 Kerbs forums**

As a result of the Health and Safety Executive's (HSE) targeting of the manual handling of concrete kerbs, sections of the construction industry involved in work around the UK requested that the HSE adopt a consistent approach to their enforcement. This resulted in the HSE organising the first kerbs forum in London in December 2003. Deadlines were set at this forum for the cessation of the manual handling of concrete kerbs in new works and for the cessation of manual handling of concrete kerbs in remedial works. These deadlines were publicised in the construction industry media and the HSE also wrote to all of the local authorities informing them of the outcomes from the first forum. Two further forums were held in London: the second forum was in July 2004 to check on progress on the deadlines set in the first forum and the third forum was in 2008 and covered the installation of kerbs and slabs after which a working group was set up and met in 2009. The data from the forums consisted of notes taken while attending the events which have been used in the text analysis.

## **5.2 Analysis of Text**

A coding system was produced to enable sorting of the comments made in the meetings, interviews, forums and focus groups. Every salient comment was extracted from the text and relevant criteria identified. The comments were reduced to a single line of text for inclusion in a table, as

shown in Table 19, and for each line of text the key player, category discussed, and whether the comment was positive/innovative or negative/conservative. A reference number was constructed from these three attributes e.g. a positive comment made referring to a contractor and a financial matter would be given the code 30202. A further identifier was used to indicate the source of the comment. The focus groups were referenced A1-A3, interviews from site visits B1, telephone interviews B2, comments from meetings B3 and comments from the forums C1-C4. Therefore if the above example regarding the positive comments made referring to a contractor in the financial matter was taken from the second focus group the complete reference would be 30202A2.

Focus Group 1	Designer	Manuf.	Contractor	Trainer	Client/LA	HSE	Other	Cultural	Financial	Legal	Technical	Organisational	Innovate	Conservative	Ref.
text			x						x					x	No.

Table 19 Showing an extract from the text analysis table

Each of the datasets (focus groups, forums, and interviews) was coded separately and then all of the information was combined before the data was sorted by reference number. The coding of the text data allowed the data to be sorted. The sorting of the data is represented in the text data figures. These identify the categories most frequently commented on for each key player i.e. Figure 16 shows that 'technical issues' was the most commented on category for manufacturers. The text data figures also show the proportion of comments that were either 'innovative' or

'conservative' in nature i.e. comments related to contractors as shown in Figure 17 on the whole were negative. The more frequent comments were then examined more closely to identify related topics such as "designers' lack of site awareness."

Ref.	People	Setting	Role of participants
A1	8	Focus Group	Manufacturers, Contractors, Government Representatives, Health and Safety Professionals
A2	10	Focus Group	Designers, Clients, Contractors, Manufacturers, Health and Safety Professionals
A3	6	Focus Group	Trainers, Contractors, Health and Safety Professionals
B1	23	Visits	Clients, Contractors, Manufacturers, Designers, Health and Safety Professionals
B2	36	Interviews	Manufacturers, Contractors, Government Representatives, Designers, Clients, Health and Safety Professionals.
B3	56	Safety Meetings	Mostly Health and Safety Professionals representing Local Authorities and Contractors
C1	29	Industry Forum	Cross section of industry invited by HSE
C2	50+	Industry Forum	Cross section of industry invited by HSE
C3	40+	Industry Forum	Cross section of industry invited by HSE

Table 20 Referencing of research groupings and make up of participants in groups

---

---

## 5.2.1 Designer

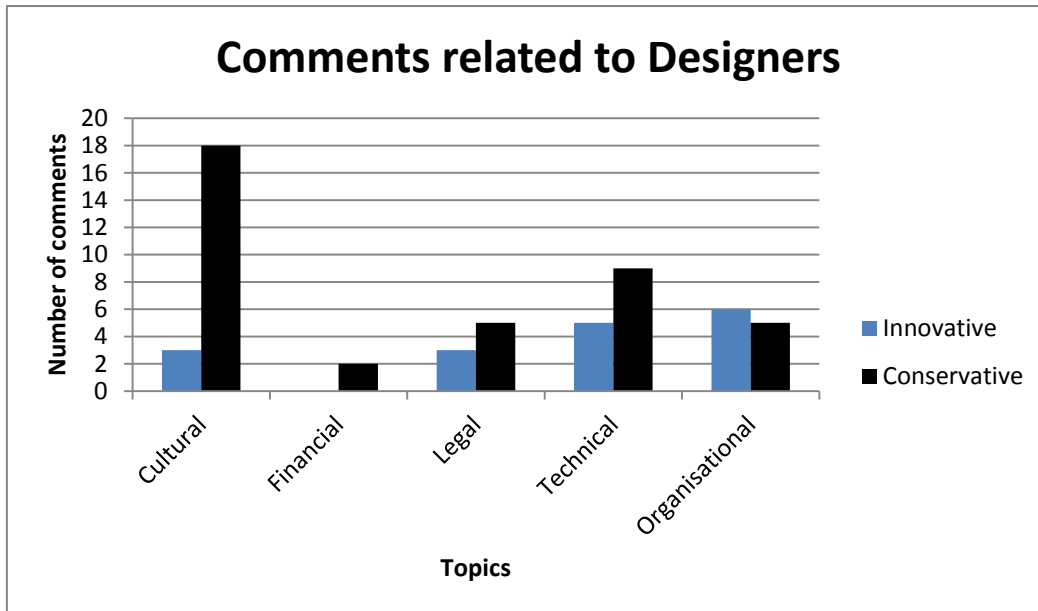


Figure 15 Comments Related to Designers

It can be seen from Figure 15 that the majority of comments were related to culture, the way that designers do things, aspects of the designer's work. These comments can be broadly divided into three categories: the designer's lack of practical site experience and awareness of site practices; the fact that designers affected by public response are more likely to choose safe specifications; and that they are more interested in their own work than the work of others more concerned with aesthetics than the ability to build and the practicalities of construction. A selection of the coded quotes is shown in the list below.

*"Designers operate in isolation from other processes in construction" - A2*

*"Designers don't think about how the traffic is to be managed" - A2*

*"Local authorities design choices open to public criticism" - A2*

---

---

"Designers/specifiers are bright people with no reference to the real world" - A2

"There is a lack of interest from designers in safe handling" - C3

"Designers need to get out on site to see what is happening" - B2

## 5.2.2 Manufacturer

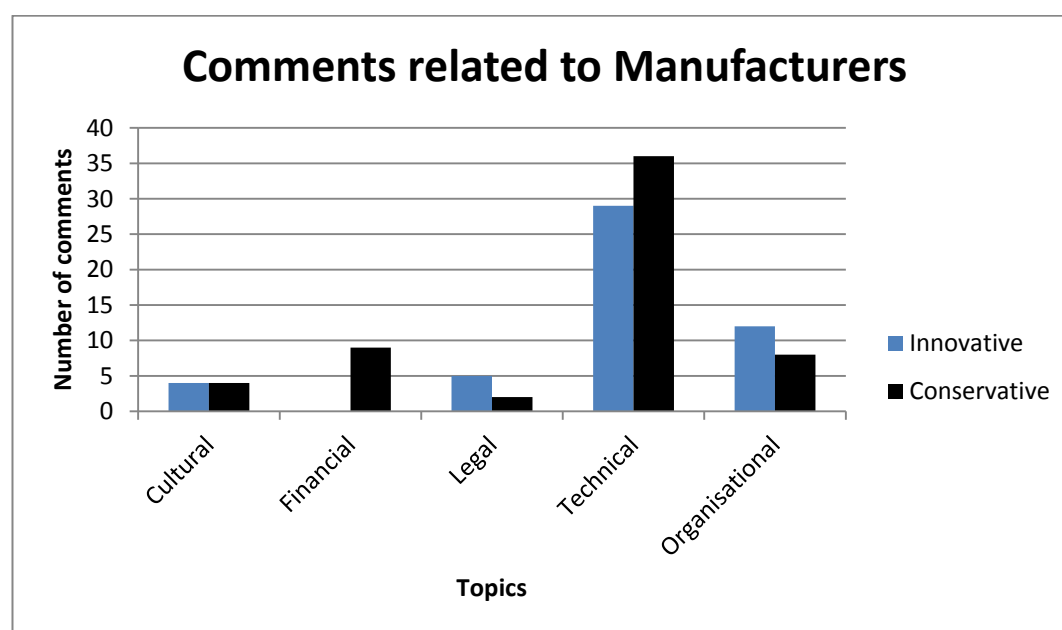


Figure 16 Comments Related to Manufacturers

Most of the comments that were related to the manufacturer concerned technical matters as can be seen in Figure 16. There were a large number of both negative and positive comments under this category and the term manufacturer covered manufacturers of concrete kerbs (and alternative products) as well as manufacturers of lifting equipment. The positive comments were mainly for lifting equipment manufacturers who were producing innovations to assist with the installation of concrete kerbs. Kerb manufacturers were praised for introducing some shorter kerbs as

---

---

well as drain/kerb units. Negative comments for kerb manufacturers related to resistance to change from the existing, perceived better, specification to un-tried and un-tested alternatives. Negative comments for vacuum lifters again related to resistance to change with the comments on failings in the performance of the vacuum lifters.

*"Plastic kerbs can be cut without producing dust" - A2*

*"Vacuum lifters can be adapted to lay kerbs below operators feet" - A2*

*"Kerb/drain units - drainage holes used for handholds" - A2*

*"Vacuum company have made equipment for lifting stone, slabs etc" - A2*

*"Probst modified machine so that hands don't go below knees" - B2*

*"Kerb/drains not British standard not tested for impact" - A1*

*"Vacuum lifter needed moving after every two kerbs" - B1*

### **5.2.3 Contractor**

For the contractor, there were a large number of negative comments in four of the five key areas as shown in Figure 17. Under the cultural topic there appeared to be three themes: workers more likely to manually handle due to a macho culture in the construction industry; back injuries so common that it appears to be inevitable; and there is a resistance to change from manual handling to mechanical means of lifting kerbs.

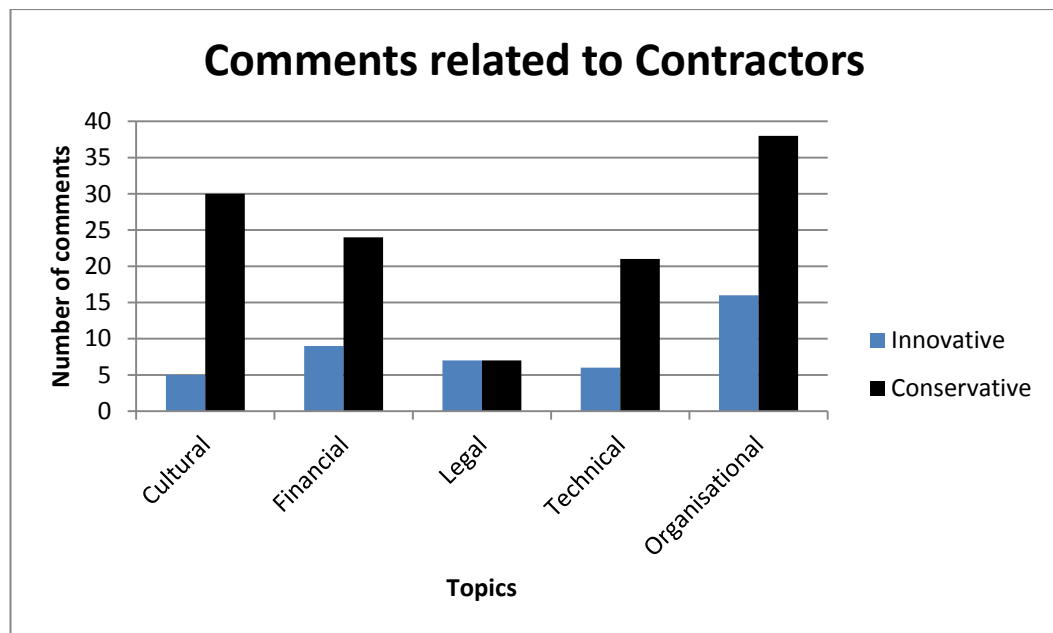


Figure 17 Comments Related to Contractors

*“Any mechanical failure and the men will revert to manual installation” - A2*

*“Most people leaving the industry knackered have laid kerbs” - A2*

*“Guys on site want to lay by hand not use a machine” - A2*

*“The workers are uneasy when you introduce something new” - A2*

*“When someone injures their knee/back/shoulder it’s just bad luck” - A3*

*“Manual handling is manly, you guys get the tea I’ll lay the last six kerbs” - A3*

Under the financial topic the overwhelming opinion is that mechanical installation of kerbs is less efficient and would therefore cost contractors money. Mechanical handling devices are seen as expensive and, if bought, contractors would probably choose the cheapest. The financial implications of pricing for work is evident with contractors asking for a level playing field, i.e. they will only consider mechanical handling if everyone has to consider it.



---

---

*"We can lay 600m by hand but only 300m by machine" - A2*

*"Difficult to follow guidelines when others price for manual installation" - A2*

*"Contractors will price for manual handling and risk an HSE fine" - A2*

*"Lifting machines would slow him down and cost him money" - B1*

*"Lifting equipment was not used as men didn't want to lose bonuses" - B1*

*"Contractors want a level playing field when pricing for work" - C1*

*"Mechanical systems are expensive especially for maintenance work" - C3*

*"Still need a level playing field regarding pricing" - C3*

Under technical matters there were no strong themes and topics seem to be divided between negative comments regarding the current manual handling method of installing kerbs and negative comments regarding alternative methods of installing kerbs. It was noted that the success of innovative equipment manufactured abroad depended on the similarities to the tasks in both countries.

*"Technology transfer suffers using German equipment on English roads" - A2*

*"Needs to get close to kerb because of intricacy of laying" - B1*

*"Hammering down of kerbs similar to HAVS problem" - B1*

*"Disc cutter used to cut kerbs to size" - B1*

*"The installer used kneepads because he had to kneel" - B1*

*"Lifting equipment trialled kept dropping kerbs" - B2*

*"When slip form is damaged have to cut out section" - B2*

---

---

The organisational comments were also largely negative covering areas regarding the organisation of the work (difficulties with stringing out, management of live traffic and getting access for lifting equipment) and the organisation of the workforce (problems related to training, difficulties with adequate supervision and not being able to provide rotation of work tasks).

*"Limited room for vacuum lifters on live carriageways" - A2*

*"Laying by hand is easy because you don't need so much room" - A2*

*"Problems refurbishing existing highways with live traffic" - A2*

*"Health doesn't appear to be considered in kerb installation training" - A3*

*"The construction industry are missing their training target by miles" - A3*

*"Supervision = 30 seconds; ready supply of materials; and left alone" - A3*

*"Supervisors think about rotation, look at the workforce and forget it" - A3*

*"In addition to laying kerbs the men did ground work including drainage" - B1*

## **5.2.4 Trainer**

Most of the comments related to the trainer, as shown in Figure 18, came under the heading of organisational and were balanced between those that were negative and those that were positive. The positive comments related to some of the good things that were being done within the training programmes.

*"Shock tactics useful if not overdone" - A3*

*"One company put everybody up to district manager through the courses" - A3*

---

---

*“In-house training aided selection of workers to suit the task” – B2*

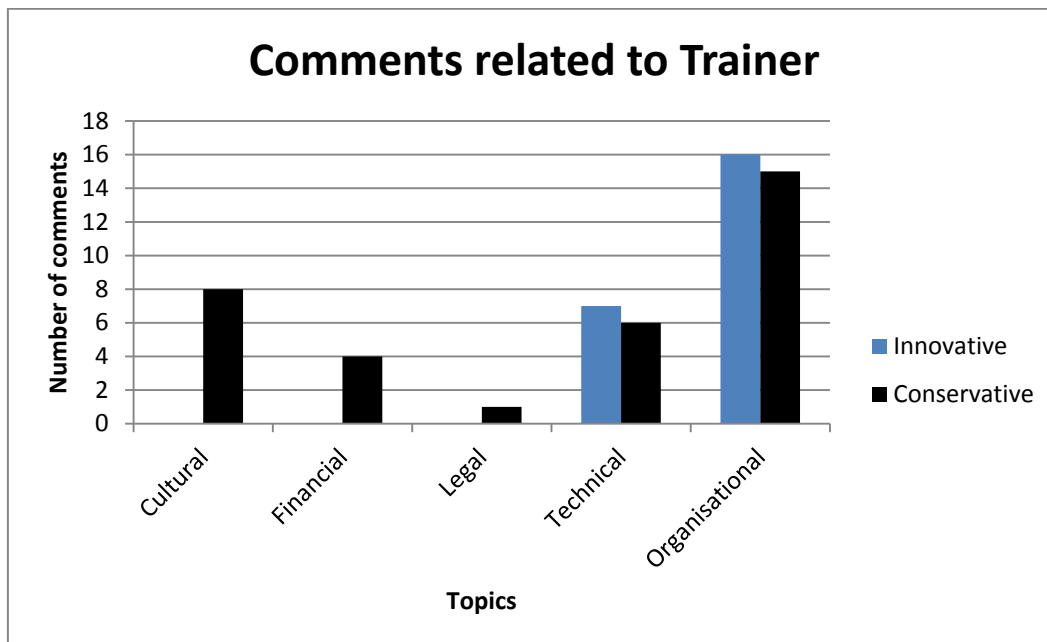


Figure 18 Comments Related to Trainer

The negative comments, however, referred to the restrictions placed on training that make the training less effective.

*“You train them in a controlled environment they go on site and it's gone” – A3*

*“Hammering and shovelling operations not mentioned on course” – A3*

*“Main contractors trained and subcontractors actually do the work” – B2*

## 5.2.5 Client

The bulk of comments for clients/local authority, as shown in Figure 19, were under the organisation and the technical headings. The main theme identified under the technical heading was that councils see themselves as

---

---

special cases. These were usually London councils referring to the use of heritage kerbs.

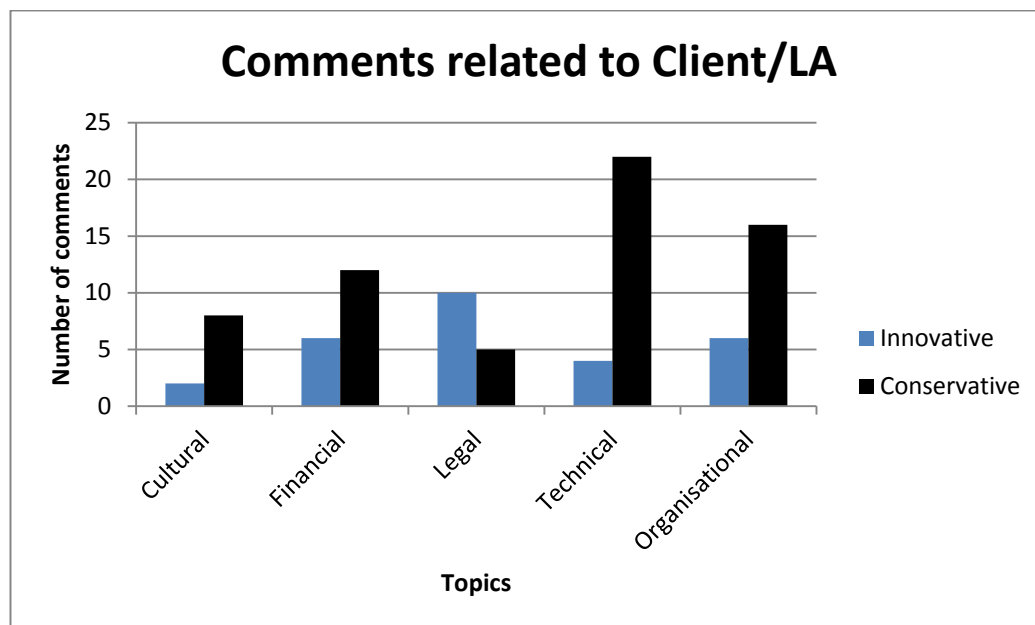


Figure 19 Comments Related to Client/LA

*“Council worried that lifters not suitable for traditional textured kerbs” - C2*

*“Council asked for permission to "walk" the kerbs rather than lifting” - C2*

*“Council asked for permission to continue using tongs” - C2*

*“London councils argue for special case - granite kerbs and congestion” - C2*

*“Certain conurbations have different needs from others i.e. London” - C3*

The organisational issues referred to the way the concrete kerbs were stored in council depots in such a way that extra manual handling was required.

*“Council storage depot had no lifting equipment for kerbs” - B1*

---

---

---

*“Fork lift taken close to Council storage stack then kerbs manually handled” – B1*

*“Storage of different kerbs increased M/H due to bad access for forklift” – B1*

*“Kerb layers lift own kerbs when collecting from storage” – B1*

## 5.2.6 Health and Safety Executive

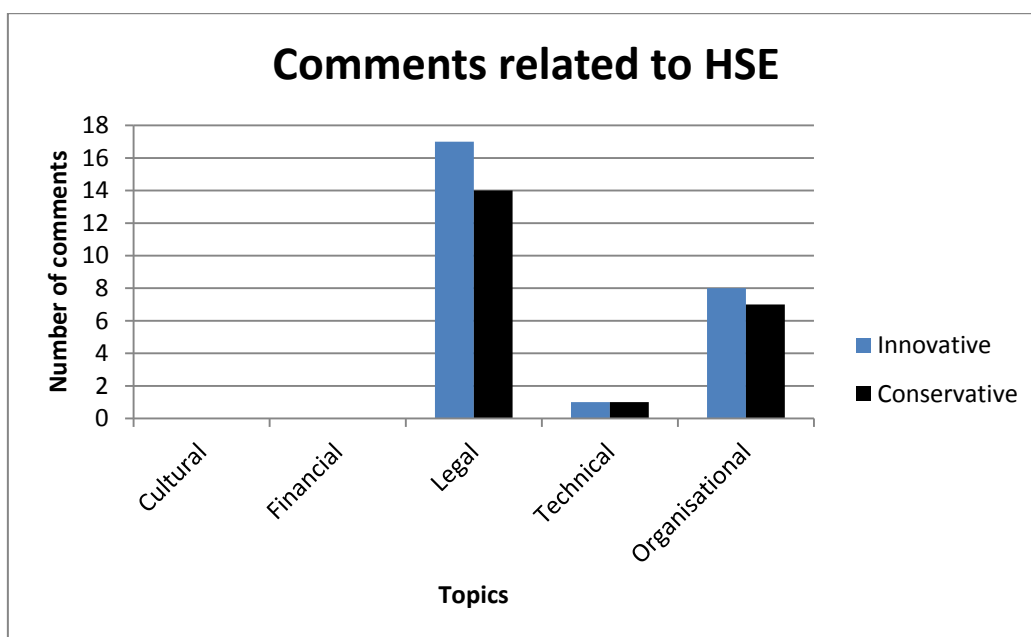


Figure 20 Comments Related to HSE

For the Health and Safety Executive (HSE) the bulk of the comments understandably came under the legal section, as shown in Figure 20. There was a fairly even spread between positive and negative comments. For the positive comments people saw the HSE action (enforcement) as the main driver behind the raised awareness of the issue. However, the negative comments criticised the HSE for inconsistencies during enforcement leading to uncertainties in the industry and the need for industry agreed deadlines for any changes.

“HSE enforcement initially drove change to cherry pickers then costs” - A2

“It is being enforced where people have got nothing” - A2

“HSE not just picking on contractors as everyone has a role to play” - A2

“HSE expecting contractors to move away from manual handling” - B3

“HSE want a move from majority laid by hand to laid mechanically” - C1

“Contractors are asking when to use mechanical/when manual handling” - A2

“The advice you get from the HSE is not consistent” - A3

“HSE using prohibition orders but varies across country” - B2

“HSE state that there is potential for inconsistencies in enforcement” - C2

“Kerbs forum deadlines produced by HSE were illegal” - C3

## 5.2.7 Culture

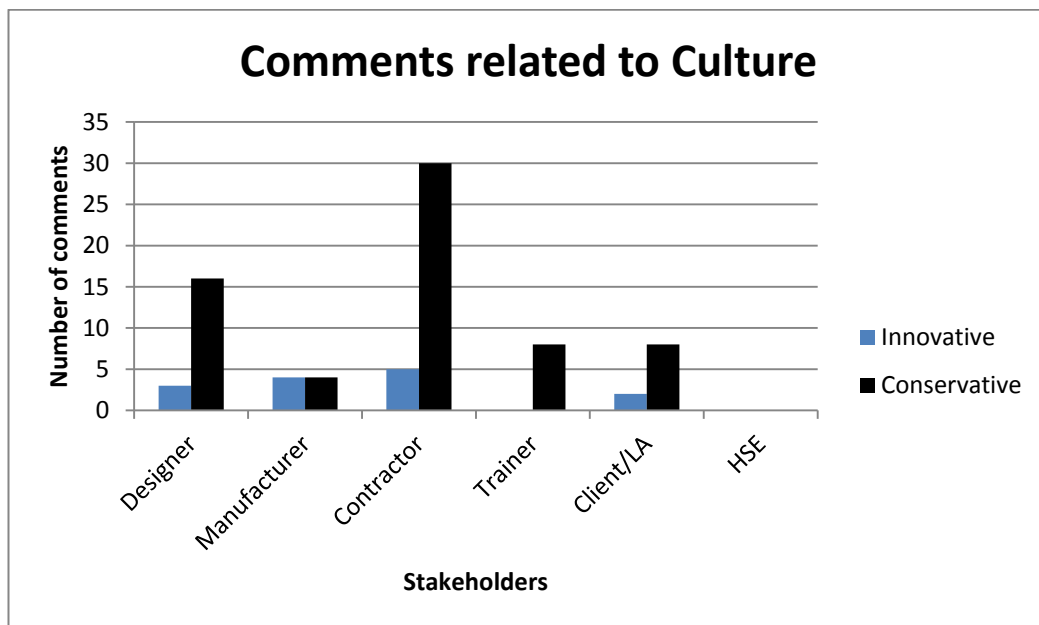


Figure 21 Comments Related to Culture

---

---

When talking about culture, designers and contractors received the most comments and these were predominantly negative (see Figure 21). As mentioned previously when looking into the designer comments, they can be broadly divided into three categories: the designer's lack of practical site experience and awareness of site practices; the fact that designers are affected by public response and are more likely to choose safe specifications; and they are more interested in their own work than the work of others so they are more concerned with things like appearance and aesthetics than the ability to build and the practicalities of construction.

*"Designers operate in isolation from other processes in construction" - A2*

*"Designers don't think about how the traffic is to be managed" - A2*

*"Local authorities design choices open to public criticism" - A2*

*"Designers/specifiers are bright people with no reference to the real world" - A2*

*"There is a lack of interest from designers in safe handling" - C3*

*"Designers need to get out on site to see what is happening" - B2*

For the contractor there appeared to be three themes: workers are more likely to manually handle due to a macho culture in the construction industry; back injuries are so common that it appears to be inevitable; and there is a resistance to change from manual handling to mechanical means of lifting kerbs.

*"Any mechanical failure and the men will revert to manual installation" - A2*

*"Most people leaving the industry knackered have laid kerbs" - A2*

*"Guys on site want to lay by hand not use a machine" - A2*

*"The workers are uneasy when you introduce something new" - A2*

---

*“When someone injures their knee/back/shoulder it’s just bad luck” – A3*

*“Manual handling is manly, you guys get the tea I’ll lay the last six kerbs” – A3*

## 5.2.8 Finances

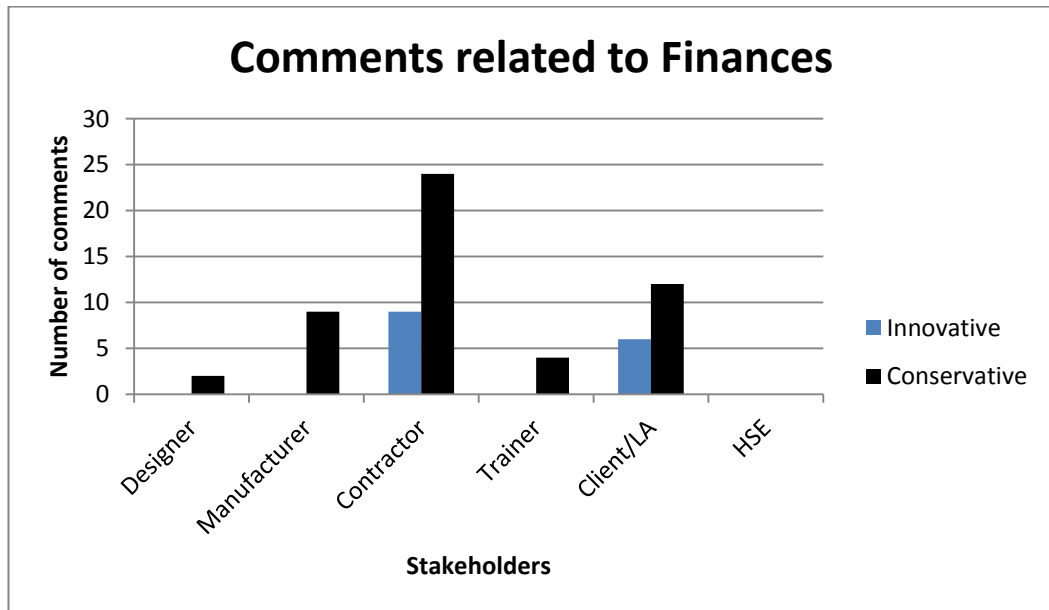


Figure 22 Comments Related to Finances

Approximately three quarters of the comments relating to finances, see Figure 22, were negative and approximately three quarters of all of the comments related to the contractor and client stakeholders.

For the contractor, the overwhelming opinion was that mechanical installation of kerbs is less efficient and would therefore cost them more money. Mechanical handling devices were seen as expensive and if they did buy them the contractors would probably choose the cheapest. The financial implications of pricing for work is evident with contractors asking for a level playing field, ie they will only consider mechanical handling if everyone has to consider it.



---

---

*"We can lay 600m by hand but only 300m by machine" - A2*

*"Difficult to follow guidelines when others price for manual installation" - A2*

*"Contractors will price for manual handling and risk an HSE fine" - A2*

*"Lifting machines would slow him down and cost him money" - B1*

*"Lifting equipment was not used as men didn't want to lose bonuses" - B1*

*"Contractors want a level playing field when pricing for work" - C1*

*"Mechanical systems are expensive especially for maintenance work" - C3*

*"Still need a level playing field regarding pricing" - C3*

For the client, the comments were predominantly negative and referred to the way that the client/local authority organised the pricing of contracts and the way that they used bonuses or the amount of work carried out by those installing kerbs.

*"Local authorities do not like slip form because of their fixed budget" - A1*

*"Local government will still accept the lowest tender" - A2*

*"LAs given set pot of money subcontractors using lifters costs more" - A2*

*"They said they wouldn't use kerb lifters because it slowed them down" - B1*

*"Men tried to lay heavy bus stop kerbs by hand to get bonus" - B1*

*"Knew of man who laid up to 700m. They could do 200m a day on bonus" - B1*

---

---

## 5.2.9 Legislation

There were more positive than negative comments related to legislation (see Figure 23). Approximately 60% of the comments were related to the client and the Health and Safety Executive. For the client, which was usually a local authority, the positive comments were due to the client's response in the first case to legislation and to the outcomes of the forums.

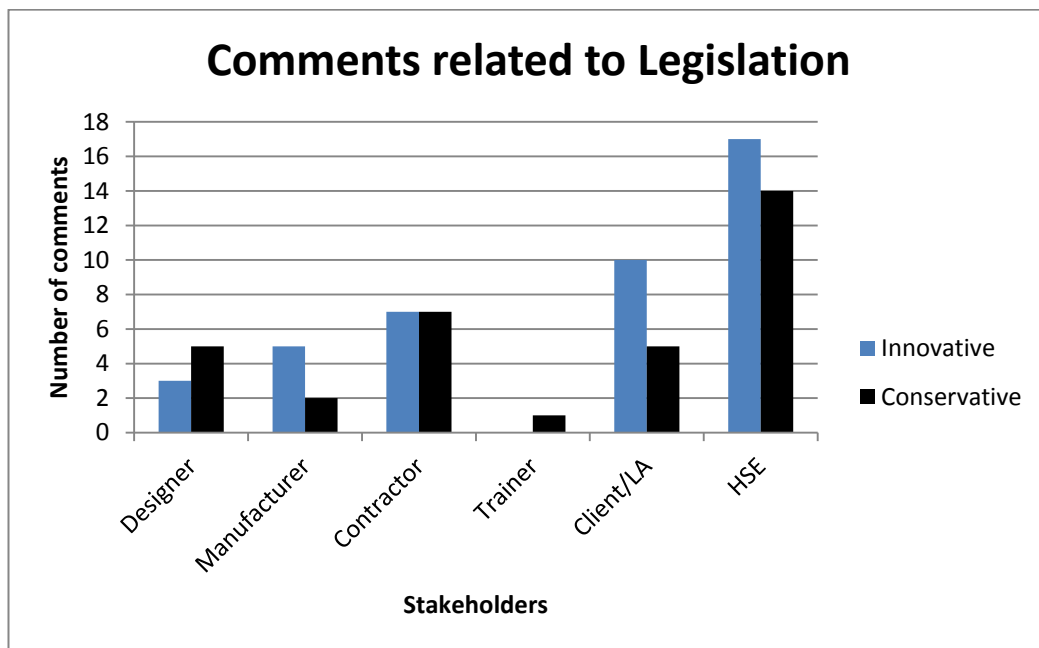


Figure 23 Comments Related to Legislation

*"Council instructing their designers to consider mechanical handling" - B2*

*"Council used smaller length kerbs" - B2*

*"Client told contractor to use kerb lifters" - B2*

*"Council looking to write guidelines after forum deadlines announced" - B2*

*"Many councils replied positively to HSE letter following first forum" - C2*

---

---

*"Clients looking to eliminate kerbs following first forum" - C2*

For the Health and Safety Executive (HSE), as mentioned previously, the bulk of the comments understandably came under the legal section. There was a fairly even spread between positive and negative comments. For the positive comments people saw the HSE action (enforcement) as the main driver behind the raised awareness of the issue, whilst the negative comments criticised the HSE for inconsistencies during enforcement leading to uncertainties in the industry and the need for industry agreed deadlines for any changes.

*"HSE enforcement initially drove change to cherry pickers then costs" - A2*

*"It is being enforced where people have got nothing" - A2*

*"HSE not just picking on contractors as everyone has a role to play" - A2*

*"HSE expecting contractors to move away from manual handling" - B2*

*"HSE want a move from majority laid by hand to laid mechanically" - C1*

*"Contractors are asking when to use mechanical/when manual handling" - A2*

*"The advice you get from the HSE is not consistent" - A3*

*"HSE using prohibition orders but varies across country" - B2*

*"HSE state that there is potential for inconsistencies in enforcement" - C2*

*"Kerbs forum deadlines produced by HSE were illegal" - C3*

## **5.2.10 Technical**

For comments related to technical matters (see Figure 24) there were almost twice as many negative comments as positive comments. Approximately

---

---

half the comments were related to the manufacturer and then there were a sixth of the comments related to the contractor and a sixth related to the client.

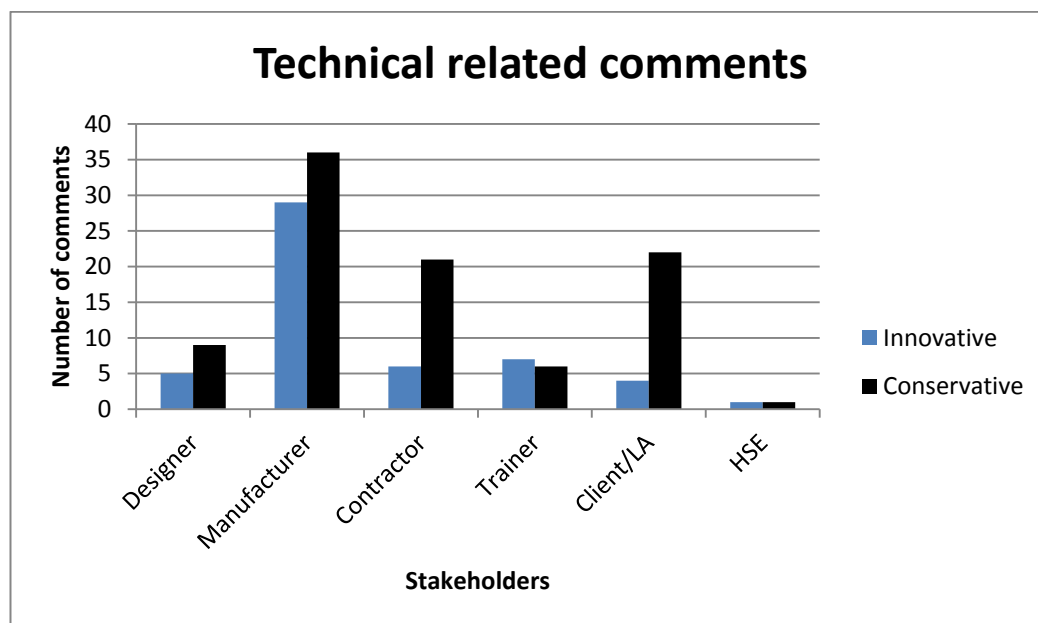


Figure 24 Technical Related Comments

As mentioned previously, there were a large number of both negative and positive comments about the manufacturer under this category, with the term manufacturer covering manufacturers of concrete kerbs (and alternative products) as well as manufacturers of lifting equipment. The positive comments were mainly for lifting equipment manufacturers who were producing innovations to assist with the installation of concrete kerbs. Kerb manufacturers were praised for introducing some shorter kerbs as well as drain/kerb units. Negative comments for kerb manufacturers related to resistance to change from the existing, perceived better specification to un-tried and un-tested alternatives. Negative comments for vacuum lifters again related to resistance to change with the comments on failings in the performance of the vacuum lifters.

---

---

*"Plastic kerbs can be cut without producing dust" - A2*

*"Vacuum lifters can be adapted to lay kerbs below operators feet" - A2*

*"Kerb/drain units - drainage holes used for handholds" - B1*

*"Vacuum company have made equipment for lifting stone, slabs etc" - B1*

*"Probst modified machine so that hands don't go below knees" - B2*

*"Kerb/drains not British Standard - not tested for impact" - A1*

*"Vacuum lifter needed moving after every two kerbs" - B1*

There were no strong themes under technical matters regarding contractors, as mentioned above, and topics seemed to be divided between negative comments regarding the current manual handling method of installing kerbs and those regarding alternative methods of installing kerbs.

*"Technology transfer suffers using German equipment on English roads" - A2*

*"Needs to get close to kerb because of intricacy of laying" - B1*

*"Hammering down of kerbs similar to HAVS problem" - B1*

*"Disc cutter used to cut kerbs to size" - B1*

*"The installer used kneepads because he had to kneel" - B1*

*"Lifting equipment trialled kept dropping kerbs" - B2*

*"When slip-form is damaged have to cut out section" - B2*

The main theme identified under the technical heading regarding the client was that, as previously mentioned, councils see themselves as

---

---

special cases. These were usually London councils and it usually referred to the use of heritage kerbs.

*“Council worried that lifters not suitable for traditional textured kerbs” - C2*

*“Council asked for permission to "walk" the kerbs rather than lifting” - C2*

*“Council asked for permission to continue using tongs” - C2*

*“London councils argue for special case - granite kerbs and congestion” - C2*

*“Certain conurbations have different needs from others ie London” - C3*

## 5.2.11 Organisation

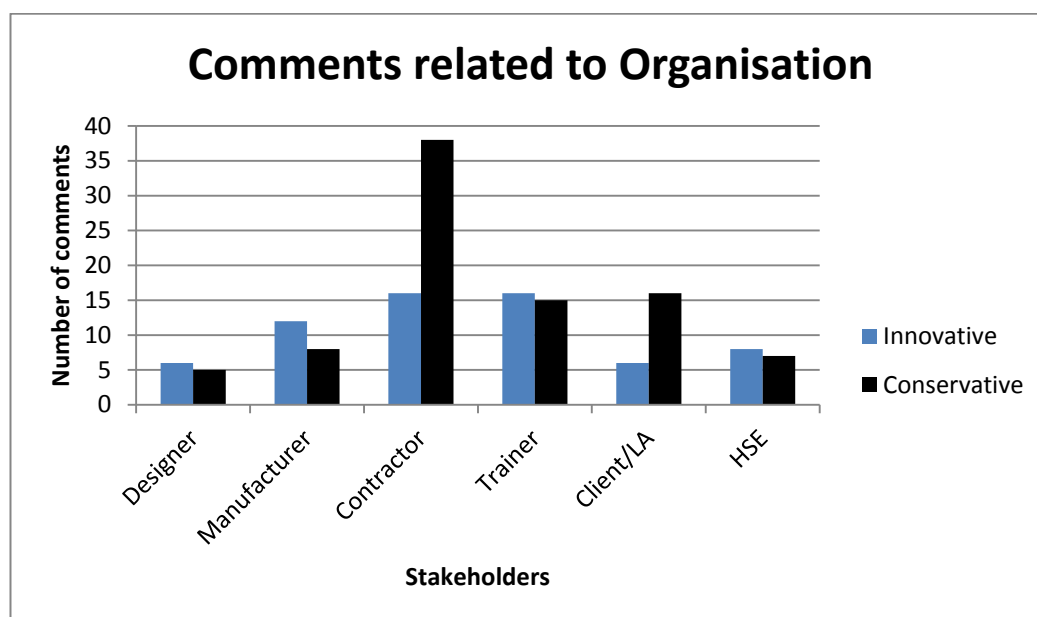


Figure 25 Comments Related to Organisation

For comments related to organisational issues approximately 60% of the comments were negative (see Figure 25). Around one third of the comments were related to the contractor and about 20% of the comments were related to the trainer.

---

---

For the contractor, as mentioned above, the organisational comments were largely negative covering areas regarding the organisation of the work (difficulties with stringing out, management of live traffic and getting access for lifting equipment) and the organisation of the workforce (problems related to training, difficulties with adequate supervision and not being able to provide rotation of work tasks).

*"Limited room for vacuum lifters on live carriageways" - A2*

*"Laying by hand is easy because you don't need so much room" - A2*

*"Problems refurbishing existing highways with live traffic" - A2*

*"Health doesn't appear to be considered in kerb installation training" - A3*

*"The construction industry are missing their training target by miles" - A3*

*"Supervision = 30 seconds; ready supply of materials; and left alone" - A3*

*"Supervisors think about rotation, look at the workforce and forget it" - A3*

*"In addition to laying kerbs the men did ground work including drainage" - B1*

For the trainer, as previously mentioned, the comments were balanced between negative and positive. The positive comments related to some of the good things that were being done within the training programmes.

*"Shock tactics useful if not overdone" - A3*

*"One company put everybody up to district manager through the courses" - A3*

*"In-house training aided selection of workers to suit the task" - B2*

The negative comments referred to the restrictions placed on training that make the training less effective.

---

---

*“You train them in a controlled environment they go on site and it's gone” – A3*

*“Hammering and shovelling operations not mentioned on course” – A3*

*“Main contractors trained and subcontractors actually do the work” – B2*

### **5.3 Distribution of text analysis comments**

The text of the data obtained from safety meetings, interviews, focus groups/expert panels and kerbs forums was analysed and results obtained from coded salient comments from the key stakeholders relating to several categories. The following three tables illustrate the distribution of the comments obtained from the text analysis. Boxes containing higher amounts of comments have darker shading. Following each of the tables there is a brief description of the reasons for the various combinations of key stakeholders and categories.

	Culture	Financial	Legal	Technical	Organisational
Designer	21	2	8	14	11
Manufacturer	8	9	7	65	20
Contractor	35	33	14	27	54
Trainer	8	4	8	13	31
Client/LA	10	18	15	26	22
HSE	0	0	31	2	15



Table 21 Sum of comments for each stakeholder/category

From examining the distribution of comments within the stakeholder/category matrix, as shown in Table 21, it can be seen that large amounts of comments were concentrated under the contractor heading. This is most likely due to the contractor being in the centre of the kerb installation process. Most comments were related to technical matters regarding the manufacturer. This included matters related to the manufacture of concrete kerbs; discussions related to mechanical lifting equipment; and discussion related to a wide variety of alternatives to concrete kerbs. Most of the legal comments referred to the Health and Safety Executive (HSE). Finally, there were many comments related to designers and culture, possibly due to industry interest in the ability of designers to affect health and safety in the construction process and also that industry consultation taking place regarding the revision of the Construction Design and Management (CDM) regulations at the time of the research.

	Culture	Financial	Legal	Technical	Organisational
Designer	3	0	3	5	6
Manufacturer	4	0	5	29	12
Contractor	5	9	7	6	16
Trainer	0	0	0	7	16
Client/LA	2	6	10	4	6
HSE	0	0	17	1	8

Table 22 Sum of positive comments for each stakeholder/category

The largest number of positive comments within the stakeholder/category matrix, see Table 22, were for technical matters related to the manufacturer. This category covered both kerb component manufacture and lifting equipment manufacture. Drain/kerb units were praised for combining two operations into one, being light weight and using recycled materials; plastic kerbs were praised for reducing weight, removing the issue of dust inhalation and using recycled materials; and there were positive comments regarding adaptations to lifting equipment which addressed technical issues raised by contractors.

	Culture	Financial	Legal	Technical	Organisational
Designer	18	2	5	9	5
Manufacturer	4	9	2	36	8
Contractor	30	24	7	21	38
Trainer	8	4	1	6	15
Client/LA	8	12	5	22	16
HSE	0	0	14	1	7

Table 23 Sum of negative comments for each stakeholder/category

Examination of the distribution of comments within the stakeholder/category matrix, as shown in Table 23, shows that many of the negative comments concerned the cultural, financial, technical and

---

---

organisational matters relating to the contractor. In addition, there was a large number of negative comments for technical matters relating to the manufacturer and to the client/LA. The negative comments on the technical category were regarding the resistance of the contractor and client to the products that manufacturers were trying to introduce. Contractors also had a lot of negative comments under the organisational category relating to problems of training, difficulties with adequate supervision and not being able to provide rotation of work tasks; under culture there were comments regarding the macho culture within the construction industry and the perception that back injuries were inevitable; under the financial category the main concern was that contractors were not adopting assistive equipment or materials because of their initial cost without conducting a full financial assessment (including costs for injured workers absences).

## **5.4 Focus Group Questions**

A set of questions was established for each focus group appropriate to the topic under discussion (manufacturing/lifting equipment, design and training). The text data obtained from all of the safety meetings, interviews, kerbs forums and focus groups was sorted for relevance to each of the focus group questions. The findings from this exercise are shown under the question headings below. Details of the composition of the focus groups can be found in section 3.9.7.

---

---

### 5.4.1 Questions prepared for focus group meeting on manufacturing and lifting equipment

FG1 Q1	How have we arrived at using kerbs?
--------	-------------------------------------

Comments relating to the first question in the first focus group indicate that kerbs are used because they have performed well for decades, because they provided an appropriate solution on certain types of roads and, as well as structural performance, they also provided aesthetic properties that meet the needs of certain designers.

*“Concrete kerbs specified because they performed well over 50 years” – A2*

*“Kerbs needed on the narrow roads to the strengthen edges” – A2*

*“Kerbs on minor rural roads used for appearance not necessity” – A2*

FG1 Q2	Can we change kerbs?
--------	----------------------

Most of the discussion was focused on reducing the existing concrete kerb unit to produce a smaller concrete kerb. There was some confusion because manufacturers were saying that they hadn't been asked to produce smaller kerbs while local authorities were saying that they had been using smaller kerbs. However, it was felt that there was a reluctance to manufacture smaller kerbs because of increased production costs and that they were still too heavy to handle and whilst increasing the number of repetitions for the task.

---

---

*"Haven't been asked to make smaller units" - B1*

*"half-sized kerbs are being manufactured" - A1*

*"Manufacture 20 kg kerbs but nobody bought them" - C3*

*"Council annoyed having changed to smaller kerbs now must mechanise" - C2*

*"Council used smaller length kerbs" - B2*

*"Kerb manufacturers had trialled alternative designs" - A1*

*"Smaller kerbs increase costs of production and number of repetitions" - A1*

*"Smaller kerbs still too heavy to handle manually" - A1*

It appeared that kerb sections (thickness of a kerb front to back) have been reduced at some time in the past and some people felt that, although it did not solve the problem of manually handling heavy concrete kerbs, workers would benefit considerably if installing the reduced section kerbs.

*"Reducing kerb sections would help manual handling considerably" - A2*

*"Trainer thought reducing kerbs to 80% thickness would be better" - B2*

*"Using 4 inch kerbs like we did 30 years ago could reduce lifting" - A3*

Another method of managing heavy loads, increasing the load to make it too heavy to handle, was discussed. It was thought that this would lead to an increase in the use of mechanical lifters but it was pointed out that if the kerbs were increased in length some form of reinforcement would be required so that they could be handled without breaking.

---

---

*“Increasing the size of kerbs would increase the use of lifters” - A2*

*“Making kerb products twice the size will help eliminate handling” - C4*

*“Larger kerbs would need reinforcing” - A2*

When discussing some form of alteration to the existing concrete kerb unit, manufacturers were concerned that, by including sockets for lifting, this would expose them to litigation in the event of some form of lifting accident. In contrast it was said that this same practice had been carried out in Germany. The inclusion of handholds was also discussed but it was thought that this would say that manual handling was acceptable and rather there should be labels on the kerbs saying that they should not be handled.

*“German kerbs have holes in them for lifting devices” - A1*

*“Manufacturers are worried about being sued if they install lifting sockets” - A3*

*“Introducing handholds will say manual handling is okay” - A1*

*“Suggested that kerbs carry a label saying not to handle” - C1*

*“Manufacturers need to put weights onto products” C4*

Other comments related to the manufacturer of the concrete kerb units saying that it was difficult to change from the existing concrete kerb specification because of the use of local materials and the inexpensive nature of existing units. Manufacturers could not see sensible alternatives to the dense concrete kerb being used at present. Furthermore, manufacturers stated that they were concerned about making changes that would reduce the robustness of the product but at the same time it was

---

---

stated that concrete kerbs used to be produced with a higher specification than that required in the British Standard; manufacturers had reduced specifications to the level of the British Standard over time.

*“Using local materials meant difficult to change kerb specification”* – B1

*“There are no sensible alternatives to heavy materials”* – C3

*“Difficult to invest in concrete kerb production because product is cheap”* – B1

*“Manufacturers are worried about reducing robustness of product”* – A1

*“Old kerbs were better than the British Standard - new concrete kerbs aren't”* – A2

FG1 Q3	Is there an alternative to concrete kerbs?
--------	--

Although at the advent of the research plastic kerbs have not yet been produced, they were undergoing feasibility studies/testing with manufacturers and were therefore being discussed in the meetings, focus groups and forums. There appeared to be several benefits from using these units as they were environmentally sustainable, did not produce dust when cutting to size and had an obvious reduction in weight. However, the prospective kerb manufacturers were concerned about their ability to introduce this new product into what they perceived was a conservative construction industry.

*“Plastic kerbs are environmentally sustainable (taken back and recycled)”* – A2

---

---

*"Plastic kerbs can be cut without producing dust" - A2*

*"Plastic kerbs manufacturer concerned about conservative industry" - A2*

*"Difficult to get plastic kerbs accepted until they are used" - A2*

*"Plastic kerbs being developed from recycled materials" - B2*

*"Plastic kerbs weighing 11kg are less likely to damage than concrete" - B2*

In contrast to plastic kerbs, kerb/drain units were already being produced and used in the industry, their main benefit being that they combine two operations by using one unit to provide the road edge and roads drainage. Although these units were generally lighter and smaller than the British Standard concrete kerb unit and could be handled more easily by the workers, there were several concerns: they did not appear to be suitable for mass production; and there were some suggestions that they were not robust enough to replace the traditional concrete kerbs in every situation.

*"Kerb/drain units reported as being good to work with" - B1*

*"Kerb/drains require 1 mould per day - not feasible in mass production" - A1*

*"Kerb/drains not British standard not tested for impact" - A1*

*"Kerb/drain units strength questionable compared to concrete" - A2*

With all lightweight products being produced, it was stated that using them only reduced the risks from manually handling rather than eliminating the risks.

*"Using 5 kg kerbs not seen as elimination but lower end of scale" - C3*



---

---

*“Lightweight products do not overcome manual handling issues” - C4*

The question of the robustness of alternatives to the traditional concrete kerb was also raised when discussing kerbs made from asphalt and recycled rubber.

*“Contractor introduced mastic asphalt kerbs and plastic kerbs” - C3*

*“Recycled rubber kerbs heavy and have questionable durability” - A1*

*“Asphalt kerbs have been used but not robust under traffic use” - A2*

Other suggestions for alternatives to the traditional concrete kerb unit were discussed including 1m strips with drainage channels along the edges of roads where space was available and incorporating larger kerbs within the footpaths.

*“New roads have 1m strip and drainage channel instead of kerb” - A2*

*“Benelux/Germany have large kerbs integrated with footpath” - B2*

FG1 Q4	Is lifting equipment the answer?
--------	----------------------------------

There was a lot of discussion regarding lifting equipment, partially due to the fact that the Health and Safety Executive saw this as an alternative to manual handling of concrete kerbs and were saying that contractors should look at a mechanical solution. It was obvious from the discussion

---

---

---

that there was resistance within the industry to moving from a simple, cheap solution to a mechanised, more 'expensive' solution. Comments relating to the equipment itself stated that there were problems with levelling the equipment. This was due to the operatives sometimes having to resist the lateral forces of the suspended concrete kerb when the equipment had not been levelled. Levelling the machine also meant that on inclined surfaces it required moving after installing a few kerbs. The biggest problem at the time was that, if all contractors followed The Health and Safety Executive's guidelines in moving towards a mechanised solution, there were not enough mechanical lifters available for hire or sale to carry out the work.

*"Contractors resisted call for mechanical lifters in the 1990's" - B2*

*"If machine is not level the operator has to 'fight' the machine" - B2*

*"NPK machine difficult to level so the men don't level it" - B2*

*"Vacuum lifter was difficult because lifting over your toes and pulling you" - B1*

*"Vacuum lifter needed moving after every two kerbs" - B1*

*"Not enough equipment for everyone to change to mechanical lifting" - A2*

*"Contractors being asked to use lifters but not many available to hire" - B2*

Those wanting to resist the use of mechanical lifters were quick to point out that there had been instances where kerbs had fallen off the vacuum plates during installation. Some said that use of the equipment was not feasible when installing heritage-type stone kerbs especially in the London boroughs. Manufacturers were quick to point out that modifications were available on the lifters to enable stone and even concrete slabs to be lifted;

---

---

failing this, there were also kerb grabbers available which did not rely on vacuum pads for lifting kerbs.

*"Mechanical solutions not suited to all materials" - C3*

*"Vacuum lifters not suitable to heritage kerbs because surface textured" - A2*

*"Client worried because of incidents of kerbs falling off lifting equipment." - B2*

*"Lifting equipment trialled kept dropping kerbs" - B2*

*"Problems with vacuum lifters when conservation kerbs fell off" - B2*

*"Bristol firm has produced kerb grabber that fits to mini digger" - B2*

*"Vacuum company have made equipment for lifting stone, slabs etc" - B1*

As the vacuum lifters had begun to be used there was an indication that new ways of working were required in certain situations. The use of two men to manually handle kerbs into place did not require a great amount of space and also the process was very adaptable as men could lay a few kerbs, do some other work and then lay a few more kerbs. Using the lifting equipment, contractors have the additional worry of closing traffic lanes and providing enough work to justify the use of the equipment.

*"Limited room for vacuum lifters on live carriageways" - A2*

*"Mechanical solutions interfere too much with traffic management" - C3*

*"Difficult to justify using lifter when kerbs aren't all laid at once" - B2*

*"Majority of kerbs laid in refurbishment work not suited for lifters" - A2*

*"Vacuum lifters difficult to use on housing work" - B2*

*"Construction sites often not organised to accept mechanical lifting aids" - C4*

---

---

The uptake of lifting equipment often relied on the willingness of the workers to use it. The perception by some of the workers was that mechanical equipment could not achieve the same tolerances as they could by hand. This may partially explain the concerns that equipment was not being used even when provided by the contractor.

*"Experienced kerb layer can eye them in; machines can't" - A2*

*"Any mechanical failure and the men will revert to manual installation" - A2*

*"The men were unsure about the benefit of vacuum lifters" - B1*

*"Equipment for lifting kerbs doesn't suit tall or short guys" - B2*

*"Some councils have bought equipment but men won't use it" - B3*

*"They have kerb lifters but they don't use them" - B1*

*"People won't use mechanical lifters that can't get tolerance right" - A2*

Cost was often raised when comparing mechanical and manual installation of concrete kerbs. If overall costs, including costs of accidents, were not taken into account, it was very difficult to justify the cost of investing in new equipment to replace a very economical practice.

*"They said they wouldn't use kerb lifters because it slowed them down" - B1*

*"Vacuum lifter cost meant could only buy one - making logistics a problem" - B2*

*"To use equipment costs money" - B2*

*"Getting the vacuum lifter in place slowed down production" - A3*

---

---

Despite all of the resistance stated above, it was reported that the use of lifting equipment was widespread in certain geographical areas, that manufacturers were adapting equipment to meet the needs of the contractors, and there were indications that some contractors were hopeful that vacuum lifters were going to pay for themselves in a few years. It was also pointed out that during the manufacturing process were lifted by vacuum lifters and that, while mechanisation may not be the best solution in every case, it is part of the hierarchy that the Health and Safety Executive would like the contractors to apply.

*“Mechanisation not always answer but hierarchy must be applied” - C3*

*“Every kerb is lifted by vacuum when it is manufactured” - A2*

*“Vacuum lifters paid for themselves in 2 to 3 years” - B2*

*“Most of Wales seem to have taken equipment on board” - B2*

*“Vacuum lifters can be adapted to lay kerbs below operators’ feet” - A2*

FG1 Q5	How should guidance be structured?
--------	------------------------------------

Comments related to the guidance needed for the installation of kerbs centred on the need for more detailed and appropriate guidance.

*“Interpave working on guidelines for their members” - B2*

*“Council looking to write guidelines after forum deadlines announced” - B2*

*“We need a method specification for laying kerbs” - A2*

---

---

## 5.4.2 Questions prepared for focus group meeting on design issues

FG2 Q1	How do you feel design affects health and safety on site?
--------	---

Discussions regarding design centred on frustration at designers' lack of input into reducing health and safety risks. It was felt that they worked too remotely from the construction process and did not understand how they could help.

*"Designers not aware what they are asking men to do" - A2*

*"Designers look at design not installation" - A2*

*"Designers operate in isolation from other processes in construction" - A2*

*"Designers/specifiers are bright people with no reference to the real world" - A2*

They felt protected by using British Standards when specifying materials and were reluctant to tell the contractor how to do the work. The way that designers specify methods of work and materials is likely to affect health and safety on site.

*"Designers believe not specifying method leads to best method being used" - A2*

*"Difficult for designers to specify plastic kerbs as familiar with concrete" - A2*

*"Designers use British standards to protect against legal action" - A2*

---

---

FG2 Q2
--------

Does existing documentation restrict the design of highways?
--

There appeared to be a reluctance to place installation methods within specification documents telling contractors how to do the work. It was felt that contractors were best placed to understand how the work should be carried out.

*"Clients would be reluctant to specify a method" - A2*

*"Specification shouldn't tell contractors how to do things" - A2*

Concrete kerbs are covered by a British Standard which the designers prefer when specifying and British Standards are, by their nature, conservative because they are arrived at by consensus within the industry. It was also pointed out that concrete kerbs had been around and were being installed long before The Health and Safety at Work Act.

*"British Standards require industry consensus therefore conservative" - A2*

*"Designers use British Standards to protect against legal action" - A2*

*"Concrete kerbs predate Health and Safety at Work Act" - A2*

Despite the appeal of specifying methods and materials with British standards there were examples of innovations being used that did not have the backing of a British Standard.

---

---

*“Drain/kerb units did not comply with British Standards” – A2*

*“Thin road surfaces instigated by manufacturers with no British Standard” – A2*

It was suggested in some discussions that guidance was required to separate the installation of kerbs in new build work with that in realignment and refurbishment works. A balance was sought between providing guidance for best practice and that required for the use of small equipment. Local authorities were in a position to help kerb installation by reviewing their adoption procedures and it was felt that sustainability may affect specification decisions in the future.

*“Separate guidance required for new build and realign/refurbish” – A1*

*“Guidance needs to aim between best practice and small equipment” – A1*

*“Local authorities could review planning concept and adoption procedures” – A2*

*“Eco-regulations could affect specification decisions in the future” – C4*

FG2 Q3	What do you think about the state of communication between parties in the construction process?
--------	---

The biggest issue with regard to communication concerned the role of the Health and Safety Executive and their enforcement of the manual handling regulations with regard to the installation of concrete kerbs. Large contractors were asking for consistency from the Health and Safety Executive inspectors in different parts of the country. The forums, set up



---

---

by the Health and Safety Executive, appeared to address this problem: they gave the HSE a focus for future communication with the construction industry. However, there were even inconsistencies between discussions at the forums and Health and Safety Executive communications after the forums.

*"Contractors are asking when to use mechanical/when manual handling" - A2*

*"The advice you get from the HSE is not consistent" - A3*

*"Contractors confused by a 30m limit asked for by some inspectors" - A1*

*"All HSE inspectors were sent a copy of action plan after first forum" - C2*

*"HSE issued a press release to industry after first forum" - C2*

*"Concern that 20 kg figure in documents not discussed at forum" - C2*

As previously discussed there was a call for designers to attend sites more often and specifically to speak to workers involved in the operations. A reciprocal arrangement with contractors speaking to designers about their designs was also recommended.

*"Designers should visit site more often to speak to workers" - C3*

*"Council contracting services needs help from designers" - B2*

The way stacks of kerbs were delivered to site and how this affected the operation of mechanical lifting equipment was discussed. It appeared that better communication was required between the manufacturers and the contractors. The arrangement of kerbs could reduce the efficient use of mechanical lifters and make workers resort to manual handling.

---

---

*"Some contractors want pallets but some don't" - A1*

*"Kerbs delivered without pallet leads to manual handling" - A1*

*"Packaging of kerbs a problem with certain devices" - B2*

*"Manufacturers deliver products in a way that produces handling risk" - C3*

Improvements to communication within contracting organisations needed to improve in order that estimators, supervisors and workers understood what they can do to reduce risks to workers installing concrete highway kerbs.

*"Overworked estimators just look at the scheme not details" - A2*

*"Contractors need to be involved in the process at an earlier stage" - C3*

*"Information is not given to the workers doing the work" - C3*

*"Supervisors not interested in health and don't like safety officer on site" - A3*

It was stated that the client/local authorities were communicating the need to move to the use of mechanical lifting devices to designers and contractors.

*"Council instructing their designers to consider mechanical handling" - B2*

*"Client told contractor to use kerb lifters" - B2*

---



---

FG2 Q4	Can the construction industry adopt alternatives where practices have been used for tens of years?
--------	--

There was generally a negative response to this question because of the culture of the industry being seen as conservative and the approaches that local authorities took with regard to the finances involved in their contracts. Again, designers were called upon to change in order to appreciate the effect of their decisions.

*“Trying to get the industry to change its culture is like drawing teeth” - A3*

*“Local government will still accept the lowest tender” - A2*

*“Local Authorities were given a set pot of money - subcontractors using lifters costs more” - A2*

*“Designers need to get their hands mucky to appreciate alternatives” - A3*

Despite the negative responses, there were indications that new methods were being used to reduce risks involved in replacing existing concrete highway kerbs.

*“Breaking existing kerbs instead of lifting out reduces manual handling” - A2*

*“Kerbs " chewed up" instead of manual handled on refurbishment work” - B2*

FG2 Q5	What should drive changes in construction to improve health
--------	---

---

---

	and safety?
--	-------------

The role of the contractor was discussed with regard to driving changes in the construction industry to improve health and safety. A number of reasons were put forward why the contractor was addressing these changes: the need for mechanical solutions; rising injury statistics; insurance costs; and legal compensation claims.

*"Improvements/innovations always driven by contractors" - A2*

*"Vacuum lifter design driven by contractors' need for mechanical solution" - B1*

*"Injury statistics drove contractor to reassess manual handling operations" - C3*

*"Found that mechanisation brings business as well as H&S benefits" - C2*

*"Investing in mechanisation saves on future insurance costs" - C2*

*"He said that changes driven by legal compensation claims" - B1*

When considering the client as a driver for change, there was agreement that they were in a good position having control of overall costs. However, it was thought that their ability to use this position to 'punish' contractors who continue to use manual handling operations was limited due to the shortage of contractors available to do the work.

*"Change needs to come from clients because of cost" - B2*

*"Clients can set the tone for manual handling management" - C2*

*"Clients stipulating that mechanical aids must be used would help" - A2*

*"Most times it's the client that dictates" - A1*

---

---

*"Local authorities writing to all contractors regarding level playing field" - C2*

*"Suggested that councils not use contractors who do it wrong" - C2*

*"Contractors in short supply so difficult not to use again" - A2*

When discussing what would drive designers to consider health and safety, the options ranged from promoting the ability to build in the design profession to taking legal action against designers who fail to comply with regulations. There were some indications that designers were beginning to consider site work because of the introduction of the Construction Design and Management Regulations.

*"Get designers to think about build-ability and maintenance" - A2*

*"Designers now considering site work because of CDM regulations" - A2*

*"Things won't change unless designers taken to court" - C3*

The driver for increased interest in the installation of concrete highway kerbs was enforcement by the Health and Safety Executive. They are usually motivated to carry out enforcement by huge rises in accidents or parliamentary pressure. Their enforcement activities have motivated local authorities and contractors to investigate new methods and materials. The inception of the kerbs forums also drove the issue because of deadlines issued at the forums to move away from manual handling.

*"Council interested in plastic kerbs because of legal claims by kerbers" - A2*

*"Drive for the HSE is huge rise in accidents or Parliamentary pressure" - A3*

*"Kerbs forum" convened in response to an industry request" - C2*

---

---

---

*"If manual handling restricted - slip forming may become cost effective" - A1*

*"Setting deadlines helps all stakeholders change at same time" - C2*

*"Manufacturer said sales increased of vacuum lifters after forum" - B2*

FG2 Q6	Would input from all parties concerned improve introduction of safer working practices?
--------	---

There was some indication that improvements were possible and that safer working practices could be achieved.

*"Design and procurement vital to manual handling of kerbs" - B2*

*"Designers for council specify mechanical handling" - B2*

### **5.4.3 Questions prepared for focus group meeting on training issues**

FG3 Q1	How much health awareness instruction is required in the training of kerb installation?
--------	---

The comments indicate that back injuries are seen as a way of life in the construction industry. Workers become aware of the damage that the work does to them but continue to do it while they can still earn the money.

---

---

*"It's socially acceptable and almost expected to get a back injury" – A3*

*"Men prepared to take risk of damaging back for kerber's wage" – B2*

*"Installer went to doctor with bad back and was told to stop laying kerbs" – B1*

This combined with a general attitude that health and safety is not really part of their job makes training very difficult.

*"It's a battle to get men to use eye protection and ear protection" – A3*

*"Strong men don't need training due to attitude and peer pressure" – A3*

*"The attitude is if they wear a hard hat everything else is okay" – A3*

Trainers admit that manual handling training is a small part of the kerb installation course and that, hammering and shovelling operations, which pose risks to the health of workers, are not dealt with. Sometimes training assists in reducing risks to injury but makes the job more difficult. Trainers would like the Health and Safety Executive to insist on refresher training for manual handling.

*"In our kerb installation training one hour spent on manual handling" – A3*

*"Hammering and shovelling operations not mentioned on course" – A3*

*"It would be good if HSE insisted on manual handling refresher training" – A3*

*"Sometimes the method helps to reduce injury but not to do the job" – A3*

---

---

FG3 Q2	How big is the divide between training and practice?
--------	--

It is quite understandable for there to be a big divide if, as commented, the main contractors receive the training but the subcontractors actually do the work. Another reason could be that training is not reinforced by the supervisors and therefore workers return to their original practices.

*"Main contractors trained and subcontractors actually do the work" - B2*

*"Supervisors not interested in health and don't like safety officer on site" - A3*

*"Risk assessments say use kerb lifters but not policed on site" - A3*

The trainers realise that the workers will carry out the work correctly under their supervision but won't do this on their return to the construction site. They assume that clients appreciate workers cutting corners and not using lifting equipment.

*"You train them in a controlled environment they go on site and it's gone" - A3*

*"You watch them and they do it right - turn your back they do it wrong" - A3*

*"They think they're doing good, taking short cuts, not using equipment" - A3*

FG3 Q3	Do we need to train construction workers differently?
--------	---



---

---

Comments related to training construction workers differently highlighted the fact that what works for large contractors does not necessarily work for small enterprises where the emphasis may be more on earning money.

*“CSCS training ok for large contractors but not for small” - B2*

*“They get told to forget the training and go out and earn some money” - A3*

The hazardous nature of construction work is often used in training to make workers aware of the dangers. This can be by showing photographs of injuries or asking workers who have suffered severe accidents to talk to workers. It was felt that this, although useful, must not be overdone as it can only have a limited effect.

*“We tried to frighten them to do it properly” - A3*

*“Shock tactics useful if not overdone” - A3*

*“Scary pictures only motivate people for a short time” - A3*

Training to use equipment has to keep up with new developments in technology. Training can be enhanced by using manufacturers to encourage workers to adopt better practices. However, the time it takes to train workers on various pieces of equipment can vary and this must be considered before purchasing the equipment.

*“Training updated to include new technology every three to five years” - A3*

*“Manufacturers brought in to demonstrate machines on courses” - A3*

*“Workers can be won over by using equipment demonstrations” - C4*

---

---

---

*“Training time to use equipment needs to be considered before purchase” - B1*

Good practices were discussed such as companies adopting annual reviews and the use of appropriate language and regional accents on audiovisual support media. Also, in-house training could be used to match workers to the appropriate tasks.

*“Annual employment, development, review training by some companies” - A3*

*“Dust suppression DVD used appropriate language and regional accents” - C4*

*“In-house training aided selection of workers to suit the task” - B2*

FG3 Q4	With the increase in the use of mechanical lifters, do we need less training?
--------	---

It was felt in the discussion that the essentials of concrete kerb installation would be the same whether you considered installing by hand or by machine. However, using the machine would require additional training. Plant training has been cited in accident reports and there was some suggestion that managers needed to be aware of how operations are carried out on site.

*“Overall the training will be the same lifting with machines or hands” - A3*

*“Not easy to train workers in the safe use of mechanical equipment” - C3*

*“Kerb lifting equipment used for training kerb laying” - B2*

---

---

*"We need to train managers to know what's happening on the work site" - A3*

*"Report on accidents says plant training not relevant to site" - B3*

FG3 Q5	Assuming that in five years time mechanical lifters are accepted, who should provide the training?
--------	--

It was recorded that a cement company was thinking of setting up its own gangs for kerb installation work but it was not clear whether they would carry out the training themselves. Equipment manufacturers were criticised for providing awareness of how equipment worked rather than training workers to use it. There was a suggestion that training needed to be delivered by operators of the equipment not salesmen.

*"Ready Mixed Concrete looked at setting up their own gangs" - B2*

*"Manufacturers spend 20 minutes with you. It's awareness not training" - A3*

*"Workers don't receive training - just shown how to start and stop it" - A3*

## **5.5 Focus Group Exercises**

Each of the three focus groups lasted for approximately 2 hours. In order to keep the attendees fresh and alert to the questions being asked an exercise was delivered in the middle of each focus group. The exercises were based around the same theme as the focus group and so the first focus group asked the attendees to comment on various types of lifting





---

equipment and place them in order of preference. The second focus group examined the appropriateness of different kerbing methods for different design situations. The third focus group asked the attendees to examine how to target kerb installation training.

### 5.5.1 Focus group 1 exercise - Lifting equipment

The group considered a number of alternative mechanical lifting devices. They examined various aspects (training, costs, and other uses) of each piece of equipment before placing them in order of preference, see Table 24. The manual scissor clamps were poorly regarded in most aspects but required little training. The vacuum device attached to an excavator was thought of as inappropriate for general kerb laying operations but had many other uses available. The manually operated vacuum devices were considered most appropriate for kerb installation but required at least half a day's training.

Lifting Device	Focus Group Comments
Probst BZ Kerb stone handles	<ul style="list-style-type: none"> <li>• Training needs to be specific but simple</li> <li>• Other uses limited - only useful for moving a single kerb and can't even get kerbs to their location</li> <li>• Would have limited effect on existing operations</li> <li>• They would represent a trip hazard</li> <li>• Co-ordination for lifting between the men critical</li> <li>• Doesn't solve the problem because it still requires lifting and has extra weight of the equipment</li> <li>• Not popular with workmen - inflexible and leads to lifting</li> </ul>

 <p>Position – Equal last</p>	<p>by hand</p> <ul style="list-style-type: none"> <li>• Wrist deviation on picture</li> <li>• Look to have straight backs but probably not in practice</li> <li>• Doesn't actually share the load equally</li> </ul>
<p>Screwfix Grab</p>  <p>Position – Equal last</p>	<ul style="list-style-type: none"> <li>• Training as for handles – needs to be specific</li> <li>• Other uses – nil suited only to fixed length of kerbs</li> <li>• Effect on existing operations– can't get tight up against last kerb</li> <li>• Lower therefore more bending required</li> <li>• Handles appear to be short therefore difficult to use</li> <li>• The height of the two operatives critical</li> <li>• Difficult to walk with it</li> <li>• Still have to manually handle</li> </ul>
<p>NPK Tornado</p>  <p>Position –third</p>	<ul style="list-style-type: none"> <li>• Detailed training required for operator and banksman or need a good driver</li> <li>• Considerable amount of other uses because of large carrying capacity</li> <li>• Effect on other operations – room required for the machine, ties up expensive machine</li> <li>• Not very accurate</li> <li>• Still needs manual handling for final positioning</li> <li>• Can be too big to get into small areas</li> </ul>
<p>NPK Fork mounted model</p>  <p>Position – Equal first</p>	<ul style="list-style-type: none"> <li>• Training – detailed to achieve optimum speed – ½ day</li> <li>• Other uses – multiple purpose with pad exchange</li> <li>• Can be adapted for other things</li> <li>• Effect on existing operations – space needed for the machine</li> <li>• Equipment needs to be level to work</li> <li>• Kerbs need to be on pallets</li> <li>• Excellent positioning</li> <li>• Removes manual handling</li> <li>• It takes the kerb stack along with it</li> <li>• Noise of machine might be a problem</li> </ul>


<p>Probst Fork mounted model</p>  <p>Position – Equal first</p>	<ul style="list-style-type: none"> <li>• Training – detailed training required because efficiency of equipment dependent on it – ½ day</li> <li>• Other uses – multi function vacuum system</li> <li>• Effect on existing operations – needs space so best suited to new build</li> <li>• Not independent: needs forked lifter</li> <li>• Kerbs need to be on pallets</li> <li>• Fails to safe</li> <li>• Maintenance costs</li> <li>• Still bending to complete operation</li> </ul>

Table 24 Focus group exercise – Lifting equipment

## 5.5.2 Focus group 2 exercise – Appropriate design solutions

In this exercise, two groups worked out the appropriateness of concrete kerbs and their alternatives in each of six design situations. There was accord in the responses of the two groups for two or three alternatives for each situation as shown in Table 25.

It was found from the exercise that slip forming (in concrete or asphalt) was best suited for car parks or trunk roads. Lighter kerbs were most appropriate for housing estates in city centre designs. The combined drain/kerb unit was suited to trunk roads, minor rural roads and access or slip roads.

A block paved solution was most suitable for housing estates in city centres. Designs which have no kerbs in them could be used on trunk roads on minor rural roads and the traditional concrete highway kerb were best suited to car parks and minor rural roads.

	Housing estate	Car park	Trunk road	Minor rural road	City centre	Access or slip roads
Slip forming in concrete or asphalt	2	9	10	4	6	10
	5.5	8	9	6.5	2	No Score
Lighter kerb	10	10	10	10	10	10
	8	2.5	2.5	2.5	8	No Score
Combined drain/kerb	10	10	10	10	10	10
	4	2	8.5	8.5	2	10
Block paving incorporating kerb	10	10	0	0	10	0
	9	2.5	0	0.5	9	No Score
No kerb	0	10	10	5	0	4
	0	0.5	10	8	0	No Score
Concrete kerb	10	10	10	10	10	10
	7	8	0	8	7	0
Notes: Second Focus Group Meeting Exercise – Appropriate Design Scores in Bold indicate agreement between groups			Score of 10 = Most Applicable Score of 0 = Least Applicable Group A Scores Shown in Shaded Rows Group B Scores Shown in Un-shaded Rows			

Table 25 Focus group exercise – Design issues

### 5.5.3 Focus group 3 exercises – Targetting the trainer

The attendees in the training focus group were given a table which included, in the first column, three of the key stakeholders along with any related training issue and they were asked to complete the remaining two columns of the table. The second column asked which of the issues would have the greatest effect on the health of the workers and the final column asked for reasons for this.

A combination of all of the attendees' responses is shown in Table 26. They indicate that good manual handling training was of benefit to the workers but the benefits would not be realised without similar training being provided for the designers and supervisors

Training intended for / Training issues	Which will have greatest effect on health of the workers	Reasons
Kerb Layers / How to lay kerbs and health implications of hammering, shovelling, manual handling etc...	<i>The worker gaining good appreciation of the 'manual handling' factor in each operation/tool/procedure. (Risk of Injury)</i>	<i>This won't happen unless supervisors trained. To achieve safe operation the major driver will be 'self-discipline' as supervision tends to be variable (in intensity)</i>
Designers / Effect of manual handling on kerb layers. Range of methods of kerb installation available – slip form, different materials, repair and not using kerbs at all	<i>Need understanding/ knowledge (practical hands on experience) of what is involved in actual installation</i>	<i>Avoid/reduce at source if possible. If design is right everything else will run from that. Will lead to awareness of the problems and prompt ideas for improvements</i>
Supervisors / Detailed look at main methods. Appropriate situation for using each. Health implications of each and brief look at full range of alternatives	<i>The supervisor to be aware of his role and responsibility and maintain standards and safety on site.</i>	<i>This is needed / essential as it will only happen if supervisors say so. Most supervisors believe it is not their responsibility. Has the wrong perception.</i>
Other	<i>To increase the understanding that resources, including Plant, Training and Innovation, are worth being made available.</i>	<i>If there is no technological progress, we will continue to chase our own tail.</i>
Notes: Third Focus Group Meeting Exercise – Targeting the Training Focus Group Comments Shown in Italics		

Table 26 Focus group exercise – Training issues



---

---

Manual handling awareness training provided for designers was considered to be the most beneficial for the workers. It was felt that if the design is right that everything else will follow and that if the designers were aware of the problems in the kerb installation work, then this would prompt ideas for improvements.

## **5.6 Summary**

Section 5.2 of this chapter concentrated on the analysis of text derived from safety meeting notes, telephone and site visits meeting notes, kerbs forums notes and focus groups/expert panel transcripts. Included are the graphical representations of the comments related to key stakeholders, categories of information and combinations thereof.

Section 5.4 covers the focus groups/expert panels and is subdivided by the questions used in the three focus groups. For each question there is a description of the findings from the text analysis together with lists of relevant comments taken from the text analysis table.

Finally section 5.5 provides details of the results of the focus group exercises; one for each of the three focus groups. These include the rating of mechanical lifting equipment, relevance of design solutions compared with kerb installation alternatives, and an assessment of targeting of training for kerb installation.

This results chapter deals only with the analysis of text data collected from the research. For details of results obtained from the observation of the various kerb installation methods carried out during the site visits see chapter four. Discussion of all of the results can be found in chapter 6 which follows this chapter. The conclusions of the research are in chapter 8.

---

---

## 6 DISCUSSION

### 6.1 Introduction

This chapter brings together the data obtained from the two stages of research: observations of the kerb installation work (chapter 4) and the analysis of text from the meetings and interviews (chapter 5) to address the aim, objectives and research questions presented in the previous chapters. In it, the main issues arising out of the research are discussed in relation to the findings from the literature review (chapter 2). Conclusions drawn from this synthesis and the interpretation of results are presented in chapter 8.

The observation work was used to obtain a clear picture of the installation process and the current management methods. The focus groups and interviews enabled key issues to be discussed with and between industry stakeholders. As well as addressing the research questions, contributions to the theory and practice along with implications for the industry stakeholders obtained from the findings are detailed in chapter 7.

#### 6.1.1 Answering the research questions

The overall aim of the research was to increase the understanding of the reasons behind the continued use of manual handling for the installation of concrete highway kerbs in the construction industry and the change produced by the HSE enforcement. In order to achieve this aim, five research questions were formulated and assessed during this research.

1. What are the key functions and considerations of the training of workers in the installation of highway kerbs?
2. Do alternatives to the manual handling of concrete highway kerbs pose any risks?

- 
- 
3. How could the Design for Safety concept improve the installation of highway kerbs?
  4. How is the risk of injury to the workers affected by the organisation of the work?
  5. In what way can the culture of those in the supply chain affect the introduction of technical innovations?

The research questions are answered, in turn, in each of the next five sections and a summary provided in section 6.7.

#### 6.1.1.1 What are the key functions and considerations of the training of workers in the installation of highway kerbs?

A report by the HSE investigating manual handling training practices (Haslam et al. 2007) emphasised the need for promoting risk awareness. The report said that this was most likely to be achieved through industry and task specific training tailored to the recipients' level of knowledge and understanding of the risks.

From discussions with workers during the site visits, it was apparent that they were aware of the effect on their health of the manual handling work that they were carrying out. Comments from the focus group discussions indicated that injury was seen by the workers as part of the job when working in construction.

*"If you went in to any dining room and said "Put your hand up if you have a back injury" on any project and you get seven out of 10 put their hands up, that means it's socially acceptable and almost expected"*

This makes awareness training and the adoption of equipment to reduce risks difficult if the workers think that injury is inevitable. There were also comments relating to a general negative attitude towards health and

---

---

safety by the workers when considering basic health and safety such as eye and ear protection.

*“It's a battle to get them to use eye protection or ear protection when they are using a compressor.”*

This is in line with research into the use of personal protective equipment (PPE) (Helander, 1991) which reported that PPE provided to workers was not comfortable to wear and would therefore not be used. Training therefore needs to be supported by purchase of appropriate equipment.

Information obtained from the focus groups, interviews and kerbs forums were useful in producing the management guidance, as detailed in chapter 7. Positive comments related to some of the good things that were being done within the training programmes such as the use of shock tactics (use of graphic photographs of workers involved in accidents) to engage/motivate the worker as long as this was not overdone. One company put everyone up to district manager level through the training, and the use of in house training helped in selecting workers appropriate to the task. There were also negative comments with equipment manufacturers being criticised for providing awareness of how equipment worked rather than training workers to use it. There was a suggestion that training needed to be delivered by operators of the equipment not sales staff.

Discussions in the training focus group highlighted the need for training of the use of equipment to keep up with new developments in technology. It was also said that training can be enhanced by using demonstrations from equipment manufacturers to encourage workers to adopt better practices. This reinforces the statement in the Health and Safety Executive report on training (Haslam et al, 2007) that training style should include a practical element which should ideally be task specific. However, trainers

---

---

in the focus groups said that the time it takes to train workers on various pieces of equipment can vary and this had to be considered before purchasing the equipment.

*“What we still tend to do is that we will bring in the firm to do a demo on certain pieces of kit, on certain courses.”*

It was felt in the discussion that the essentials of concrete kerb installation would be the same whether installed by hand or by machine. However, machine use would require additional training. Plant training has been cited in accident reports and there was some suggestion that managers needed to be aware of how operations are carried out on site; the same point being made in research into European and International standards in manual handling (Dickinson, 1995) which states that those involved in the work and job design need targeting for training as information and training alone was not sufficient.

*“I would look at doing a lot of awareness training for managers; and your contract agents; and your managers above those, as to what is going off in the workplace and make them aware of their responsibilities to the men that are doing the job.”*

The focus groups found that good practices were being used such as companies adopting annual reviews and the use of appropriate language and regional accents on audiovisual support media. Where possible, using in-house training to assist in the selection of workers for the most suitable tasks is beneficial also. However, trainers thought that if the Health and Safety Executive insisted on refresher training for manual handling this would benefit to the whole process.

---

---

6.1.1.2 Do alternatives to the manual handling of concrete highway kerbs pose any risks?

This question was primarily answered by the postural analysis exercise and from the observation of the workers using the alternatives. From the postural analysis results, it could be seen that the most arduous tasks involved in the traditional manual handling operations (usually lifting the kerb into place, see Figure 26) posed a very high risk of injury to workers. The other tasks involved (included shovelling of concrete bedding materials and hammering the kerbs into place with a mallet) rated from medium to high risk.



Figure 26 Existing manual handling operations

Postural analysis results for the alternatives were generally much improved with ratings of negligible to medium risk of injury. However, the installation of steel formwork to produce a ‘kerb race’ required workers to adopt postures that put them at high risk of injury. This had to be considered in the context that the work removed the need for kerbs to be installed twice so was in effect replacing very high risk operations with high-risk operations. Also, the use of vacuum lifters greatly reduced the postural loading results but maintenance of the equipment required workers to adopt postures rating high and very high risk.

---

---

Ergonomic design improvements have been made in manufacturing but not seen in construction. This was confirmed from the observation work with lifting clamps not allowing workers to adopt comfortable postures while installing the kerbs and alterations being required to vacuum lifters in order to allow workers to adopt more comfortable postures when placing kerbs with machines.

It was understood from the interviews that new vacuum lifting equipment had been trialled and that the concrete kerbs kept falling off. This was obviously of concern as the kerbs on average weigh 67 kg and therefore presented a risk of injury (cuts, bruises, breakages etc) to the workers' lower limbs. However, it was suggested by supporters of the equipment that workers who did not want to adopt the new equipment were more than capable of making the kerbs drop to emphasise their case.

During one of the site visits, representatives from the local authority/client carried out audio readings to check noise levels adjacent to the vacuum lifting equipment being used. It was found that the equipment which was powered by a diesel generator exceeded the safe working limits and therefore the operator was required to wear ear protection.

The vacuum lifters developed by the Probst Company were observed at the beginning of the project and it was noted that the hands of the operator had to go below his knees in order for the concrete kerb to be placed on the ground. Towards the end of the project observation of a demonstration of Probst equipment showed the use of a spacing tube that allowed the operator to place the kerbs on the ground while keeping a more erect posture.

From the literature review, research examining the use of mechanical lifting aids in the manufacturing industry (Nussbaum et al 2000) stated that consideration of the operators ability to resist lateral forces when using the equipment was required. Discussions with operators of the vacuum lifting equipment referred to the need to 'fight' with the equipment sometimes. It was discovered after discussions within the equipment manufacturers that the machines had to be levelled every time they were moved to a new position otherwise additional lateral loading was introduced to the operation. So, when the installation work was

---

---

carried out on an inclined road, some operators tended to save time by not levelling the machine, choosing instead to deal physically with the lateral loads that resulted.

Alternative kerb products, because they tended to be lighter than the existing kerbs, were advertised as a solution to the manual handling problem. However, installation of these products still required the workers to adopt out-of-neutral postures (bent over to position the kerbs and manually shovelling concrete bedding materials). The kerb and drainage product obviously reduced risks because two installation operations are replaced by one, whilst the plastic kerbs reduced risks associated with manually handling the load as they were considerably lighter than either kerb/drain products or shorter/lightweight concrete kerb products, and they also reduce the risk of dust inhalation as airborne dust when cutting was reduced.

#### 6.1.1.3 How could the Design for Safety concept improve the installation of highway kerbs?

Two years after the introduction of the 1994 Construction Design and Management regulations (Baxendale, Jones 2000) Baxendale and Jones found that designers were still not considering how their designs were carried out in practice. Discussions relating to the design of carriageways in the focus groups revolved around the contractors' general frustration with designers' lack of appreciation of site practices and designers explaining the reasons behind their design choices.

*"Designers don't think about how the traffic is to be managed"*

From the focus groups, interviews and kerbs forums, comments can be broadly divided into three categories: the designer's lack of practical site experience and awareness of site practices; the fact that designers are affected by public response and are more likely to choose safe specifications; and that they are more interested in their own work than the work of others so they are more concerned with things



---

---

like appearance and aesthetics than they are to build ability and the practicalities of construction.

*“Designers need to get out on site to see what is happening”*

These comments from the research are in line with published work stating that incorporating contractors experience and knowledge at the design stage can improve project ‘buildability’ and eliminate occupational health and safety problems at source (Lingard, Rowlinson 2005). Some designers thought that contractors were better placed to choose the best method for adoption on site and therefore felt happier leaving this to the contractor. Designers working for Local Authorities, because they were open to public scrutiny, said that they would be reluctant to use new or innovative products and processes in favour of the tried and tested, British Standard, concrete highway kerbs.

The literature review showed there to be considerable research into the role of designers in reducing health and safety risks in construction (Behm 2005, Baxendale, Jones 2000, Hecker, Gambatese 2003, Toole 2002). But it appeared that a combination of the concrete highway kerb performing well over a long period of time and the construction industry having a conservative culture meant that it was difficult for designers to use alternatives. Contractors felt that designers did not understand how contractors dealt with the designs on site. The designers said that they also preferred to use products and processes that had British Standards in order to protect themselves from legal action should any future event occur that linked their design to any adverse events.

Several suggestions were made in the focus groups and the safety meetings that designers needed to spend more time on site speaking to contractors and gaining a better understanding of the construction process.

*“Designers look at what they are designing but don't look at how you install it.”*

It was felt that this would be to the benefit of both parties. Similar findings were reported in research carried out by the Health and Safety Laboratory (Reid, Pinder & Monnington 2001), investigating musculoskeletal problems in the construction

---

---

industry, which said that designers often had no thought or concept of how the job was to be carried out.

Some impetus from designers seemed likely as there were several comments regarding their responsibilities under the CDM regulations. A number of the comments, made by various parties, suggested that designers needed to attend site more and speak to contractors about construction methods; those designers who follow the regulations would find it necessary to do this.

An example of a related innovation that had been successfully introduced was thin road surfaces. These did not have a British Standard but the manufacturers had obtained British Board of Agrément (the UK's major authority offering approval of construction products, systems and installers) certification for their products which enabled designers to have confidence in specifying them.

#### 6.1.1.4 How is the risk of injury to the workers affected by the organisation of the work?

The construction industry has been referred to as one that portrays a conservative and at times "laggardly" approach to new ideas (Barthorpe et al, 2000), mainly due to its fragmented nature and lack of ability to invest time and money into innovation, research and development. Reference has also been made to the fact that the industry was highly resistant to change over a period of 40 years from the Second World War (Fox, 2007). An investigation of the organisational cultures of architects and contractors (Ankrah & Langford, 2005) found that there are many areas in which they have significant differences. This research intended to investigate the way in which the supply chain dealt with changes and the working relationships between partners. This section shows how these partners worked together in the organisation of the work.

By examining the role of the manufacturer, it was possible to identify how their methods of delivery affected the organisation of the kerb installation

---

---

work by the contractor which, in turn, presented risks of injury to the workers. The manufacturers were beginning to change from delivering the kerbs on timber pallets to delivering them held together with nylon bands and shrink wrapped in polythene (see Figure 27 **Error! Reference source not found.**). This had little effect on the existing method of installing concrete kerbs by hand. However, for contractors to be able to use the vacuum lifting equipment, they had to provide their own timber pallets so that the packs could be picked up by the forks of the vacuum lifting machines. There was therefore an increased risk of injury to workers through the manual handling of the timber pallets.

There was also an issue with the order in which the manufacturers packed the kerbs. If the kerbs were placed back to back, every other kerb has to be turned around before it could be picked up with the profiled head of the vacuum lifters. This not only affected the efficiency of the mechanical lifting, but it meant that the workers had to operate the machinery for longer to achieve the same amount of work thus increasing the likelihood of their being injured. The way in which the manufacturers packaged the kerbs, Figure 27, also presented a potential hazard (fracture/damaged limbs) for the operator. As the stacks of kerbs were held together with nylon straps, there was a possibility that heavy kerbs in the top layer of the stack could fall once the straps were cut.

The research into mechanical lifting devices detailed in the literature review (and referred to in the discussion related to research question 2) explained that the devices reduced compressive forces in the spine but articulated arm type devices failed to reduce hand forces (Nussbaum et al. 2000). It was reported that the organisation of the kerb installation work when the carriageway was sloping (which increased the frequency of the need to level the equipment) posed a risk of injury. The operator sometimes chose to “fight” with the machine as it supported the kerb

---

---

weight rather than take time to level the machine to reduce the lateral forces.



Figure 27 Packaging of Concrete Highway Kerbs



Figure 28 Al-Vac machine

Probst machine

Two manufacturers (Al-Vac and Probst – Figure 28) appeared to provide the majority of vacuum lifting equipment for kerb laying operations in the

---

---

UK. Both worked on the basis that the machine and a pallet of kerbs are carried on the forks of a loader shovel or telescopic loader. The vacuum lifter had a boom along which the vacuum tube and suction plate were supported and allowed considerable positional movement of the suspended kerb. The machines differed in the boom type and hand controls (one on a ring, the other handlebar type). This research did not investigate how German-developed vacuum lifting equipment was used in its country of origin, so it was not known why the equipment had to be modified once it had started to be used in the UK.

Contractors expressed concern that the arrangement of supporting a vacuum lifter on a forked vehicle presented great difficulties with the organisation of work along busy carriageways and crowded high streets. Workers were therefore put at risk of injury from manual handling as contractors persisted with manual operations which were more flexible, fitting easily into the organisation of the work. This difficulty began to disappear over time as more versatile methods became available for the carriage of the vacuum lifter including individual trailers and adaptations to flatbed trucks.

Demonstrations of the vacuum lifting equipment at construction industry expositions showed the equipment to be very efficient in manoeuvring the heavy concrete units from timber pallets onto the ground and back again. It was only when the operations were discussed in more detail in the focus groups that the difficulties in using the equipment as a replacement in various construction operations could be seen. The existing manual handling method was very flexible because it only used two operatives (who could be doing other work when not installing kerbs), it did not take up much space and was equally effective for a variety of kerb materials with various textured finishes. The use of vacuum lifting equipment, however, required additional planning to accommodate closure or partial

---

---

closure of lanes of traffic; demanded enough work in one go to justify the deployment (and often hire) of the equipment; and necessitated trials of the equipment to establish its suitability on the materials to be used (the vacuum pads used to pick up kerbs had difficulties with some textured finishes).

The widely used practice of manually handling concrete highway kerbs has proved to be too competitive for the practice of forming extruded concrete kerbs. At the present time, the use of slip forming equipment for extruded concrete sections (see Figure 29) appears to have disappeared as a practice in the UK (the researcher was only able to inspect this work in the Republic of Ireland). This equipment appeared to be used globally with examples of its use in Australia, India, the USA and Ireland. Despite recorded use of this equipment for at least 30 years in the UK, it was not widely used during the research period. Reasons for its greater use in other countries may be due to the type of work (large unobstructed highways) and climates more suitable for casting concrete outside.

It was reported from a visit to inspect the slip forming of kerbs that many clients did not favour this method because it was expensive to bring back the equipment in the event of damage to the kerb. However, as the profile of a kerb is a simple shape, it should not be difficult to construct the appropriate formwork for remedial casting. There should be no manual handling implications with removal because the damaged kerb as a whole could not be picked up. A method for breaking up the cast kerb mechanically, the CutaKerb system, could be used to remove long lengths of slip formed kerb.

In most new build situations, while the use of manual handling still existed, it was unlikely that slip forming would be considered. However, with the expected move towards mechanical installation following the HSE enforcement measures, it is likely that the use of slip forming will be

---

---

considered again. A cost exercise needs to be carried out to compare the benefits of slip forming against that of using vacuum lifters.



Figure 29 Slip Forming Equipment in Use

The effectiveness of manual handling training was brought into question in the findings of the literature review (Haslam et al. 2007, Kroemer 1992, Burgess-Limerick 2003, Martimo et al. 2008). The focus group on training had identified the fact that training for installation of kerbs would not alter significantly if they were being installed by vacuum lifters rather than by hand. It was not evident, however, whether the organisation of the work (delivery of kerbs, control of live traffic), which was important when changing from manual handling to mechanical equipment, would be included in the training.

---

---

Shovelling and hammering operations, which were identified as risks to the workers health from the posture analysis, were reported as not being part of the training received for concrete kerb installation whereas manual handling was. It was also noted that health and safety training in construction was more often than not carried out only once, 'one hit', and was generally not reinforced. There was also a call for the HSE to insist on manual handling refresher training.

If methods change on site and mechanical equipment is increasingly used, it is important that the workers and supervisors understand the implications of this change. So, it was interesting to note from the focus groups, that training sessions for the installation of concrete highway kerbs were attended by main contractors, presumably by people who would supervise the work, but the subcontractors who specialise in the installation of concrete highway kerbs did not normally attend.

Training workers to use mechanical lifting equipment needs to be carefully formulated so that training reflects new technology available to the men on site and manufacturers of the lifting equipment should be involved with the training (provided demonstrations of their equipment) wherever possible. In addition, the time taken to train workers with equipment has to be considered at the time of purchasing the equipment. If all this is done correctly, it was commented that the use of equipment could win the approval of workers to change from manual practices.

#### 6.1.1.5 In what way can the culture of those in the supply chain affect the introduction of technical innovations?

There is general agreement among researchers and practitioners that innovation is a vital proponent of success (Egbu, 2004) and, according to



---

---

Egan (1998), there is a growing awareness of the importance of innovation in the construction industry. Despite this, the results of this research found widespread resistance to change:

- Kerb manufacturers were reluctant to change from producing a simple product that sells in its millions;
- Clients were reluctant to change from choosing the lowest tender;
- Designers were reluctant to change from using products that have the assurance of a British Standard;
- Contractors were reluctant to change from using a work method that was simple to organise;
- Subcontractors were reluctant to put health before pay with the present system.

One reason for this reluctance to change could be that introducing innovations is a risky business (Tomala and Senechal, 2004) and that only a small percentage of innovations achieve significant success.

The casual, fragmented and hierarchical nature of the construction industry illustrates the incapability of the industry to operate in a coordinated, homogenous way when dealing with universal issues such as innovation (Barthorpe et al, 2000). Often, changes are required because the existing practices are inadequate. It is the individual's engagement with and transformation of the existing practices that constitute change. Therefore, individuals are often at the vanguard of change (Billet & Somerville, 2004). Although the above examples refer to organisations and their reluctance to change, in each case it will often be the responsibility of an individual to make the final decision.

---

---

## 6.2 Manufacturers

The view that the construction industry was conservative in nature and slow to change was presented in the concluding chapter of proceedings from a research and practice symposium (Hecker, Gambatese 2004). This view was also noted in the focus group responses from concrete product manufacturers. Concrete highway kerbs have been produced with little or no variation in their specification for several decades. Whilst individual units cost only a few pounds, millions of units are sold in the construction industry every year. During the focus group discussions and at one of the kerbs forums, it was stated that the manufacturers did not produce shorter kerbs because there was no demand for them.

*“we would like to make small components but have not been asked to”*

Contrary to this, one of the local authorities complained that they had introduced shorter kerbs to address manual handling issues and now had to change again to even larger kerbs because the HSE were asking everyone to move towards the use of mechanical lifting equipment for installation. The resistance from the concrete kerb manufacturers was also evident in their criticism of the alternatives.

Manufacturers were reluctant to change from using concrete products with some simply aiming to reduce the weight to below 25 kg not fully understanding the residual health issues associated with the installation of the products on site.

There appears to be a widespread belief in the industry (and this was noted in comments during the research) that reducing the weight of construction equipment or materials to 25 kg overcomes any manual handling issues. This is not the case. Whilst a reduced load does not in all cases stop the introduction of new materials, it does provide the users of those materials with a false sense that they are removing manual handling

---

---

risks. When discussing reducing the weight of kerbs with the operatives, they often referred to the reduction in weight of cement bags from 50 kg to 25 kg as a solution to manual handling problems. The manufacturers of the smaller combined kerb/drain units indicated in their promotional literature that weights of units around 25 kg were suitable for manual handling.

During the research the person who had established the production of plastic kerbs with the same overall dimensions shape as the British Standard concrete kerb was interviewed. He had seen his product as a solution to Local Authorities' need to adopt sustainable practices as it was produced from recycled materials. When the manual handling of concrete kerbs became an issue, this helped him to promote his product even further. Plastic kerbs, weighing about 9kg are now being used on roads in the UK and this change in practice, adopting an innovative product, came about from the actions of an individual.

### 6.3 Designers

In the focus group in which design issues were specifically addressed, designers were asked why they continue to specify concrete highway kerbs when a range of alternatives are now available. There was some indication that they relied upon established documents for the design decisions and steered away from telling the contractor how work should be carried out.

*"Designers design to British standards. The Highways Agency design manual has guidance for correct construction good practice. How the contractor constructs the pavement is up to him. That this is now changing with the CDM regulations but the standards do not reflect that."*

---

---

The designers expressed no willingness to specify products that did not provide them with the assurance of a British Standard.

*“Standards give you a confidence that if you use them you do not end up in court but to get a standard agreed you have to have a general consensus in industry and with the clients. So in some sense it is a conservative document but it doesn't mean you have to apply this standard to innovate. It is just a good practice guide.”*

Although the designers usually work within design practices/consultancies or for Local Authorities, many of them are able to make design decisions as individuals. So it will take the actions of well-informed individual designers specifying innovative alternatives over a number of years before the majority of designers are comfortable in changing the way they work.

## **6.4 Contractors**

Following the first kerbs forum, the Health and Safety Executive had to respond to questions from contractors concerned about the deadlines by which they were expected to move away from manual handling methods to the use of mechanical lifting equipment.

*“The use of mechanical methods may have a major impact on traffic management with the need for increased road closures to carry out repairs. This appears to contradict government initiatives designed to reduce traffic congestion.”*

This topic had already been raised at the second focus group meeting in answer to the question - How do you feel the design affects health and safety on site?

*“The biggest problem that we have got is, where we are trying to refurbish existing highway, we have got to keep traffic around us moving, we've got a*

---

---

*mechanical lifting machine, we've got problems servicing it with kerbs because we've got to get those from storage or a stockpile somewhere, possibly outside the limit of the site some suitable grass verge. The problem we've got is a JCB entering the live carriageway lane, in between traffic lights movements, just to overtake a mechanical machine. You have to protect the pedestrians as well if you've got a significant piece of machinery in the live lane."*

*"Designers look at what they are designing but don't look at how you install it. They put restrictions on the contractor, especially with laying kerbs, and don't consider the traffic management scheme and the amount of room you've got."*

The contractors were able to go into great detail about the difficulties that the use of the mechanical lifting equipment would cause to the work. However, they did not discuss how easy it was for them to use the manual handling methods to carry out the work.

## **6.5 Clients**

Research carried out by the Health and Safety Executive (HSE) (Haslam et al. 2007) talked about promoting the right culture to achieve safer working practices. In the focus group discussions, the ability of the industry to adopt new practices and procedures was questioned and the issue of culture was raised. Comments were made regarding the general conservative nature of the industry. More specific details were raised regarding Local Authorities' methods of procurement. Local Authorities were still required to accept the lowest tender which meant that, unless it was written in the tender that mechanical handling equipment should be used, contractors would price for manual handling of highway kerbs as this was the cheaper method. Subcontractors would then not consider using lifting equipment as this would put them at a disadvantage when tendering for projects.

---

---

## 6.6 Workers

The construction industry is often criticised for having a macho culture. Koningsveld and van der Molen (Koningsveld 1997) characterised construction culture as most conservative with the work physically straining and having traditional work methods and work organisation. It is a much noted aspect of innovation that old skills become redundant (Seymour and Rooke, 1995). Changing from manual installation of the kerbs to mechanical installation means that the installers require a new skill, operating the equipment, but it is not necessary for installers to have the same physical strength as before.

The operators interviewed, who had previously laid kerbs using clamps but now used vacuum lifters, reported feeling less worn out after a day's work. There were no reports of aches and pains to the hands after using the controls and the equipment was found to be easy to operate with a relatively short amount of training. The current installers of concrete kerbs are worried that this will allow a larger number of workers to be able to carry out the tasks even though it could help prolong the working lives of existing kerb layers.

In research investigating culture change and learning in coal mining work, it was found that workers still cut corners to save time and energy. Young coal miners continued to maintain that saving hours by cutting corners and lifting things that are too heavy was justified (Billet & Somerville, 2004). A report by the HSE investigating manual handling training practices (Haslam et al. 2007) emphasised the need for promoting risk awareness. The report said that this was most likely to be achieved through industry and task specific training tailored to the recipients' level of knowledge and understanding of the risks.

---

---

From discussions with workers during the site visits, it was apparent that they were aware of the effect on their health of the manual handling work that they were carrying out. Comments from the focus group discussions indicated that injury was seen by the workers as part of the job when working in construction.

This makes awareness training and the adoption of equipment to reduce risks difficult if the workers think that injury is inevitable. There were also comments relating to a general negative attitude towards health and safety by the workers when considering basic health and safety such as eye and ear protection.

*"It's a battle to get them to use eye protection or ear protection where they are using a compressor."*

Following anecdotal evidence, it was initially thought that clamps were provided by the employers but not used by the operatives. The site visits demonstrated that this was not the case and there were examples where regular use of clamps was evident. However, when financial bonuses were in place, the more skilled workers claimed that they found it quicker to lay kerbs by hand.

## **6.7 Summary**

A combination of findings from the literature review, observation work and text analysis have enabled all of the research questions, listed at the start of this chapter, to be answered to some degree. The industry culture, with workers seeing injuries as being inevitable, makes it difficult to provide awareness training and to encourage them to move away from heavy manual handling work. There were signs that training was engaging with workers more if equipment manufacturers provide demonstrations in the training classes.

---

---

Using the postural analysis, it was confirmed that the existing manual handling operations posed a significant risk of injury. The alternatives to manual handling on the whole reduced risks of injury, especially where the load had been reduced/removed but issues such as kerbs falling off vacuum plates, noise of equipment and maintenance of equipment need to be investigated further.

Designers not seeing their work as part of the on-site construction process prevents them designing out health and safety risks. There were no signs that the CDM regulations were having an effect by making designers consider the health and safety implications of their work.

It could be seen in the findings that manufacturers need to understand how their products are being used so that they can organise delivery and modifications to suit the industry. On site, any changes to work operations with the introduction of new components, materials and equipment need to be carefully considered with regard to their effect on existing management of construction tasks.

Although the research did not set out to measure attitudes, there was considerable resistance to changing the existing practices from all of the supply chain members. Their reasons for resisting change ranged from fear of legal action to difficulties with organising the work. This tended to confirm the conservative nature of the industry but there are signs that individuals are starting to make a difference by pushing through innovations.

The full literature review can be seen in chapter 2 and the observational results and text analysis results discussed in this chapter can be seen in detail in chapter 4 and chapter 5. Details of practical outcomes from the research are included in chapter 7. The conclusions from these discussions along with recommendations for further work can be seen in chapter 8.



---

---

## 7 PRACTICAL OUTCOMES

It was always intended that there should be some practical outcomes for the construction industry from this research. This was in part due to the fact that the initial work was being funded by the Construction Health and Safety Group and the follow on projects were also funded by industry bodies.

### 7.1 Back to Design

The Back to Design: manual handling of highway kerbs & Multimedia CD-ROM was produced for the Construction Health and Safety Group. The manual contained details of the research by Loughborough University together with information on the life cycle of concrete kerbs (design, manufacture, installation, repair, removal); designing out the use of concrete kerbs; and details of alternative kerb units (plastic kerbs, rubber kerbs, combined drain/kerbs). There were recommendations for all of the key stakeholders and the kerb installation process and within the appendices there were details of the focus group exercises; postural analysis results and task analysis breakdowns.

The multimedia CD-ROM was designed as a training tool to complement the manual. It contained small libraries of video clips and photographs obtained from the site visits of the various installation methods. There were also a number of PowerPoint presentation slides available on the disc to be used for awareness training. Although the content was predominantly related to the kerb installation process, it was hoped that the materials could be used to support any manual handling or construction health and safety training. A copy of both the manual and

---

---

the CD-ROM were disseminated to all of the Construction Health and Safety Group members. The manual can be seen in appendix 10.3.

## **7.2 Interpave handling guidance**

The Handling Kerbs: guide to the handling of precast concrete kerbs and Handling Paving Flags: guide to the handling of precast concrete paving flags were produced for the trade association Interpave. During research carried out to produce the Back to Design manual and CD-ROM, Loughborough University were contacted by Interpave, the trade association for the concrete kerb manufacturers, who wanted to provide guidelines regarding the safe installation of their products for their members. This work was carried out directly after the original research and guideline documents were produced for handling kerbs and for handling paving flags. The Interpave kerb handling guidance can be seen in appendix 10.4.

The handling kerbs guidelines were intended to help with the reduction of risks resulting from installation of highway kerbs and relate to currently available equipment. They were not intended to replace the contractor's obligations to assess and manage risk in accordance with the Construction (Design and Management) Regulations and indicated that work should still be done in accordance with all relevant, current legislation.

The handling paving flags guidelines was developed soon after the kerb handling guidance as the operations involved were similar. This work was also likely to be done by some of the same contractors with materials bought from Interpave members. The manual handling of paving slabs was not being targeted at the time and so this was a proactive move by the

---

---

trade association for the benefit of its members. The Interpave paving flags handling guidance can be seen in appendix 10.5.

### **7.3 CECA Health Management Toolkit**

Findings from the concrete kerb installation research were used as part of another research project by Loughborough University to produce a Health Management Toolkit for the Civil Engineering Contractors Association (CECA). As part of their Health and Safety Action Plan and Strategy, CECA worked with Loughborough University to develop some simple management strategies for reducing the incidence of ill health amongst employees and sub-contractors. Every effort was taken to align the project with other ongoing work on managing occupational health by other industry bodies, such as the Construction Industry Advisory Committee (CONIAC). The Toolkit is designed to be suitable for use in any contracting company and is freely available as a resource to all those who could benefit in UK construction.

A participative approach was used with civil engineering company directors/health and safety managers to examine current health management practice and barriers to such systems. A Toolkit of best practice for managing occupational ill health, which included health related KPIs, educational aids, and basic health monitoring processes was produced. Dialogue with health and safety management yielded useful feedback. After management interviews with contractors both large and small, 5 key health issues were identified as the main ill health effects within the civil engineering sector:

- hand arm vibration syndrome (HAVS)
- muscular problems

- 
- 
- dermatitis and hand injuries
  - noise-induced deafness
  - respiratory problems

Information obtained from the kerb installation research was made available to the project to support its development, especially sections dealing with muscular problems and training.

### **7.3.1 Potential benefits of the CECA Toolkit**

The principal benefit of the Toolkit would be the establishment of meaningful occupational ill health management arrangements for construction contractors. This would directly address one of the most difficult implementation issues facing the construction industry's Revitalising Health and Safety in Construction programme (DETR 2000). This ultimately would help drive the industry's targets on reducing ill health amongst its workforce. The active management of health issues features heavily in the agendas of all the construction umbrella organisations and in key initiatives such as Rethinking Construction (Egan 1998a) and Accelerating Change (Egan 2002a). Improving health and safety conditions in construction are also an essential component in helping to solve the industry's retention and recruitment problems. Another potential benefit would be the reduction of Employers Liability Insurance premiums for contractors adopting the developed approach.

---

---

### **7.3.2 Work system factors and roles and responsibilities for various kerb installation operations examples**

More detailed task-specific guidance is shown in the following sections based on the balance theory (Smith, Sainfort 1989) model for work systems and considerations that need to be made by the key stakeholders (client, designer, contractor, manufacturer, trainer, and HSE) for construction work involving kerb installation.

In order to provide the construction industry with guidance for the installation of concrete kerbs, a combination of general information (kerb installation process, table of roles and responsibilities) and more specific information (kerb installation scenarios) is required. The following section provides six scenarios chosen to highlight some of the details that not are possible to include in a general process.

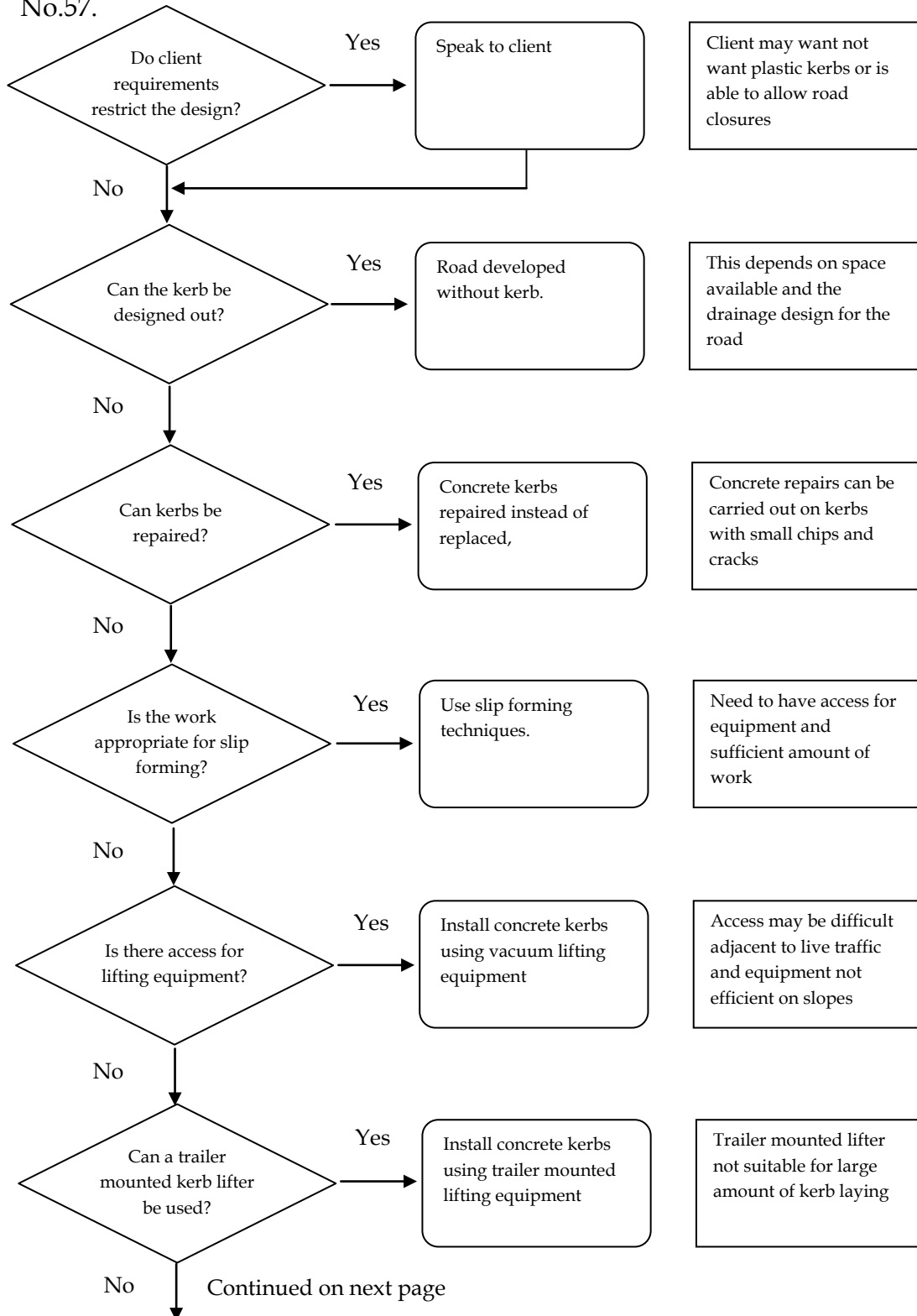
### 7.3.3 Kerb installation operations scenarios

<b>Install kerbs on new housing estate</b>	<b>Install kerbs in new supermarket car park</b>
Heavily twisted road layout. New drainage will be separate. The area is generally flat. Client does not want block paving.	Car park is generally made up of block paving. Car park slopes from bottom left to top right-hand corner.
<b>Replace kerbs on trunk road</b>	<b>Install new kerbs on rural road</b>
Live traffic to be dealt with. Gullies need adjustment but existing drainage is adequate and will not be replaced.	Live traffic to be dealt with. May not need kerbs because of verge width. Drainage has to be replaced at the same time.
<b>Replace existing kerbs on a high street</b>	<b>Replace kerbs on access or slip road</b>
Seven kerbs chipped and cracked. Distance from kerb/road edge to shop fronts is 4.5 m. Existing kerbs form gutter for drainage.	Junction to be closed while work carried out. Alterations also required to drainage.

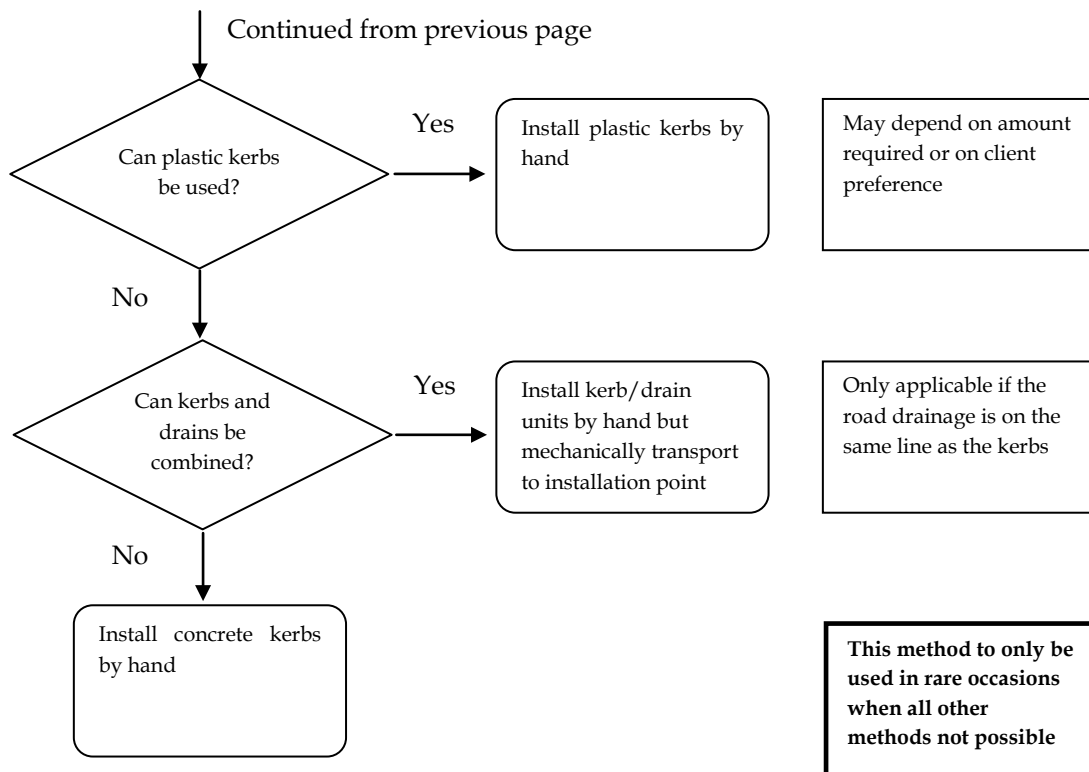
### 7.3.4 Key Stakeholder – Roles and Responsibilities

	Design	Preparation	Installation	Residual risks	Long term
<b>Client</b>	Check that client requirements do not restrict design choice	CDMc to inform client of risks in preparation work	Client to state in tender that manual handling (m/h) not allowed	CDMc to inform client of possible residual risks	CDMc to make sure client aware of maintenance issues
<b>Designer</b>	Go through hierarchy of measures to choose design. Design out if possible.	Designer to visit site to see what preparation work is required for each design	Need to understand how the various options are carried out on site	What equipment/ operations are required with the chosen design	Designer needs to consider sustainability and accessibility affect of design
<b>Contractor</b>	Discuss chosen method with designer as per CDM	Risk assessment to cover preparation work	<b>INSTALL KERBS</b>	Manage residual risks such as noise levels of equipment	Lessons learnt from installation recorded
<b>Manufacturer</b>	Has m/h been considered in delivery, installation and long term	Any manual handling of materials required in the delivery	Materials and equipment need to be appropriate for different situations	Materials and equipment used to reduce m/h must not increase other risks	Speak to contractor to make alterations to equipment as necessary
<b>Trainer</b>	Training must include for latest kerb units and lifting equipment	Training needs to cover delivery, setting up and stringing out	Training required for use of lifting equipment	Include residual risks in training	Training required for maintenance and removal tasks
<b>HSE</b>	HSE construction information sheet No. 57	Guidance to include for preparation work	HSE construction information sheet No. 57	Residual risks need to be listed in guidance and understood by inspectors	Update guidance to include for new materials and equipment

Decision making process for kerb installation in accordance with hierarchy from the Health and Safety Executive's Construction Information Note No.57.







**NOTE: This process has been developed using the findings from the research into the manual handling of concrete highway kerbs and is for guidance only. It is intended that the process be presented to industry professionals for their views in order to verify its accuracy and revise as necessary.**

### 7.3.5 Install kerbs on new housing estate

Organisation	Environment
Focus groups exercise indicated that lighter kerb and block paving would be the preferred solutions. However, block paving solution is not wanted by the client. The focus group discussion highlighted a kerb race as an alternative to early installation of concrete kerbs.	The twisting road layout would have made access for lifting equipment difficult but this not required from the two solutions. The environment should not affect installation with lightweight kerbs or the installation of a kerb race.
Equipment	Task
If repair works were required using concrete kerbs, larger lifting equipment could be replaced with small trailer mounted lifting. This would not be appropriate for installation on the entire housing estate. Steel forms required for the kerb race. No additional equipment required for lightweight kerbs.	The use of the kerb race would include the manual handling of the steel forms as well as hammering in of pins and shovelling of concrete. The use of lightweight kerbs reduces the risks associated with lifting and carrying of concrete kerbs but does not reduce risks associated with posture and increases the repetitive nature of the work. There would also be risks associated with shovelling of concrete bedding material.
Individual	Suggested procedure
Make sure operatives have required training for manual handling of steel forms. Ensure appropriate personal protective equipment is made available for protection from exposure to cement.	Use plastic kerbs as they are less likely to crack or chip than concrete kerbs so will not require replacement in the same numbers.

### 7.3.6 Install kerbs in new supermarket car park

Organisation	Environment
Focus groups exercise indicated that slip forming and traditional concrete kerb would be the preferred solutions. However, the car park is block paved so need to consider integrating the kerb into the block paving.	The car park slopes from the bottom-left to the top-right hand corner so this would have a considerable effect on the use of vacuum lifting equipment which needs to be level in order to work. The equipment would have to continually be adjusted making the operation uneconomical. Slopes may also affect use of slip forming equipment.
Equipment	Task
Mechanical lifting equipment required to install traditional concrete kerbs. Specialised equipment required to install large areas of block paving at a time. Slip forming equipment requires access for concrete to be delivered to feed the machine.	From the postural analysis results the slip forming work had the least obvious risks associated with it. If the block paving equipment is able to incorporate the kerb detail, it will also have little manual handling risks. The use of vacuum lifters to install concrete kerbs had risks associated with hammering in the pins and shovelling concrete.
Individual	Suggested procedure
Training required for use of vacuum lifting equipment, slip forming equipment and block paving equipment. Slip forming and traditional kerbs have risks associated with contact with cement. Training required generally to make workers aware of appropriate PPE and being aware of manual handling risks associated with delivery of materials and moving them around site.	The site slopes would rule out the use of the vacuum lifting equipment. A decision between the other two options would depend on the paving equipment being able to incorporate the kerb detail and the slip forming equipment being able to work on the car park slopes.

### 7.3.7 Replace kerbs on trunk road

Organisation	Environment
Focus groups exercise indicated that slip forming, combined drain/kerb and using no kerb would be the preferred solutions. However, as the existing drainage does not require replacing the kerb/drain is not an option.	Both of the options remove the risk associated with manual handling of kerbs installation adjacent to live traffic. The trunk road traffic would provide too much wear and tear for an asphalt kerb.
Equipment	Task
Slip forming an asphalt kerb would be incorporated with the road surfacing operations. Slip forming a concrete kerb would require slip form equipment and concrete lorries.	From the postural analysis results, the concrete slip forming work had the least obvious risks associated with it. If no kerb was used, the risks would have been designed out.
Individual	Suggested procedure
Training would be required for the use of the concrete slip forming equipment. The asphalt kerb would be included in the road surfacing operation. Training would be required to make workers aware of appropriate PPE and being aware of manual handling risks associated with delivery of materials and moving them around site. Workers would need training to be aware of risks associated with working next to live traffic.	A slip formed asphalt kerb would not stand up to trunk road traffic conditions. A slip formed concrete kerb would have removed virtually all manual handling risks from the installation. The designing out of the kerb would be the best solution providing that there was sufficient room available either side of the carriageway and that the efficient drainage of the road could still be achieved.

### 7.3.8 Install new kerbs on rural road

Organisation	Environment
Focus groups exercise indicated that combined drain/kerb and the traditional concrete kerb would be the preferred solutions. However, there is space available to design out the kerb.	There are no slope or space restrictions for the use of vacuum lifting equipment.
Equipment	Task
Mechanical lifting equipment required to install traditional concrete kerbs. The equipment could also be used to install the drain/kerb units.	The drain/kerb unit installation would require manual handling unless lifting equipment was used. Using lifting equipment to install traditional kerbs would reduce manual handling of the kerbs but there would be risks associated with hammering and shovelling operations.
Individual	Suggested procedure
Make sure operatives have required training for lifting equipment, ensure appropriate personal protective equipment is made available for protection from exposure to cement, hearing protection	First choice would be to design out the kerb if the road layout and drainage were appropriate. Second choice would be to install drain/kerbs if installed with vacuum lifter otherwise use traditional kerbs installed with a vacuum lifter.

### 7.3.9 Replace existing kerbs on high street

Organisation	Environment
<p>Focus groups exercise indicated that using a lighter kerb and block paving would be the preferred solutions. However, the existing concrete kerb is used as part of the drainage channel and with the small amount being replaced would rule out block paving. Results from the safety meetings indicated that repairing kerbs was an option.</p>	<p>Neither option would require as much space as the use of lifting equipment but the option to replace would need a greater working area to accommodate the breaking out and reinstatement operations.</p>
Equipment	Task
<p>Equipment required to break out existing kerbs.</p>	<p>If replacing the kerbs, the existing kerbs would have to be broken out and the rubble manually handled. There would also be associated risks with shovelling of concrete.</p>
Individual	Suggested procedure
<p>Training required for hydraulic breakers. Operatives require training for application of concrete repair materials. Training would be required to make workers aware of appropriate PPE and being aware of manual handling risks associated with delivery of materials and moving them around site.</p>	<p>Repair the seven damaged kerbs with proprietary concrete repair mortars. This would remove manual handling risks and reduce disruption to high street pedestrian traffic.</p>

### 7.3.10 Replace kerbs on access or slip road

Organisation	Environment
Focus groups exercise indicated that using a combined drain/kerb unit was the preferred solutions. However, as the junction is to be closed, lifting equipment should also be considered.	Junction to be closed while work carried out so no live traffic to contend with. Slip road slopes down to main road so will affect the use of lifting equipment.
Equipment	Task
Mechanical lifting equipment required to install kerbs.	Lifting equipment would reduce manual handling risks, as shown in the postural analysis results, but the sloping site would make the equipment difficult to use. Using a combined kerb/drain unit would combine the two operations and reduce but not remove the manual handling risks.
Individual	Suggested procedure
Make sure operatives have required training for lifting equipment, ensure appropriate personal protective equipment is made available for protection from exposure to cement, hearing protection.	Before choosing which method to use, the amount of work being carried out needs to be considered against each of the operations. Is the amount of time taken to level the machine going to risk the workers resorting to manual handling or will the number of drain/kerb units be too great to handle for the operatives to handle?

---

---

## 8 CONCLUSIONS

*“Manual handling is the major source of injury to construction workers. Every year, one third of all construction industry accidents reported to the HSE involve manual handling. These represent only a part of the actual problem, as many back injuries go unreported.”*

- Health and Safety Executive, (HSE 2000).

### 8.1 Kerb installation

At the start of this research the installation of concrete highway kerbs by hand was widespread and included other risk activities (hammering and shovelling) in addition to manual handling. Concrete kerbs are cheap construction products, mass produced to a standard profile from basic materials. Installation by hand makes little difference to the overall cost of a line of kerbs.

The Health and Safety Executive wanted the construction industry to move from the majority of concrete highway kerbs being installed by hand to the majority being installed by mechanical means. The research supported the fact that the majority of work was being carried out using manual handling. Reports by stakeholders that the numbers of vacuum lifters available to do this work was limited supported this.

The Health and Safety Executive provided an effective driver, enforcement of the manual handling regulations with regard to concrete kerb installation by hand, to change existing practices in the construction industry.



---

---

The following sections provide details of the main conclusions from the research and Table 28 outlines the positive and negative aspects associated with the key stakeholders.

## 8.2 Culture

A definition of culture is “it’s the way we do things round here”. The way that the construction industry procures work normally means that the lowest tender wins. This reinforces the use of cheaper manual handling over mechanisation of tasks. There were a number of findings related to the construction industry culture:

- It was said in the focus groups that trainers found it hard to train workers to work safely in an industry where injury is seen as an occupational hazard;
- There were two areas of the designers’ culture affecting the move away from manual handling. They use the heavy concrete kerbs because they come with the reassurance of a British Standard and they are not interested in finding out how their design decisions are acted upon on site;
- The industry needs to, and is taking steps to, dispel the myth that reducing the weight of materials and equipment to 25kg removes manual handling risks;
- Different key stakeholders at many of the meetings indicated that it would be beneficial for designers to attend site more often and talk to the workers in order to have a greater awareness of how their designs affected the construction process;
- Many of the workers appear to be happy to install the concrete kerbs by hand as it was a skill they had learned and they received reasonable remuneration for carrying it out. Some said that they

---

---

could install kerbs more quickly if they were twice the length and half the weight.

### **8.3 Cost**

The construction industry in the UK is very competitive and profit margins are low. During the research, there was a repeated call from contractors for a 'level playing field'.

Contractors wanted clients to state that mechanical installation method should be used and that this should be included in tender documentation. It was suggested that some contractors were prepared to price the work with the intention of carrying it out by manual installation and risk the chance of a fine from the Health and Safety Executive if they were caught.

### **8.4 Enforcement/ Guidance**

Inconsistencies in the HSE's approach to enforcement and guidance documentation made the transition from manual to mechanical methods difficult for those involved with the kerb installation work:

- Stakeholders wanted guidance detailing to work in accordance with the Health and Safety Executive's request for a move towards mechanical handling operations;
- Although contracts include for smaller blocks and bags of cement to satisfy manual handling requirements, they do not allow for mechanical handling of kerbs;
- Workers resist complying with some operations because other operations are carried out with apparent immunity;
- Guidance was prepared from the research findings for the producers of concrete kerbs, through their trade association

---

---

Interpave. These documents were made available free from the Association primarily for their clients but also so that installers could benefit from information.

## **8.5 Technical issues**

Manufacturers seeking to introduce alternatives to manual handling of concrete kerbs have been disregarded in the past because of their cost compared with the manual handling operation. The HSE's enforcement of manual handling had opened up opportunities for innovation:

- The solutions were being imported from abroad with the vacuum lifting devices being developed in Europe;
- The adoption of mechanisation had been held up by equipment supplied from Germany and Denmark having to be adapted to suit the tasks it was being used for in the UK;
- Operations such as slip form paving, which had declined in the UK, was now a more attractive option as the manual handling operations began to disappear;
- By introducing new methods of installing concrete kerbs and kerbs made from lightweight materials, the most significant of the hazards, the weight of the concrete kerb, has been removed but other operations with kerb laying and carrying out similar types of work remain.

## **8.6 Organisation**

Installing the kerbs by hand was very useful when organising work on congested road construction sites which often were adjacent to live traffic.

---

---

Asking contractors to give up this method for one using mechanical equipment required a big change in the organisation of their work.

Training to install concrete highway kerbs was being given to supervisors rather than the installers of the kerbs, and the number of training centres especially for local authority work had reduced considerably. The effectiveness of any training for the installation of concrete highway kerbs was compromised by commercial pressures to carry out the work using traditional methods and also by the lack of supervision of the men who have been trained.

Trainers wanted better supervision of the workers following training so that their instruction was not lost when the workers were left unsupervised on site. They were also keen for the Health and Safety Executive to insist that refresher training be carried out for manual handling.

## **8.7 Communication**

The kerbs forums which were used to bring the key industry stakeholders together to discuss the continued manual handling of concrete kerbs seem to have addressed a communication problem as there had been communication failings between key stakeholders:

- Designers were unaware of construction practices;
- Manufacturers of existing products were not aware of how the packaging of their products affected site operations;
- Manufacturers of new products were not aware that products should not be manually handled;
- Where attempts have been made to tackle the problem, some of these have been hindered because other parties are not considering the problems;

- 
- 
- Many safety associations and individuals in the UK had been working in parallel to solve the problem which lead to a fractured approach rather than a cohesive industry-led approach to tackling the issue.

## **8.8 Strengths and limitations of the research**

The researcher is expected to recognise the strengths and weaknesses of his research and the boundaries to available conclusions drawn (Denscombe 2002). All research has to be carried out with some resource constraints (time, money and opportunity) and the researcher has to manage the resources available. As this was an externally funded project, the time was limited to 12 months and funding was available for one researcher only.

This research benefited from the topic under consideration, the manual handling of concrete highway kerbs, having a high profile within the construction industry due to recent Health and Safety Executive activity immediately prior to the commencement of the research. The collection of a large amount of rich data was achieved through careful selection (large amount of relevant experience in construction and with the task in hand) of industry experts to be interviewed and attend focus groups.

The timescale to produce the guidance material for the project sponsor meant that the literature review and the early interviews and site visits were carried out in parallel. Also, as little research had been carried out into the manual handling of concrete products in the construction industry, there was little previous research work to build on.

---

---

Interpretive research methods and analyses are often criticised for lack of rigour. The rich data obtained by asking experts open ended questions is difficult to apply statistical analyses to. The development of the design of the research has also meant that the researcher appears to have been “designing the plane whilst flying it” with research questions being produced after data collection. This is mainly due to the short timescale of the project and needing to collect data at the earliest opportunity.

To manage the research under these constraints, a steering group (made up of two experienced construction industry members and the research supervisor) met in Loughborough and London every other month. Bimonthly progress reports were also required for submission to the sponsor, Construction Health and Safety Group, prior to the steering group meetings.

Generally, researchers like to use the study of a phenomenon to move towards more universal statements that apply in all situations at all times. This research included postural analysis results from the observation of the tasks which should be able to be repeated. However, results from the interviews and focus groups regarding the perceptions of those involved in the supply chain will have changed since the research was carried out, not least because of the publications produced by the researcher.

Whilst the researcher has, at all times, set out to be impartial whilst carrying out interviews, the fact that the researcher has a history, in the construction industry reaching professional level as a structural engineer, will be open to criticism. However, the thesis contains explicit details of the approach taken by the researcher, along with the way in which resulting data was analysed sufficient for others to judge the final conclusions.

---

---

## 8.9 Contribution of thesis

In the research presented in this thesis, there are three main areas where contributions to theory and practice have been made.

### 8.9.1 Research knowledge

This thesis has added to research into manual handling and construction health and safety. This can be seen in the following answers to the research questions.

Research question I - *What are the key functions and considerations of the training of workers in the installation of highway kerbs?*

Training for kerb laying consisted of showing the trainees how to construct a kerb line and manual handling training was added separately. There was no evidence that workers were being trained to assess and manage the risk.

Research by Laukkanen (Laukkanen 1999) and Helander (Helander 1991) emphasised the need for workers to be trained in task-specific risk assessment, whereas this research found that manual handling training was not task-specific but added on.

There was an overriding belief that training was difficult because of the macho culture in the industry and the feeling that getting an injury was inevitable.

Research question II - *Do alternatives to the manual handling of concrete highway kerbs pose any risks?*

The observation work, including postural analysis, has added to existing research mainly from other industries (Laukkanen 1999) (Davis, Sheppard

---

---

1980) confirming the risk of injury of the manual handling operation and the reduced risks through the use of alternatives. However, some of the alternative methods initially introduced risks (i.e. kerbs falling from lifting equipment and lateral forces from handling of vacuum lifter handles) to the kerb installation operation.

Research question III - *How could the design for safety concept improve the installation of highway kerbs?*

From the analysis of the text data numerous instances of designers' failings were highlighted. There was a perception that they could be doing more with regard to specification of the roads and understanding of site practices. More research is required to see if this is the case.

Research question IV - *How is the risk of injury to the workers affected by the organisation of the work?*

From the research, it was shown that the organisation of work using the manual handling operation was far more flexible than using the mechanical means that the Health and Safety Executive (HSE) were recommending. The manual handling operation continued partly because of the low frequency of enforcement by the HSE. Further research is needed to examine the approach to enforcement by the HSE.

Research question V - *In what way can the culture of those in the supply chain affect the introduction of technical innovations?*

Existing research examining culture refers to advances in technology and the external pressures it places on either organisations (Schein 1980) or national groups (Hofstede 2001). The construction industry, which is seen



---

---

to have a conservative culture, does not yet appear to be equipped to deal with these advances. This is supported by the findings which include responses from the industry resisting demands from the HSE to change operations from manual handling to using lifting equipment.

Schein's research looked at organisations as complex systems. The kerb installation supply chain could possibly be considered as an organisation but certainly as a complex system. The research identified failings in the system, ineffective communication of measures required to enable the change from manual handling to take place.

A number of Journal, national and international conference papers have been published, see Table 27, providing details of manual handling and occupational health in the construction industry and the introduction of construction equipment.

### **8.9.2 Producing construction industry guidance for the management of highway kerb installation**

The second area of contribution is the publication of industry guidance for the installation of highway kerbs. This includes the "Back to Design - manual handling of highway kerbs" manual produced by the author of this thesis for the research sponsors, the Construction Health and Safety Group (CHSG). Hard copies of this manual together with an interactive CD-ROM containing audiovisual training material were distributed to all of the members and electronic copies are openly available from the safety group's website.

This thesis includes a diagrammatic model, in accordance with the Health and Safety Executive's Construction Information Note No. 57, to improve the decision making process of key stakeholders to improve health and safety and easy identification of injury risks. In order to solve these

---

---

occupational injuries, such as work-related musculo-skeletal disorders, the crucial benefit of adequate information communication provided through the guidance is a great advantage for planning a healthy kerb installation process. This model needs further research to test and prove its practical application.

### **8.9.3 Providing input to construction industry bodies for their occupational health guidance literature.**

The third area of contribution is the researcher's use of the knowledge gained from the project to work with a construction industry body, Civil Engineering Contractors Association (CECA), and a trade association, Interpave, to produce guidance material for improving occupational health. The CECA guidance covers key areas of occupational health to which this research contributed to the manual handling section. The Interpave guidance targeted not only the installation of concrete highway kerbs but also guidance was produced for the installation of concrete paving slabs.

Other research outputs derived from this research are as follows:

### **8.10 Recommendations for further research**

Exploratory investigations similar to this should be carried out for the manual handling of concrete blocks in construction industry masonry work and also the manual handling of bagged construction materials. These two operations were subject to targeted enforcement and regulation by the Health and Safety Executive prior to their involvement with the manual handling of concrete highway kerbs. Comparisons can then be drawn across the three separate manual handling operations.

---

---

The role of the designer in the kerb installation process was generally criticised by other stakeholders in this research. This may have had something to do with parallel discussions of the designers' role within the Construction Design and Management Regulations. Research should be carried out with designers to find working practices that will enable them to better consider the health of site workers when producing their designs.

As indicated in the discussion section, other research has criticised manual handling training as having little effect on the health and well-being of workers. Indications from the focus group that concentrated on training were that the current methods adopted in the construction industry fell short of what was required. Therefore research should be carried out with contractors and training organisations to find out why current practice is failing and look for better methods to adopt in order to improve manual handling training.

The experience of the introduction of alternative kerb units produced with recycled materials into the kerb installation process has shown the benefit of multiple drivers for introducing change. These units were being developed to satisfy local authorities' need to adopt sustainable practices before the manual handling of concrete kerbs became an issue. Having the added benefit of improving health and safety practices accelerated the adoption of the units as an alternative product. Further research into the benefits of multiple drivers needs to be carried out.

Year	Title	Publication / Conference	
<b>2003</b>			
Bust, P.D., Gibb, A.G.F. and Haslam, R.A.,	"Manual Handling During Installation of Highway Kerbs", The Ergonomics Society of Korea (eds), Seoul, Korea, ISBN 8990838 10 X, [CD-ROM].	Proceedings of the XVth Triennial Congress of the International Ergonomics Association and 7th Joint Conference of Ergonomics Society of Korea/Japan Ergonomics Society	C
Bust, P.D.	Manual handling during installation of highway kerbs presentation	Construction Safety Challenging the Norm and Good Neighbouring - Health and Safety Executive London November 2003	S
<b>2004</b>			
Bust, P.D. and Gibb, A.G.F.,	Manual handling of highway kerbs - Presentation	Construction Health and Safety Group, Chertsey - Launch of Back to Design publication	S
Bust, P.D. and Gibb, A.G.F.,	Back to Design - Manual handling of highway kerbs	Construction Health and Safety Group, Chertsey, UK, 2004, 75 pp, ISBN 1 873844 56 5.	B
Bust, P.D.	Manual handling during installation of highway kerbs presentation	Health and Safety Executive/Merseyside and Cheshire Construction Safety Group Liverpool March 2004	S
Bust, P.D., Gibb, A.F.G. and Haslam, R.A.	Manual handling in the construction industry: Finding a format for change	Contemporary Ergonomics 2004, Taylor and Francis, London, pp 235-239.	C
Bust, P.D.	Handling Kerbs: Guide to the handling of precast concrete kerbs	Interpave - Precast concrete paving and kerb association	B
Bust, P.D.	Manual handling including kerb lifting presentation	North West Construction Safety Group Seminar. Manchester	S

		October 2004	
Bust, P.D.	Manual handling presentation	Association of Planning Supervisors/Bromley Council October 2004	S
<b>2005</b>			
Bust, P.D., Gibb, A.G.F. and Haslam, R.A.,	"Manual Handling in Construction: Lessons from highway kerbs", Rethinking and Revitalising Construction Safety, health, environment & quality,	Proceedings of the triennial international conference, Port Elizabeth, South Africa, 2005, pp 442-449.	C
Bust, P.D., Gibb, A.G.F. and Haslam, R.A.,	"Manual Handling of highway kerbs-focus group findings",	Applied Ergonomics, 36, 2005, pp 417-425.	J
<b>2009</b>			
Bust, P.D.	Manual handling of concrete kerbs in the construction industry; the response by contractors to enforcement presentation	'Coping with Health and Safety Legislation' - IOSH/South Cumbria Occupational Health and Safety Group	S

Key -

C	Conference Paper	J	Journal Paper	P	Conference Poster
S	Invited Speaker	B	Book	R	Report

Table 27 Kerbs Research – Publications and Presentations

Negatives	Key stakeholders	Positives
Lack of site knowledge; specifying conservative options.	Designer	Starting to adopt role under CDM.
Changing packaging without understanding consequences to site operation, thinking that lightweight products are acceptable.	Manufacturer	Introducing lifting equipment; introducing alternative kerbs; producing guidance for installation; concrete kerbs quality down to British Standard.
Continuing to manual handle; emphasising faults in new equipment to avoid using it; pricing for manual handling.	Contractor	Pushed for forums.
Fewer training centres; training supervisors and not operatives.	Trainer	Involving equipment manufacturers in training.
Claiming special circumstances; accepting lowest tenders.	Client	Local Authorities using vacuum lifters.
Inconsistencies in enforcement and documentation; delay in producing guidance and then not listening addressing industry requests.	HSE	Enforcement.
Poor communication between stakeholders; manual handling still an issue in construction.	General	Increased use of mechanical lifting.

Table 28 Negative and positive aspects of kerb installation associated with key stakeholders

---

---

## 9 REFERENCES

- Abbott, C. & Allen, S. 2005, "Facilitating innovation: the role of the centre for construction innovation", *International Journal of Strategic Property Management*, vol. 9, no. 2, pp. 79-89.
- Alasuutari, P. 1995, *Researching culture: Qualitative method and cultural studies*, SAGE publications Ltd, London.
- Annett, J. & Duncan, K.D. 1967, "Task analysis and training design", *Hull University, Psychology Department. Microfiche.*, .
- AP Koningsveld, E. 1997, "History and future of ergonomics in building and construction", *Ergonomics*, vol. 40, no. 10, pp. 1025-1034.
- Ayoub, M.M. 1992, "Problems and solutions in manual materials handling: the state of the art", *Ergonomics*, vol. 35, no. 7, pp. 713-728.
- Barthorpe, S., Duncan, R. & Miller, C. 2000, "The pluralistic facets of culture and its impact on construction", *Property management*, vol. 18, no. 5, pp. 335-351.
- Baxendale, T. & Jones, O. 2000, "Construction design and management safety regulations in practice--progress on implementation", *International Journal of Project Management*, vol. 18, no. 1, pp. 33-40.
- Behm, M. 2005, "Linking construction fatalities to the design for construction safety concept", *Safety Science*, vol. 43, no. 8, pp. 589-611.
- Bernard, B.P. 1997, "Musculoskeletal disorders and workplace factors: a critical review of epidemiologic evidence for work-related musculoskeletal disorders of the neck, upper extremity, and low back", *US.Department of Health and Human Sciences. NIOSH*, .
- Berndsen, M.B. 1990, "Appliances for pavours: an evaluation of purchase and use", *Ergonomics*, vol. 33, no. 3, pp. 361-366.
- Blayse, A.M. & Manley, K. 2004, "Key influences on construction innovation", *Construction Innovation: Information, Process, Management*, vol. 4, no. 3, pp. 143-154.

- 
- 
- Bruseberg, A. & McDonagh-Philp, D. 2002, "Focus groups to support the industrial/product designer: a review based on current literature and designers' feedback", *Applied Ergonomics*, vol. 33, no. 1, pp. 27-38.
- Buchanan, R.A. 2006, *Brunel: the life and times of Isambard Kingdom Brunel*, Continuum International Publishing Group, London.
- Buchholz, B., Paquet, V., Punnett, L., Lee, D. & Moir, S. 1996, "PATH: A work sampling-based approach to ergonomic job analysis for construction and other non-repetitive work", *Applied Ergonomics*, vol. 27, no. 3, pp. 177-187.
- Buckle, P.W., Stubbs, D.A., Randle, I.P.M. & Nicholson, A.S. 1992, "Limitations in the application of materials handling guidelines", *Ergonomics*, vol. 35, no. 9, pp. 955-964.
- Burdorf, A., Govaert, G. & Elders, L. 1991, "Postural load and back pain of workers in the manufacturing of prefabricated concrete elements", *Ergonomics*, vol. 34, no. 7, pp. 909-918.
- Burgess-Limerick, R. 2003, "Squat, stoop, or something in between?", *International Journal of Industrial Ergonomics*, vol. 31, no. 3, pp. 143-148.
- Bust, P., Gibb, A.G.F. & Haslam, R. 2005, "Manual handling of highway kerbs--focus group findings", *Applied Ergonomics*, vol. 36, no. 4, pp. 417-425.
- Carayon, P. & Smith, M.J. 2000, "Work organization and ergonomics", *Applied Ergonomics*, vol. 31, no. 6, pp. 649-662.
- Castles, S. 2004, "The Factors that Make and Unmake Migration Policies1", *International Migration Review*, vol. 38, no. 3, pp. 852-884.
- Chaffin, D.B., Stump, B.S., Nussbaum, M.A. & Baker, G. 1999, "Low-back stresses when learning to use a materials handling device", *Ergonomics*, vol. 42, no. 1, pp. 94-110.
- Chinda, T. & Mohamed, S. 2008, "Structural equation model of construction safety culture", *Engineering, Construction and Architectural Management*, vol. 15, no. 2, pp. 114-131.
- Choudhry, R.M., Fang, D. & Mohamed, S. 2007, "The nature of safety culture: A survey of the state-of-the-art", *Safety Science*, vol. 45, no. 10, pp. 993-1012.



- 
- 
- Christensen, W.C. & Manuele, F.A. 1999, *Safety through design*, National Safety Council Press.
- Christie, B., Scane, R. & Collyer, J. 1995, "Evaluation of human-computer interaction at the user interface to advanced IT systems" in *Evaluation of Human Work*, Second edn, Taylor and Francis, London, pp. 310-356.
- Cox, S. 1998, "Safety culture: philosopher's stone or man of straw?", *Work & Stress*, vol. 12, no. 3, pp. 189-201.
- Creswell, J.W. 2003, *Research design*, Second edn, Sage Publications, Thousand Oaks, California. USA.
- Crotty, M. 1998, *The foundations of social research: Meaning and perspective in the research process*, Sage Publications Ltd. California. USA.
- Davis, P.R. & Sheppard, N.J. 1980, "Pattern of accident distribution in the telecommunications industry.", *British journal of industrial medicine*, vol. 37, no. 2, pp. 175.
- De Villiers, M.R. 2005, "Three approaches as pillars for interpretive information systems research: development research, action research and grounded theory", *Proceedings of the 2005 annual research conference of the South African institute of computer scientists and information technologists on IT research in developing countries* South African Institute for Computer Scientists and Information Technologists, , pp. 142.
- Denscombe, M. 2002, *Ground Rules for Goal research: a 10 point guide for social researchers*, Open University Press, Buckingham, UK.
- Denzin, N. & Lincoln, Y. 2000, *The Handbook of Qualitative Research*, 2 ed. edn, Footprint Books, NSW. Australia.
- Department of the Environment, Transport and Regions 2000, *Revitalising Health and Safety Strategy Statement*, Department of the Environment, Transport and Regions, UK.
- Dickinson, C.E. 1995, "Proposed manual handling international and European Standards\* 1", *Applied Ergonomics*, vol. 26, no. 4, pp. 265-270.
- Douglas, M. 1970, *Natural Symbols: explorations in cosmologies*, Routledge, London.
- Drury, C.G. 1983, "Task analysis methods in industry", *Applied Ergonomics*, vol. 14, no. 1, pp. 19-28.

- 
- 
- Duffy, B.M. 2004, "Techniques and Procedures for an Effective Communication of Health and Safety Information" in *Designing for Safety and Health in Construction - Proceedings from a Research and Practice Symposium*, eds. S. Hecker, J. Gambatese & M. Weinstein, University of Oregon Press, Oregon. USA., pp. 118-135.
- DuTemple, L.A. 2003, *The Hoover Dam*, Lerner Pub Group, Minneapolis. USA.
- EC 1993, *Europe for health and safety at work, Social Europe 3/93, DG V, European Commission, Office for Official Publications of the European Communities, Luxembourg.*
- Egan, J. 2002a, "Accelerating change", *Rethinking construction. Strategic Forum for Construction* Construction Industry Council, London.
- Egan, J. 2002b, *Accelerating change: a report by the strategic forum for construction*, Construction Industry Council, London.
- Egan, J. 1998a, "Rethinking construction: The report of the construction task force", *DETR, London*, .
- Egan, J. 1998b, *Rethinking construction: The report of the construction task force*, DETR, London.
- Egbu, C.O. 2004, "Managing knowledge and intellectual capital for improved organizational innovations in the construction industry: an examination of critical success factors", *Engineering, Construction and Architectural Management*, vol. 11, no. 5, pp. 301-315.
- Fandel, J. 2006, *Golden Gate Bridge*, Creative Education Publishing. USA.
- Farid, F., El-Sharkawy, A.R. & Austin, L.K. 1993, "Managing for Creativity and Innovation in A/E/C organizations", *Journal of Management in Engineering*, vol. 9, no. 4, pp. 399-409.
- Fellows, R. & Liu, A. 2008, *Research methods for construction*, Blackwell Pub, Oxford, UK.
- Fox, P.W. 2007, "The culture of the construction industry" in *People and Culture in Construction: A reader.*, eds. A. Dainty, S. Green & B. Bagilhole, Taylor & Francis, London., pp. 278.
- Gale, A.W. 1994, "Women in non-traditional occupations: the construction industry", *Women in Management Review*, vol. 9, no. 2, pp. 3-14.

- 
- 
- Gambatese, J.A. 2008, "Research issues in prevention through design", *Journal of Safety Research*, vol. 39, no. 2, pp. 153-156.
- Gann, D. 2000, *Building innovation: complex constructs in a changing world*, Thomas Telford Services Ltd, London.
- García, M.Á. 2005, "Challenges of the construction sector in the global economy and the knowledge society", *International Journal of Strategic Property Management*, vol. 9, no. 2, pp. 65-77.
- Gesey, M., Glass, J. & Bouchlaghem, N.M. 2006, "iCON: A web-based innovation assessment tool for construction organisations.", *The joint international conference on construction culture, innovation and management (CCIM)*, ed. M. Dulaimi, The British University in Dubai (BUiD), Dubai, UAE.
- Gibb, A. 2004, *Health-Safety's Poor Cousin-The Challenge for the Future*, Taylor & Francis, London.
- Gibb, A. 2003, *D4h-Designing for health-Best practice exemplars*, XXVII International Symposium On Health And Safety Management, Lisbon, Portugal.
- Glendon, A.I. & Stanton, N.A. 2000, "Perspectives on safety culture", *Safety Science*, vol. 34, no. 1-3, pp. 193-214.
- Grandjean, E. 1983, *Occupational Health Aspects of Construction Work*, World Health Organisation, Geneva.
- Guldenmund, F.W. 2000, "The nature of safety culture: a review of theory and research", *Safety Science*, vol. 34, no. 1, pp. 215-257.
- Gundewall, B., Liljeqvist, M. & Hansson, T. 1993, "Primary prevention of back symptoms and absence from work: a prospective randomized study among hospital employees", *Spine*, vol. 18, no. 5, pp. 587.
- Hadikusumo, B. & Rowlinson, S. 2002, "Integration of virtually real construction model and design-for-safety-process database", *Automation in Construction*, vol. 11, no. 5, pp. 501-509.
- Hamilton, E.J. 1942, "Profit Inflation and the Industrial Revolution, 1751-1800", *The Quarterly Journal of Economics*, vol. 56, no. 2, pp. 256-273.

- 
- 
- Hartmann, A. 2006, "The role of organizational culture in motivating innovative behaviour in construction firms", *Construction Innovation: Information, Process, Management*, vol. 6, no. 3, pp. 159-172.
- Harty, C. 2005, "Innovation in construction: a sociology of technology approach", *Building research and information*, vol. 33, no. 6, pp. 512-522.
- Haslam, C., Clemes, S., McDermott, H., Shaw, K., Williams, C. & Haslam, R. 2007, *Manual handling training-Investigation of current practices and development of guidelines*, Health and Safety Executive, Norwich. (UK).
- Haslam, R.A., Hide, S.A., Gibb, A.G.F., Gyi, D.E., Pavitt, T., Atkinson, S. & Duff, A.R. 2003, "Contributing factors in construction accidents", *Applied Ergonomics*, vol. 36, no. 4, pp. 401-415.
- Hatch, M.J. 1993, "The dynamics of organizational culture", *Academy of management review*, , pp. 657-693.
- Health and Safety Executive 2003, *Revitalising Health and Safety in Construction*, Health and Safety Executive, UK.
- Hecker, S. & Gambatese, J. 2004, "Training Students for Design Safety in Construction", *ASSE Professional Development Conference and Exposition* American Society of Safety Engineers, , 7-10 June 2004.
- Hecker, S. & Gambatese, J.A. 2003, "Safety in design: a proactive approach to construction worker safety and health", *Applied Occupational and Environmental Hygiene*, vol. 18, no. 5, pp. 339-342.
- Helander, M. 1980, "Safety challenges in the construction industry", *Journal of Occupational Accidents*, vol. 2, no. 4, pp. 257-263.
- Helander, M.G. 1991, "Safety hazards and motivation for safe work in the construction industry", *International Journal of Industrial Ergonomics*, vol. 8, no. 3, pp. 205-223.
- Hignett, S. & McAtamney, L. 2000, "Rapid entire body assessment (REBA)", *Applied Ergonomics*, vol. 31, no. 2, pp. 201-206.
- Hofstede, G.H. 2001, *Culture's consequences: Comparing Values, Behaviours, Institutions, and Organizations Across Nations*. Second edn, sage, Thousand Oaks, California. USA.

- 
- 
- Holmström, E. & Ahlborg, B. 2005, "Morning warming-up exercise--effects on musculoskeletal fitness in construction workers", *Applied Ergonomics*, vol. 36, no. 4, pp. 513-519.
- Holstein, J.A. & Gubrium, J.F. 1995, *The active interview*, Sage Publications, Inc, Thousand Oaks, California.
- Holstein, J.A. & Staples, W.G. 1992, "Producing Evaluative Knowledge: The Interactional Bases of Social Science Findings\*", *Sociological Inquiry*, vol. 62, no. 1, pp. 11-35.
- Holt, A.S.J. 2002, *Principles of health and safety at work*, Sixth edn, IOSH Services Limited, Wigston, UK.
- HSC 1993, *ACSNI Study Group on Human Factors: Third Report - Organising for Safety*, HSE Books, Sudbury, UK.
- HSE 2000, *Backs for the Future*, Health and Safety Executive, Norwich (UK).
- Jackson, S. & Philip, G. 2005, "Organizational Culture and the Management of Technological Change: A Theoretical Perspective", *ECIS 2005 Proceedings*, , pp. 149.
- James, P. 1993, *The European Community A positive force for UK health and safety law?* Institute of Employment Rights, London (UK).
- Jassawalla, A.R. & Sashittal, H.C. 2002, "Cultures that support product-innovation processes", *The Academy of Management Executive* (1993-2005), , pp. 42-54.
- Jones, J.R., Huxtable, C.S., Hodgson, J.T., Britain, G. & Statistical Office of the European Communities 2001, *Self-reported work-related illness in 1998/99: results from EUROSTAT ill-health module in the 1999 Labour Force Survey summer quarter*, Health and Safety Executive, Norwich (UK).
- Kaminskas, K.A. & Kazlauskaite, R. 2008, "Ergonomics for reduction of low back stress of construction workers", *SVEIKATOS*, [Online], , pp. 116. Available from: [www.sam.lt/mokslas.htm](http://www.sam.lt/mokslas.htm).
- Kaukiainen, A., Sillanpää, J., Lappalainen, J., Viljanen, M. & Nyberg, M. 2002, "New Equipment to Lighten the Work Load of Construction Workers", *International Journal of Occupational Safety and Ergonomics*, vol. 8, no. 2, pp. 209-224.

- 
- 
- Kee, D. & Karwowski, W. 2001, "LUBA: an assessment technique for postural loading on the upper body based on joint motion discomfort and maximum holding time", *Applied Ergonomics*, vol. 32, no. 4, pp. 357-366.
- Kivi, P. & Mattila, M. 1991, "Analysis and improvement of work postures in the building industry: application of the computerised OWAS method", *Applied Ergonomics*, vol. 22, no. 1, pp. 43-48.
- Knapik, J.J. & Sharp, M.A. 1998, "Task-specific and generalized physical training for improving manual-material handling capability", *International Journal of Industrial Ergonomics*, vol. 22, no. 3, pp. 149-160.
- Koningsveld, E.A.P. 1997, "History and future of ergonomics in building and construction", *Ergonomics*, vol. 40, no. 10, pp. 1025-1034.
- Kroemer, K.H.E. 1992, "Personnel training for safer material handling", *Ergonomics*, vol. 35, no. 9, pp. 1119-1134.
- Kuiper, J.I., Burdorf, A., Verbeek, J.H.A.M., Frings-Dresen, M.H.W., van der Beek, A.J. & Viikari-Juntura, E.R.A. 1999, "Epidemiologic evidence on manual materials handling as a risk factor for back disorders: a systematic review", *International Journal of Industrial Ergonomics*, vol. 24, no. 4, pp. 389-404.
- Laborers' Health & Safety Fund of North America 2010, , *Ergonomics & Construction - the Smart Move: Back, Shoulder, Knee and Other Musculoskeletal Problems*. Available: <http://www.lhsfna.org/index.cfm?objectid=EB4CE18C-D56F-E6FA-9F264298BF045289> [2010, .
- Langford, J.D. & McDonagh, D. 2003, *Focus groups: supporting effective product development*, Taylor and Francis, London.
- Latham, M. 1994, *Constructing the team: final report: joint review of procurement and contractual arrangements in the United Kingdom construction industry*, Her Majesty's Stationary Office, London.
- Latza, U., Pfahlberg, A. & Gefeller, O. 2002, "Impact of repetitive manual materials handling and psychosocial work factors on the future prevalence of chronic low-back pain among construction workers", *Scandinavian journal of work environment and health*, vol. 28, no. 5, pp. 314-323.

- 
- 
- Laukkanen, T. 1999, "Construction work and education: occupational health and safety reviewed", *Construction Management and Economics*, vol. 17, no. 1, pp. 53-62.
- Le Gros Clark, W.E. 1976, "Ergonomics" in *Oxford English Dictionary*, 2nd edn, Oxford University Press, Oxford.
- Ling, F.Y.Y. 2003, "Managing the implementation of construction innovations", *Construction Management and Economics*, vol. 21, no. 6, pp. 635-649.
- Lingard, H. & Rowlinson, S.M. 2005, *Occupational health and safety in construction project management*, Taylor & Francis, London.
- Litsios, S. 2001, "William Crawford Gorgas (1854-1920)", *Perspectives in biology and medicine*, vol. 44, no. 3, pp. 368-378.
- Mack, K., Haslegrave, C.M. & Gray, M.I. 1995, "Usability of manual handling aids for transporting materials", *Applied Ergonomics*, vol. 26, no. 5, pp. 353-364.
- MacLeod, D. 2000, *The rules of work: a practical engineering guide to ergonomics*, CRC Press, Inc.
- Manseau, A. & Shields, R. 2005, *Building tomorrow: innovation in construction and engineering*, Ashgate Pub Co, Aldershot, UK.
- Martimo, K.P., Verbeek, J., Karppinen, J., Furlan, A.D., Takala, E.P., Kuijer, P.P.F.M., Jauhiainen, M. & Viikari-Juntura, E. 2008, "Effect of training and lifting equipment for preventing back pain in lifting and handling: systematic review", *British medical journal*, vol. 336, no. 7641.
- Martínez Aires, M.D., Rubio Gámez, M.C. & Gibb, A. 2010, "Prevention through design: The effect of European Directives on construction workplace accidents", *Safety Science*, vol. 48, no. 2, pp. 248-258.
- McAtamney, L. & Nigel Corlett, E. 1993, "RULA: a survey method for the investigation of work-related upper limb disorders", *Applied Ergonomics*, vol. 24, no. 2, pp. 91-99.
- Merlino, L.A., Rosecrance, J.C., Anton, D. & Cook, T.M. 2003, "Symptoms of musculoskeletal disorders among apprentice construction workers", *Applied Occupational and Environmental Hygiene*, vol. 18, no. 1, pp. 57-64.

- 
- 
- Miller, P. & Brankovic, A. 2010, "Building a "creative culture" for sustainable innovation", *IESE Research Papers*, .
- Morse, J.M. & Richards, L. 2002, *Read me first for a user's guide to qualitative methods*, Sage Publications, Inc, Thousand Oaks, California, USA.
- Mugo, F.W. 2008, "Sampling in research", Retrieved from <http://www.socialresearchmethods.net/tutorial/Mungo/tutorial.htm>, .
- Nussbaum, M.A., Chaffin, D.B. & Baker, G. 1999, "Biomechanical analysis of materials handling manipulators in short distance transfers of moderate mass objects: joint strength, spine forces and muscular antagonism", *Ergonomics*, vol. 42, no. 12, pp. 1597-1618.
- Nussbaum, M.A., Chaffin, D.B., Stump, B.S., Baker, G. & Foulke, J. 2000, "Motion times, hand forces, and trunk kinematics when using material handling manipulators in short-distance transfers of moderate mass objects", *Applied Ergonomics*, vol. 31, no. 3, pp. 227-237.
- Paquet, V.L., Punnett, L. & Buchholz, B. 2001, "Validity of fixed-interval observations for postural assessment in construction work", *Applied Ergonomics*, vol. 32, no. 3, pp. 215-224.
- Park, M., Nepal, M.P. & Dulaimi, M.F. 2004, "Dynamic modeling for construction innovation", *Journal of Management in Engineering*, vol. 20, pp. 170.
- Patton, M.Q. 2002, *Qualitative research and evaluation methods*, Sage Publications, Thousand Oaks, California. USA.
- Pheasant, S. 1991, *Ergonomics, work and health*, Macmillan Press, London.
- Rabinowitz, D., Bridger, R.S. & Lambert, M.I. 1998, "Lifting technique and abdominal belt usage: a biomechanical, physiological and subjective investigation", *Safety Science*, vol. 28, no. 3, pp. 155-164.
- Reichstein, T., Salter, A.J. & Gann, D.M. 2005, "Last among equals: a comparison of innovation in construction, services and manufacturing in the UK", *Construction Management and Economics*, vol. 23, no. 6, pp. 631-644.
- Reid, A., Pinder, A. & Monnington, S. 2001, *Musculoskeletal problems in bricklayers, carpenters and plasterers: Literature review and results of site visits*, Health and Safety Laboratories, Sheffield (UK).



- 
- 
- Resnick, M. & Chaffin, D.B. 1997, "An ergonomic evaluation of three classes of material handling device (MHD)", *International Journal of Industrial Ergonomics*, vol. 19, no. 3, pp. 217-229.
- Robson, C. 2002, *Real world research: A resource for social scientists and practitioner-researchers*, Wiley-Blackwell, Oxford, UK.
- Sanders, M.S. & McCormick, E.J. 1993, *Human Factors in Engineering and Design*, Seventh edn, McGraw-Hill, New York.
- Schein, E.H. 1990, "Organizational culture.", *American psychologist*, vol. 45, no. 2, pp. 109.
- Schein, E.H. 1980, *Organizational Psychology*, Third edn, Prentice-Hall Inc, New Jersey, USA.
- Schneider, S. & Susi, P. 1994, "Ergonomics and construction: a review of potential hazards in new construction", *American Industrial Hygiene Association Journal*, vol. 55, no. 7, pp. 635-649.
- Seaden, G., Guolla, M., Doutriaux, J. & Nash, J. 2003, "Strategic decisions and innovation in construction firms", *Construction Management and Economics*, vol. 21, no. 6, pp. 603-612.
- Seaden, G. & Manseau, A. 2001a, "Public policy and construction innovation", *Building Research & Information*, vol. 29, no. 3, pp. 182-196.
- Seaden, G. & Manseau, A. 2001b, "Public policy and construction innovation", *Building research and information*, vol. 29, no. 3, pp. 182-196.
- Sebestyén, G. 1998, *Construction: craft to industry*, Taylor & Francis, London.
- Seddon, H.J. 1961, "THE MANCHESTER SHIP CANAL AND THE COLONIAL FRONTIER: The Seventeenth Robert Jones Lecture delivered at the Royal College of Surgeons of England on December 8, 1960", *Journal of Bone and Joint Surgery-British Volume*, vol. 43, no. 3, pp. 425.
- Sexton, M. & Barrett, P. 2003a, "Appropriate innovation in small construction firms", *Construction Management and Economics*, vol. 21, no. 6, pp. 623-633.

- 
- Sexton, M. & Barrett, P. 2003b, "A literature synthesis of innovation in small construction firms: insights, ambiguities and questions", *Construction Management and Economics*, vol. 21, no. 6, pp. 613-622.
- Shepherd, A. & Stammers, R.B. 1995, "Task analysis" in *Evaluation of Human Work: A Practical Ergonomics Methodology*, Second edn, Taylor and Francis, Basingstoke, Hants., pp. 129-158.
- Shipley, P. 1995, "The analysis of organisations as an aid for ergonomic practice." in *Evaluation of Human Work: A practical ergonomics methodology.*, ed. Wilson, J.R. and Corelitt, E.N., Second edn, Taylor & Francis, London., pp. 993.
- Singleton, W.T. 1982, *The Body at work: biological ergonomics*, Cambridge University Press, (UK).
- Slaughter, E.S. 1998, "Models of construction innovation", *Journal of Construction Engineering and Management*, vol. 124, no. 3, pp. 226-231.
- Slaughter, E.S. 1993, "Builders as sources of construction innovation", *Journal of Construction Engineering and Management*, vol. 119, no. 3, pp. 532-549.
- Smallwood, J., Wheeler, C. & Venter, D. 2000, "Ergonomics in Construction: Where Does it Hurt", (*Part of 2nd International Symposium on Ergonomics in Building and Construction, IEA, August 2000*)International Ergonomics Association, elcosh website.
- Smith, M.J. & Sainfort, P.C. 1989, "A balance theory of job design for stress reduction", *International Journal of Industrial Ergonomics*, vol. 4, no. 1, pp. 67-79.
- Spangenberg, S., Baarts, C., Dyreborg, J., Jensen, L., Kines, P. & Mikkelsen, K.L. 2003, "Factors contributing to the differences in work related injury rates between Danish and Swedish construction workers", *Safety Science*, vol. 41, no. 6, pp. 517-530.
- Stanton, N. & Young, M.S. 1999, *A Guide to methodology in ergonomics: designing for human use*, Taylor and Francis, London.
- Stubbs, D.A. & Nicholson, A.S. 1979, "Manual handling and back injuries in the construction industry: an investigation", *Journal of Occupational Accidents*, vol. 2, no. 3, pp. 179-190.

- 
- 
- Tashakkori, A. & Teddlie, C. 1998, *Mixed methodology: Combining qualitative and quantitative approaches*, Sage Publications, Inc, Thousand Oaks, California.
- Taylor, F.W. 1911, *The Principles of Scientific Management*, Dover Publication Inc, Mineola, NY. USA.
- Tellis, W. 1997, "Introduction to case study", *The qualitative report*, vol. 3, no. 2, pp. 1-11.
- Tolba, A.H. & Mourad, M. 2011, "Individual and cultural factors affecting diffusion of innovation", *Journal of International Business and Cultural Studies*, vol. 5, pp. 1-16.
- Tomala, F. & Sénéchal, O. 2004, "Innovation management: a synthesis of academic and industrial points of view", *International Journal of Project Management*, vol. 22, no. 4, pp. 281-287.
- Toole, T.M. 2002, "Construction site safety roles", *Journal of Construction Engineering and Management*, vol. 128, no. 3, pp. 203-210.
- Toole, T.M. 1998, "Uncertainty and home builders' adoption of technological innovations", *Journal of Construction Engineering and Management*, vol. 124, pp. 323.
- Törner, M., Zetterberg, C., Andén, U., Hansson, T. & Lindell, V. 1991, "Workload and musculoskeletal problems: a comparison between welders and office clerks (with reference also to fishermen)", *Ergonomics*, vol. 34, no. 9, pp. 1179-1196.
- Vecchio-Sadus, A.M. & Griffiths, S. 2004, "Marketing strategies for enhancing safety culture", *Safety Science*, vol. 42, no. 7, pp. 601-619.
- Vedder, J. & Carey, E. 2005, "A multi-level systems approach for the development of tools, equipment and work processes for the construction industry", *Applied Ergonomics*, vol. 36, no. 4, pp. 471-480.
- Veshosky, D. 1998, "Managing innovation information in engineering and construction firms", *Journal of Management in Engineering*, vol. 14, no. 1, pp. 58-66.
- Wassell, J.T., Gardner, L.I., Landsittel, D.P., Johnston, J.J. & Johnston, J.M. 2000, "A prospective study of back belts for prevention of back pain and injury", *JAMA*, vol. 284, no. 21, pp. 2727.

---

---

Winch, G.M. 2003, "How innovative is construction? Comparing aggregated data on construction innovation and other sectors-a case of apples and pears", *Construction Management and Economics*, vol. 21, no. 6, pp. 651-654.

Wright, E. & Haslam, R.A. 1999, "Manual handling risks and controls in a soft drinks distribution centre", *Applied Ergonomics*, vol. 30, no. 4, pp. 311-318.

Yin, R. 1994, *Case study research: Design and methods*, Sage, Thousand Oaks, California, USA.

---

---

## **10 APPENDICES**

**10.1 Task analyses**

**10.2 HSE hand-out at second kerbs forum**

**10.3 Back to Design report**

**10.4 Interpave kerb handling guidance**

**10.5 Interpave flag handling guidance**

## **Appendix 10.1**

### **Task analyses**

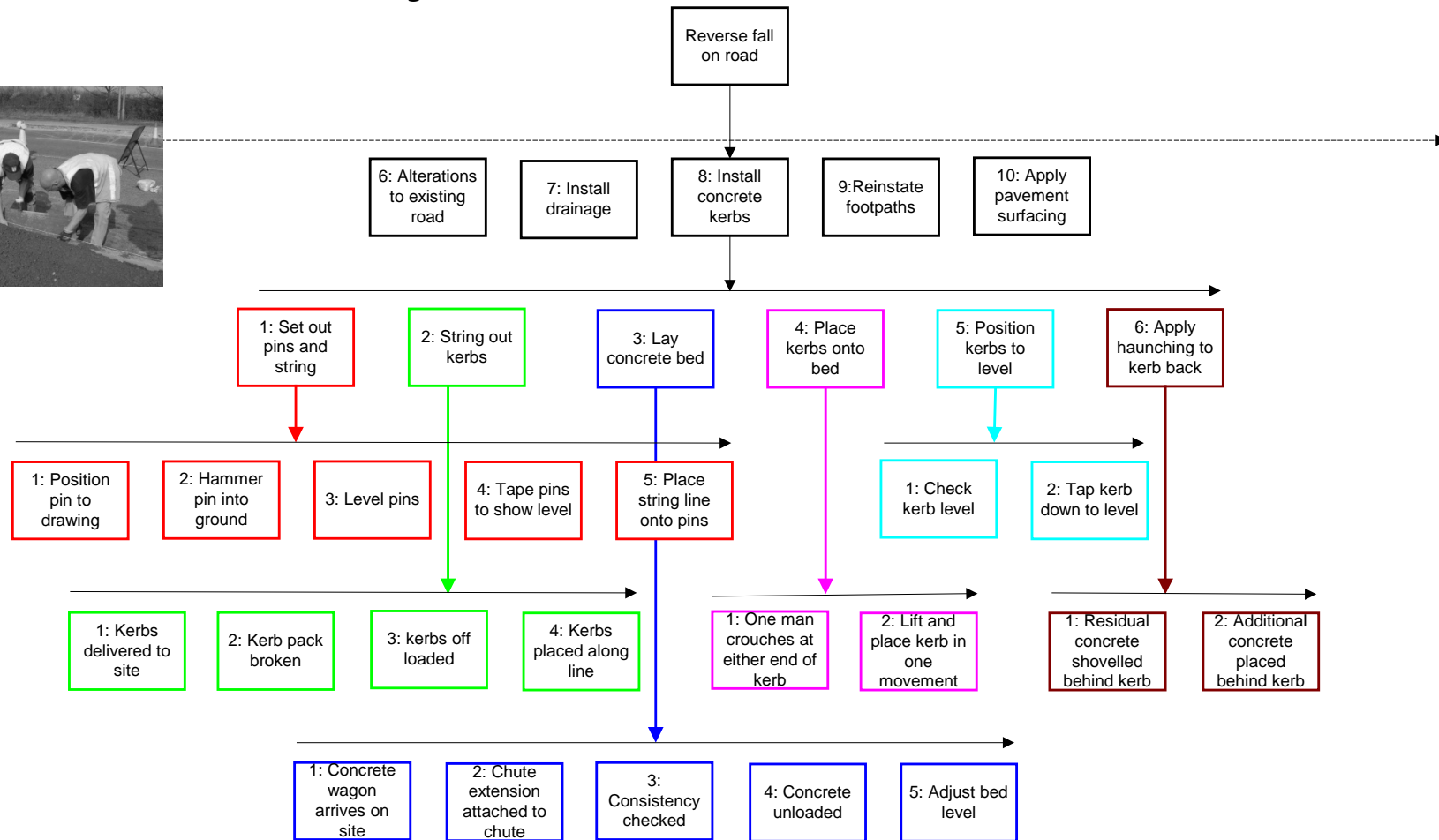
## Kerb operations for work required to reverse the falls of a trunk road

Task/Sub Task	Description	Risk	REBA Action
9	<b>915 mm long kerb 70kg in weight bedded onto existing tarmac road</b>		
9.1	<b>Set out strings and pins</b> - This operation can be carried out by the kerb or by others		
9.1.1	Steel pin positions set out on road from working drawings at regular intervals		
9.1.2	Steel pins hammered into ground by sledge/lump hammer	Use of hammer	
9.1.3	Level of tops of steel pins determined using optical levelling instrument		
9.1.4	Insulation tape placed around pins to indicate level of tops of kerbs		
9.1.5	Line (nylon fishing line) attached to pins along tops of tape		
9.2	<b>String out kerbs</b>		
9.2.1	Vehicle delivers kerbs to site		
9.2.2	Bands around kerbs cut to split pack	Kerbs could fall on feet	
9.2.3	Vehicle travels along the kerb line and kerbs taken off vehicle by hand. Breakages here mean more lifted MH as more kerbs are required	Manual Handling with long and short term problems	

9.2.4	Kerbs placed adjacent to the line ready to be lifted into place	Manual handling with long and short term problems	
9.3	<b>Lay concrete bed</b>		
9.3.1	Concrete wagon arrives on site		
9.3.2	Chute extension attached to chute	Manual handling of steel chute	
9.3.3	Consistency of concrete checked		
9.3.4	Concrete poured		
9.3.5	Level of concrete bed adjusted	Shovelling	Necessary soon
9.4	<b>Place kerbs onto bed</b>		
9.4.1	Men crouch to pick up kerb	Posture	
9.4.2	Lift and place kerb in one movement	Manual handling with long term and short term problems	Necessary soon
9.5	<b>Position kerbs to level</b>		
9.5.1	Check kerb level		
9.5.2	Crouch down and tap kerb down to level	Posture / hammering	Necessary soon
9.6	<b>Apply haunching to backs of kerbs</b>		
9.6.1	Residual concrete shovelled behind kerb	Shovelling	
9.6.2	Additional concrete placed behind kerb	Shovelling	



# Manual Kerb Installation - Hierarchical Task Analysis

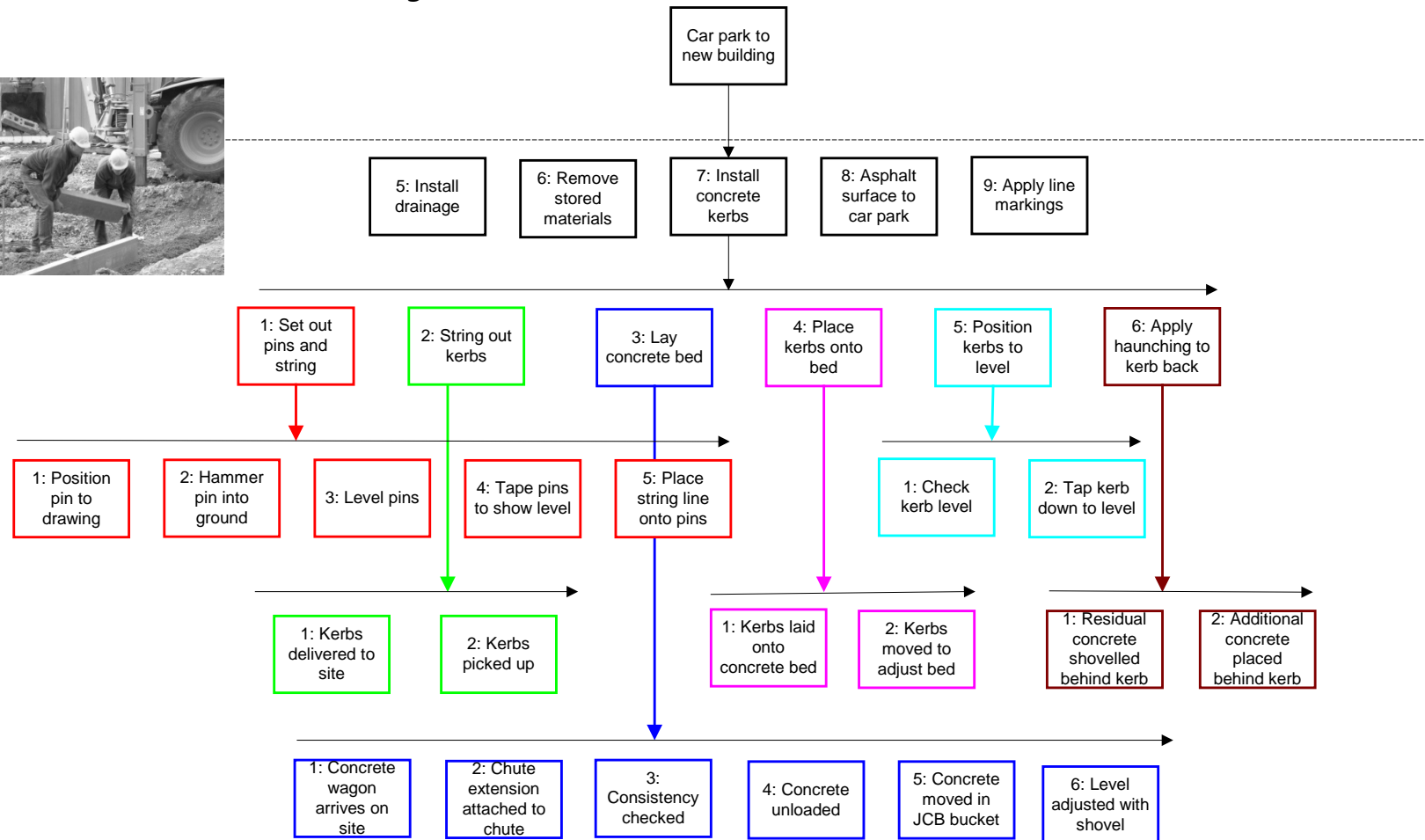


## Kerb operations for work required to install car park kerbs

Task/Sub Task	Description	Risk	REBA Action
7.0	<b>915 mm long kerb 70kg in weight bedded onto existing tarmac road</b>		
7.1	<b>Set out strings and pins</b> - This operation is carried out by the kerb layer but can be carried out by others		
7.1.1	Steel pin positions set out from working drawings at regular intervals		
7.1.2	Steel pins hammered into ground by sledge/lump hammer	Use of hammer	
7.1.3	Level of tops of steel pins determined using optical levelling instrument		
7.1.4	Insulation tape placed around pins to indicate level of tops of kerbs		
7.1.5	Line (nylon fishing line) attached to pins along tops of tape		
7.2	<b>String out kerbs</b> - breakage here means more manual handling because more kerbs required		
7.2.1	Kerbs required placed on pallets in compound	Manual handling with long and short term problems	
7.2.2	JCB takes pallet of kerbs to car park		
7.2.3	Kerbs lifted off pallet by hand to take carry to kerb line	Manual handling with long and short term problems	

7.3	<b>Lay concrete bed</b>		
7.3.1	Concrete wagon arrives on site		
7.3.2	Chute extension attached to chute	Manual handling	
7.3.3	Consistency of concrete checked		
7.3.4	Concrete poured		
7.3.5	Concrete taken to kerb line in JCB bucket		
7.3.6	Level of concrete bed adjusted	Shovelling	Necessary
7.4	<b>Place kerbs onto bed</b>		
7.4.1	Kerbs laid onto concrete bed	Posture	Necessary now
7.4.2	Kerbs lifted off to adjust bed		
7.4.3	Dropped and transition kerbs cut to position dropped access - kerbs can be pre cut by the manufacturer	Dust inhalation	
7.5	<b>Position kerbs to level</b>		
7.5.1	Check kerb level		
7.5.2	Tap kerb down to level		Necessary
7.6	<b>Apply haunching to backs of kerbs</b>		
7.6.1	Residual concrete shovelled behind kerb		
7.6.2	Additional concrete placed behind kerb		

# Manual Kerb Installation - Hierarchical Task Analysis

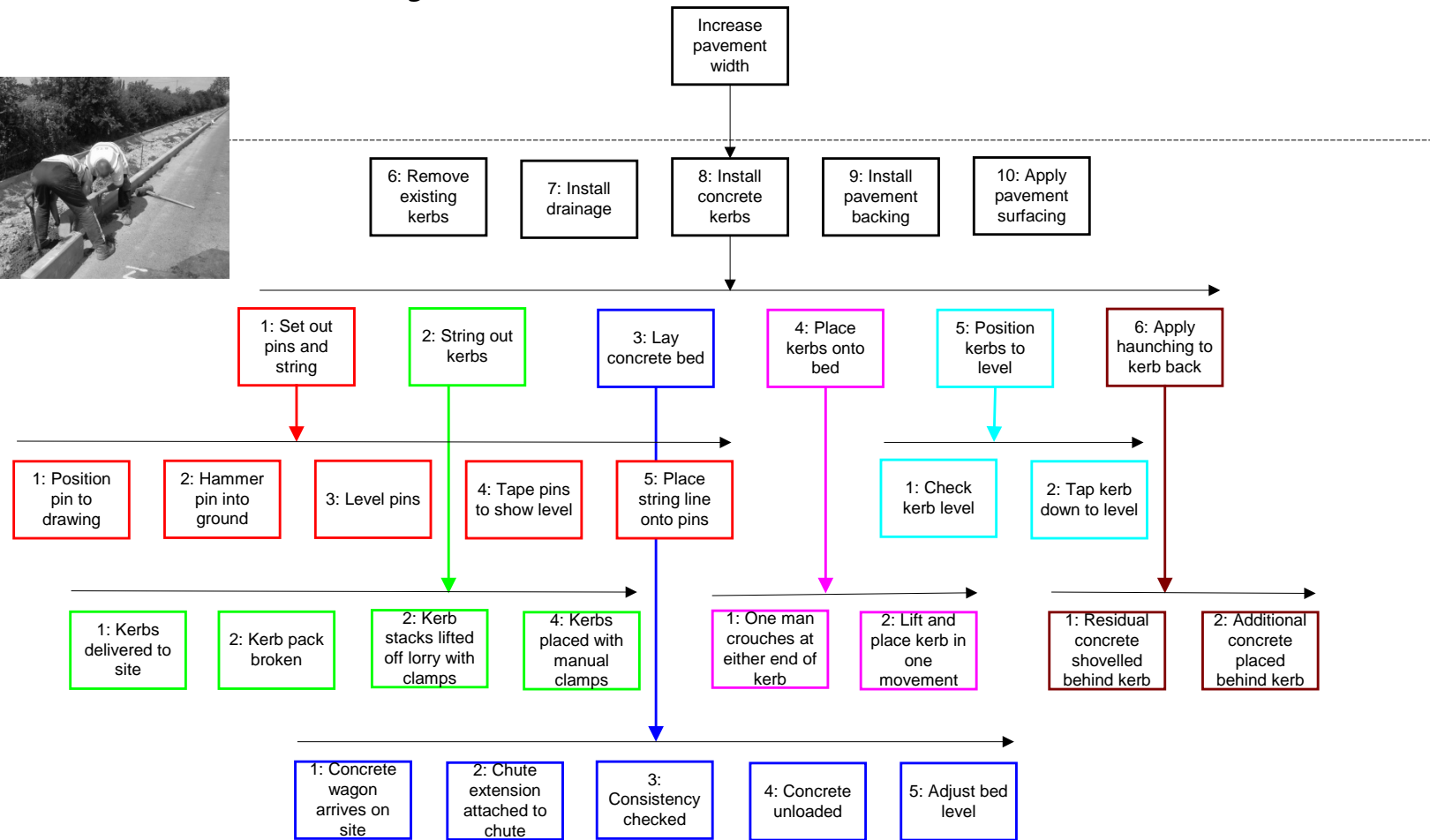


## Kerb operations for work required to increase width of footpath

Task/Sub Task	Description	Risk	REBA Action
8.0	<b>915 mm long kerb 70kg in weight bedded onto concrete bed in trench</b>		
8.1	<b>Set out strings and pins</b> - This operation is carried out by the kerb layer but can be carried out by others		
8.1.1	Steel pin positions set out on road from working drawings at regular intervals		
8.1.2	Steel pins hammered into ground by sledge/lump hammer	Use of hammer	
8.1.3	Level of tops of steel pins determined using optical levelling instrument		
8.1.4	Insulation tape placed around pins to indicate level of tops of kerbs		
8.1.5	Line (nylon fishing line) attached to pins along tops of tape		
8.2	<b>String out kerbs</b>		
8.2.1	Vehicle delivers kerbs to site		
8.2.2	Bands around kerbs cut to split pack	Kerbs can fall onto feet	
8.2.3	Kerb stacks lifted off lorry with large clamp		
8.2.4	Kerbs positioned along kerb line with manual clamps	Manual handling with long and short term problems	

8.3	<b>Lay concrete bed</b>		
8.3.1	Concrete wagon arrives on site		
8.3.2	Chute extension attached to chute	Manual handling	
8.3.3	Consistency of concrete checked		
8.3.4	Concrete poured		
8.3.5	Level of concrete bed adjusted	Shovelling	Necessary soon
8.4	<b>Place kerbs onto bed</b>		
8.4.1	Men crouch to pick up kerb	Posture	
8.4.2	Lift and place kerb in one movement	Manual handling	Necessary
8.5	<b>Position kerbs to level</b>		
8.5.1	Check kerb level		
8.5.2	Tap kerb down to level	Hammering	Necessary soon
8.6	<b>Apply haunching to backs of kerbs</b>		
8.6.1	Residual concrete shovelled behind kerb		
8.6.2	Additional concrete placed behind kerb		

# Manual Kerb Installation - Hierarchical Task Analysis



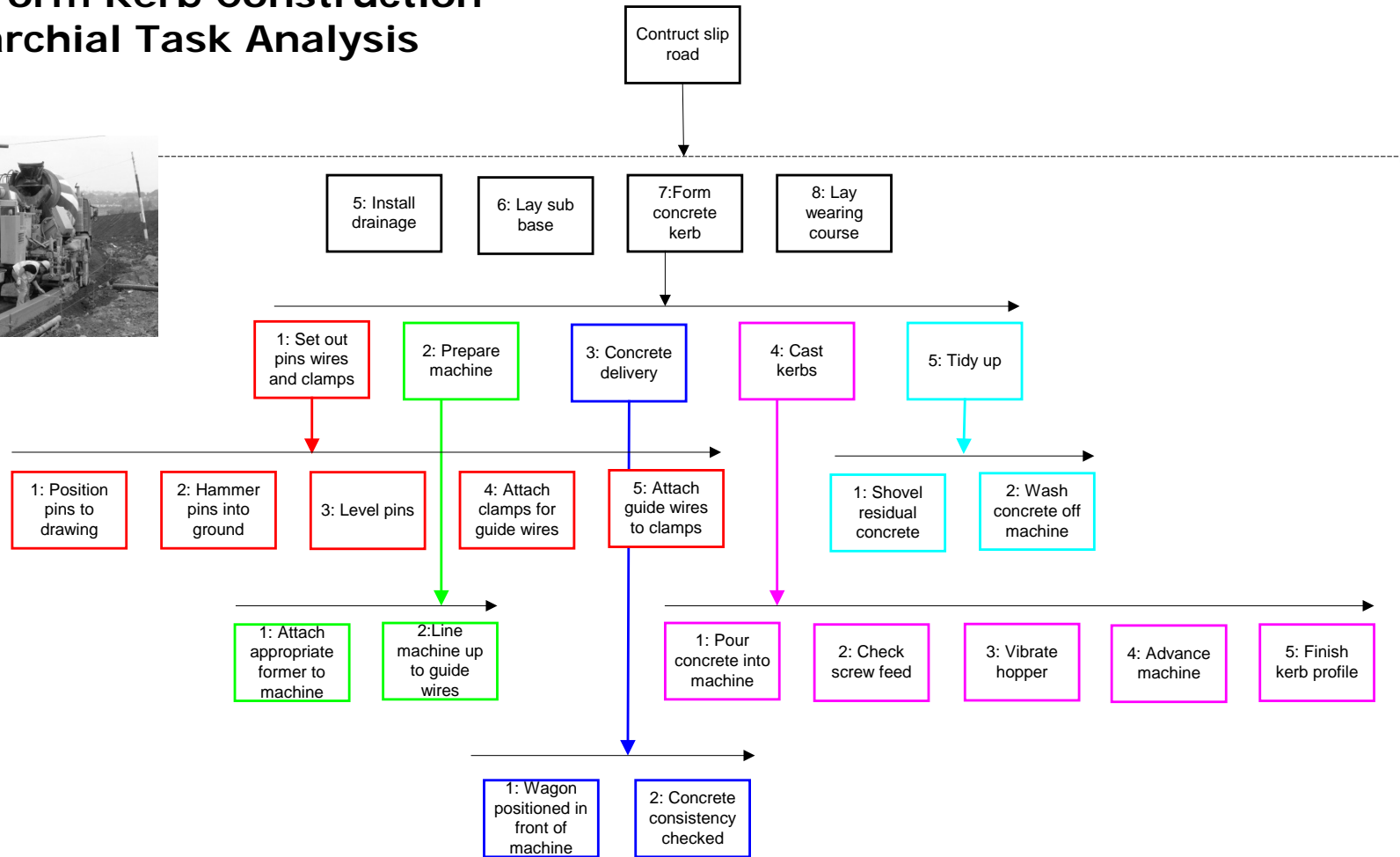
## Slip form operations to construct concrete kerb for slip road

Task/Sub Task	Description	Risk	REBA Action
7.0	<b>Concrete kerb 200mm wide by 300mm high formed on road sub base</b>		
7.1	<b>Set out pins wires and clamps</b> - This operation is carried out by the slip form gang		
7.1.1	Steel pin positions set out on road between pins set up by others		
7.1.2	Steel pins hammered into ground	Use of hammer	
7.1.2	Level of tops of pins determined using optical levelling instrument		
7.1.3	Clamps attached to pins for fixing guide wires		
7.1.4	Guide wires attached to clamps		
7.2	<b>Prepare machine</b>		
7.2.1	The correct former for the profile of the kerb is attached to the machine	Manual handling with long and short term problems	
7.2.2	The machine is manoeuvred into position so that sensors are in line with the guide wires		
7.3	<b>Concrete delivery</b>		



7.3.1	The concrete wagon is positioned in front of the slip form machine		
7.3.2	The chute extension is attached to the concrete wagon chute so that the concrete can be delivered into the hopper.	Manual handling (MH) with long and short term problems	
7.3.3	The consistency of the concrete as it is delivered via the chute is checked during the slip form operation	Using shovel with arms raised	Necessary
7.4	<b>Casting the kerb</b>		
7.4.1	Concrete is poured into the hopper of the slip form machine		
7.4.2	Screw feed on the machine draws the concrete towards the former		
7.4.3	Hopper vibrated to assist with flow of concrete and to help consolidate the kerb		
7.4.4	The machine advances to form the kerb as it moves	Static posture operating machine	May be necessary
7.4.5	The profile of the kerb is completed by hand trowel	Operative bent over to work on the kerb	Necessary
7.5	<b>Tidying up</b>		
7.5.1	Any residual concrete is placed behind the kerb	Shovelling	
7.5.2	All fresh concrete is washed off the machine with a hose		

# Slip Form Kerb Construction - Hierarchical Task Analysis



## Kerbs for new roads on housing estate

Task/Sub Task	Description	Risk	REBA Action
6.0	<b>915 mm long kerb 70kg in weight bedded onto sand/cement bed on kerb race</b>		
6.1	<b>Cast kerb race</b>		
6.1.1	Set out steel forms and restrain with steel pins	Manual handling of forms and use of hammer	Action necessary soon
6.1.2	Attach chute to wagon		
6.1.3	Concrete consistency checked		
6.1.4	Concrete poured		
6.1.5	Top of race finished with shovel		
6.1.6	Forms removed	Manual handling with long and short term problems	
6.2	<b>String out kerbs</b>		
6.2.1	Place kerbs into machine bucket	Manual handling with long and short term problems	
6.2.2	Transport to kerb line		
6.2.3	Lift kerbs out of machine bucket	Manual handling with long and short term problems	
6.2.4	Place kerbs along line of race	Manual handling with long and	

		short term problems	
6.3	<b>Lay concrete bed</b>		
6.3.1	Deliver sand to area to be used		
6.3.2	Deliver cement to area to be used		
6.3.3	Mix sand and cement		
6.3.4	Shovel mix onto kerb race		
6.3.5	Level mix with shovel		
6.4	<b>Set out string line</b>		
6.4.1	Check line and level of race		
6.4.2	Place kerbs on end		
6.4.3	Attach string lines around kerbs		
6.4.4	Position string line up from race		
6.5	<b>Lay kerbs - two man operation</b>		
6.5.1	Pick up kerb lifters		
6.5.2	Stand astride kerb		
6.5.3	Clamp kerb and lift	Manual handling	
6.5.4	Move feet to new position	Uneven postural loading	
6.5.5	Lower kerbs onto bed		

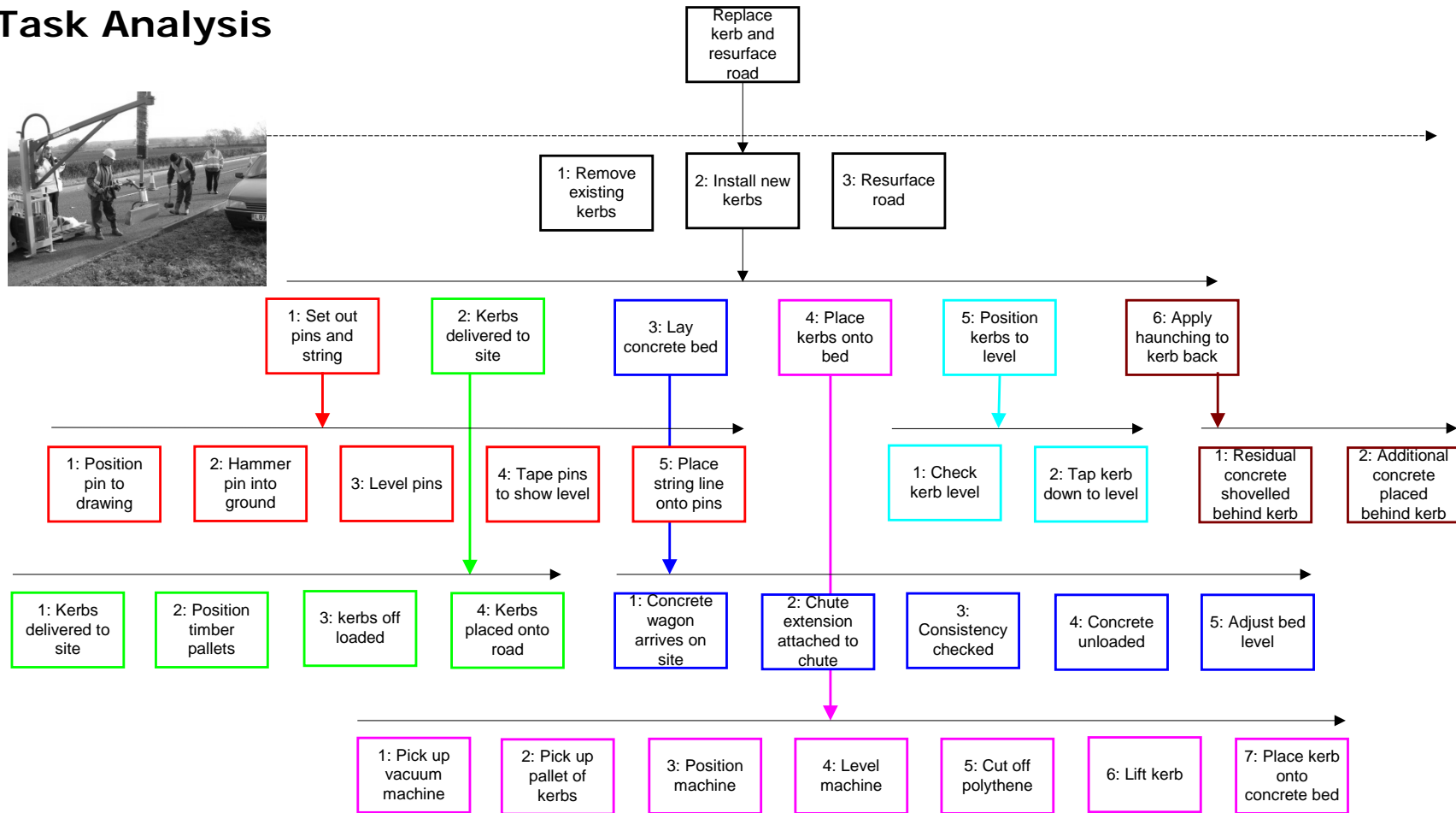


## Kerb operations required on kerb replacement / road resurfacing work

Task/Sub Task	Description	Risk	REBA Action
2.0	<b>915 mm long kerb 70kg in weight placed onto concrete bed</b>		
2.1	<b>Set out strings and pins</b> - This operation is carried out by the kerb layer but can be carried out by others		
2.1.1	Steel pin positions set out on road from working drawings at regular intervals		
2.1.2	Steel pins hammered into ground by sledge/lump hammer	Use of hammer	
2.1.3	Level of tops of steel pins determined using optical levelling instrument		
2.1.4	Insulation tape placed around pins to indicate level of tops of kerbs		
2.1.5	Line (nylon fishing line) attached to pins along tops of tape		
2.2	<b>String out kerbs</b>		
2.2.1	Lorry arrives with kerbs		
2.2.2	Timber pallets positioned to receive kerbs	Manual handling	
2.2.3	Lorry driver uses mechanical grab to off load packs onto pallets		
2.2.4	JCB used to place pallets of kerbs onto road once lorry has gone		
2.3	<b>Lay concrete bed</b>		
2.3.1	Concrete wagon arrives on site		

2.3.2	Chute extension attached to chute	MH	
2.3.3	Consistency of concrete checked		
2.3.4	Concrete poured		
2.3.5	Level of concrete bed adjusted	Shovelling	Action - necessary
2.4	<b>Place kerbs onto bed</b>		
2.4.1	JCB picks up vacuum machine on forks	Posture	
2.4.2	JCB picks up pallet of kerbs on forks	Manual handling	
2.4.3	JCB positioned adjacent to kerb line		
2.4.4	Vacuum lifter machine levelled		
2.4.5	Polythene and band cut off kerb pack	Kerbs could fall onto feet	
2.4.6	Unclamp vacuum equipment and connect to kerb		
2.4.7	Lift kerb off pallet and manoeuvre to kerb line and place onto concrete bed	Manual handling	Non - necessary
2.5	<b>Position kerbs to level</b>		
2.5.1	Check kerb level		
2.5.2	Tap kerb down to level	Hamering	May be necessary
2.6	<b>Apply haunching to backs of kerbs</b>		
2.6.1	Residual concrete shovelled behind kerb		
2.6.2	Additional concrete placed behind kerb		

# Kerb Installation with Vacuum Lifter - Hierarchical Task Analysis







## **Appendix 10.2**

**HSE Hand out at second kerbs forum**

# Kerbs Forum

*Kerbs Forum*

By



Venue:  
**City Marketing Suite**  
Corporation of London  
PO Box 270, Guildhall  
London EC2P 2EJ



Date:  
15<sup>th</sup> July 2004

**KERBS – KEY STAKEHOLDERS FORUM - 11 DECEMBER 2003  
AGREED ACTION POINTS**

*Please Note:* The control measures for each kerb laying process will be dependent upon the outcome of a manual handling risk assessment. The term 'heavy kerb' means any kerb which weighs more than 20 kg.

**ACTION TO BE TAKEN BY THE INDUSTRY**

**1. NEW BUILD PROJECTS**

**A. LONG STRETCHES OF KERBS**

Avoid any manual handling of heavy kerbs. Use mechanical handling solutions for all heavy kerb laying. *Timescale: Immediate*

**B. SHORT STRETCHES OF KERBS**

i. Move as soon as practicable to use of mechanical handling solutions for all heavy kerb laying. *Timescale: By end June 2004*

ii. If no mechanical lifting aids are immediately available, produce a timebound action plan outlining the control measures which will be used and specify a deadline for implementation. *Timescale: Immediate*

**2. SPOT REPAIRS/MAINTENANCE PROJECTS**

It is recognised that much of this work is under term maintenance and that some contracts may be part way through, so it may take some time for Clients and Contractors to make arrangements for mechanical kerb handling.

i. Secure mechanical handling solutions for all heavy kerb laying activity *Timescale: By end Jan 2005*

ii. If no mechanical lifting aids are immediately available, or contract terms need to be renegotiated, produce a timebound action plan outlining the control measures to be used and specify a deadline for implementation *Timescale: Immediate*

**ACTION TO BE TAKEN BY HSE**

1. Write to the Local Authorities (LA's):

i. Outlining their duties as a client under the Construction (Design and Management) Regulations 1994

ii. Informing them that HSE will expect mechanical handling aids to be used for kerb laying activity *Timescale: By end Jan 2004*

2. Inform all HSE construction operational inspectors of the agreement and the enforcement policy – see annex 1 *Timescale: By end Jan 2004*

3. Circulate the draft Kerbs Construction Information Sheet to stakeholders for comment *Timescale: By end Jan 2004*

4. Arrange for a follow up stakeholder meeting to be held in June 2004

*Timescale: By End April 2004*

5. Issue a press release outlining the agreed arrangements

*Timescale: Early New Year*

KERBS – KEY STAKEHOLDERS FORUM - 11 DECEMBER 2003

**LIST OF ATTENDEES**

<b>Organisation</b>
Galliford TRY
Highway Agency
Derbyshire CC
RCS
Balfour Beatty Civil Eng Ltd
Marshals plc
NHBC
Tarmac
Quarry Products Association
Carilion /MCG
Construction Confederation
Amec Infrastructure
Aggregate Industries
CECA
Carillion Roads
Accord Plc & NTMCSF
JDM Accord Plc
I.H.I.E
Balfour Beatty
Jackson Civil Eng.
Interpave
Loughborough University
Construction h. Safety
Highways & Conctruction Training Association

## APPENDIX 2

### KERBS – KEY STAKEHOLDERS FORUM - 11 DECEMBER 2003

#### HSE ENFORCEMENT POLICY

**To all construction inspectors:**

In December the construction sector chaired a meeting of key stakeholders involved in the manufacture, supply, specification and use of heavy kerbs and similar products. At the meeting, a timetable was agreed for the industry to move from a situation where the majority of heavy kerbs and similar products are laid by hand, to a situation where the mechanical handling of heavy kerbs and similar product is the industry norm.

At the forum it was agreed that:

- For new build work, manual handling of heavy kerbs will be eliminated by end June 2004;
- For spot repairs/maintenance, manual handling of heavy kerbs will be eliminated by end December 2004.

Between now and then, it was agreed that our enforcement policy will be:

**A risk assessment should be undertaken for all heavy kerb laying activity which identifies the appropriate control measures to avoid the risk of injury from manual handling.**

**The hierarchy of control will be as follows:**

1. **Question the need for heavy kerbs or similar products; then**
2. **If such products cannot be eliminated, use measures such as lighter kerb products or mechanical lifting aids to reduce risk to an acceptable level; or**
3. **If no mechanical lifting aids are available, produce a timebound action plan outlining the control measures to be used and specify a deadline for implementation within the timescales specified above;**

**If there is no/insufficient evidence that this hierarchy has been followed, inspectors should take enforcement action to:**

1. **Prohibit current or future activity which exposes workers to risk from manual handling;**
2. **Issue an improvement notice to ensure adequate management of the risk from manual handling and requiring the production of a timebound action plan to achieve compliance with the Manual Handling Regulations within the timeframes specified above.**



## **Kerb Handling**

### **Introduction**

This information sheet explains how to control the risks associated with the repetitive manual handling of kerbs and associated products.

### **Background**

Traditionally kerbs in one form or another have been specified on the majority of roads. The standard components used are principally pre-cast concrete and weigh approximately 67kg. Feature kerbs, stone kerbs or other associated products may be considerably heavier.

The weight of the components means that there is a significant risk of injury if the kerbs are handled manually. As with the risks associated with the handling of heavy blocks, it is not only the weight but also the repetitive nature of the work can progressively lead to serious injuries.

The principal hazard is the weight of the kerb components coupled with the poor posture associated with handling kerbs manually. This creates excessive stress and strain causing injury to muscles and tendons. These injuries are commonly referred to as Muscular Skeletal Disorders (MSDs). The risk of injury is largely determined by the weight of the kerb – the heavier the kerb the higher the risk of injury.

MSDs account for a significant proportion of accidents and injuries in construction. They are a principal reason for people having to leave the construction industry.



### **Risk Assessment**

The Manual Handling Operations Regulations 1992 require the employer to carry out a risk assessment for all kerb laying work. The assessment should identify what needs to be done to control the risk from handling kerbs. When

deciding what needs to be done, you may find it useful to use the following hierarchy of control measures. You will need to show that you have used solutions from the top of the hierarchy in preference to solutions lower down.

The *Hierarchy of Controls* is as follows:

- **Elimination** – Eliminate manual lifting of kerbs. (e.g. eliminate the need for kerbs during the design stage or use other construction methods such as extrusion which do not involve manual handling).
- **Total Mechanical Solution** – Ensure kerbs are always handled and laid mechanically (e.g. fork/trailer mounted or independent vacuum lifters, positive pressure/friction grabs involving no manual effort to lift). This will be a good solution for the majority of new build and many refurbishment works.
- **Partial Mechanical Solution** – Ensure that part of the process of handling kerbs is done mechanically. (e.g. using mechanical solutions to get the kerb near its final position, off-loading using a hoist). The risks from manual handling can then be reduced by using smaller/lighter kerbs. The aim should be to maximise the amount of mechanical handling.
- **Manual Handling** – In rare cases where none of the above solutions are possible, short stretches of kerb can be laid manually. Where this is necessary you should use lighter weight products and the workers should be trained in lifting safely. Tongs allow two people to share the weight of the lift but they do not protect the workers from injury. The use of tongs and lighter weight kerbs should not be seen as an alternative to mechanical handling.

#### **Precautions**

All of those involved in the specification, manufacture, supply, and installation of road edge details can help to reduce the risks from manual handling.

#### **Designers, Planning Supervisors and Clients.**

The design and planning stage should consider:

- Alternative solutions to standard modular kerb products to eliminate repetitive handling
- Eliminating the need for kerb edgings by using a different detail or alternative techniques such as extrusion of the road edge detail
- Where modular kerbs have to be used, the specification should seek to use products that are compatible with mechanical handling solutions
- Considering the use of alternative kerb components e.g lightweight products
- Identifying the risks during the lifetime of the product including issues relating to maintenance and repair



- Planning work to allow the maximum number of kerbs to be laid at one time to realise the economies of scale and promote the practicability of mechanical handling

### **Manufacturers and Suppliers**

Kerb manufacturers will need to:

- Supply kerbs in a format compatible with commonly used mechanical handling equipment
- Ensure kerbs can be removed from the pack without the need to handle them manually
- Clearly mark pack weights and component weights
- Ensure, where possible pack sizes are below 1 tonne to allow handling by a wide range of commonly used site equipment

### **Contractors**

Contractors need to plan the work to ensure risk is kept to an acceptable level. This may involve:

- Rethinking the phasing of the kerb installation to maximise the number of kerbs being laid at one time
- Laying direct from the pack rather than double handling by stringing out ahead of final laying;
- Using machinery capable of handling both packs and individual kerbs
- Using mechanical solutions for the handling of non-standard kerb details such as feature kerbs, transition kerbs, drop kerbs, quadrants (cheeses) and radius kerbs
- Providing for the safe storage and secure transport of kerbs
- Ensure that workers are trained in the safe use of mechanical lifting equipment
- Providing training in safe lifting techniques for workers involved with kerb laying

### **Mechanical kerb handling solutions**

#### **Vacuum lifters**

A number of manufacturers produce equipment to handle kerbs using vacuum technology. The machines can be fitted with a number of interchangeable heads to allow different products to be handled.

#### Self-contained

These devices can be either fitted on the forks of standard construction machines or mounted on trailers which allow the kerbs to be laid straight from the pack without the need to 'string out'. Both the attachment to the kerb and the lifting force is provided by a vacuum.

#### Fork mounted

Vacuum lifters can be mounted on standard construction lifting equipment. The advantage is that kerb laying can then be undertaken using a single machine, which carries the pack of kerbs and provides the mechanical lift.



The vacuum lifter can be powered independently or by the hydraulics of the machine on which it is mounted.

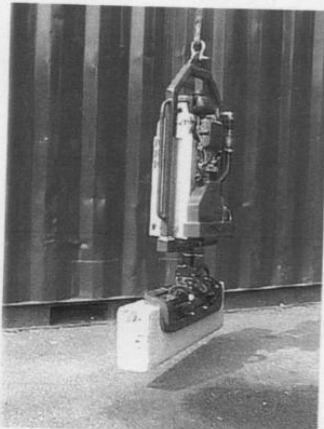
#### Trailer mounted

Trailer mounted machines offer a stand-alone handling solution that can be towed at road speeds between locations. They are useful for contractors, who lay small numbers of kerbs in multiple locations.



#### Independent

These are self-contained units, which create a vacuum to attach to the kerb. They have to be fitted to a lifting device to lift and position the load.



### **Grabs/Clamps**

A number of devices are available which clamp the kerb, either hydraulically or by friction and self-weight. Grabs have traditionally been used successfully to handle packs of kerbs and larger pre-cast components. Smaller grabs can be used to handle individual kerbs and avoid manual handling.



The grabs should be used in association with existing construction plant such as a backhoe or minidigger to provide the lifting effort. The grabs can be used to lift the kerbs from the pack and placed directly at the point of lay minimising the manual handling input.



### **Return to Work**

Employers should consider how to manage workers who have suffered manual handling injury, in particular their return to work. For some lower back injuries, staying mobile can assist recovery, and the affected person may be able to return to work to do lighter duties. You should take advice from affected person's doctor or your own company medical advisor.

### **Wider applications**

The information in this document is relevant for other precast concrete components such as drainage channels, slabs, communication ducts, copings and hard landscaping materials.

## **Appendix 10.3**

**Back to Design report**



50 years of training  
excellence

# CHSG

Construction Health and Safety Group  
John Ryder Training Centre  
St Ann's Road  
Chertsey  
Surrey KT15 9EH  
Tel: 01932 561871  
[www.chsg.co.uk](http://www.chsg.co.uk)

# Back to Design

## Manual Handling of Highway Kerbs

---

Jubilee Year Sponsorship Project  
(1952-2002)

---







**This work was sponsored by the  
Construction Health and Safety Group**



50 years of training  
excellence



# CHSG

The Construction Health and Safety Group



Health and Safety Training  
for the  
**Construction Industry**

**Construction Health and Safety Group  
John Ryder Training Centre  
St Ann's Road  
Chertsey  
Surrey KT15 9EH  
Tel: 01932 561871  
[www.chsg.co.uk](http://www.chsg.co.uk)**

## AUTHORS

<b>Phil Bust</b>	<b>APaCHe, Department of Civil and Building Engineering, Loughborough University</b>	<b>Researcher, responsible for methods development and leading the focus groups and interviews</b>
<b>Alistair Gibb</b>	<b>APaCHe, Department of Civil and Building Engineering, Loughborough University</b>	<b>Project director (construction expertise)</b>
<b>Roger Haslam</b>	<b>Health and Safety Ergonomics Unit, Department of Human Sciences, Loughborough University Loughborough University Civil and Building Engineering Department Loughborough Leicestershire LE11 3TU</b>	<b>Project director (ergonomics / human factors expertise)</b>



All rights reserved. No part of this publication may be reproduced, stored in a retrieval system, or by any means (electronic, mechanical, photocopying, recording or otherwise) without the prior written permission of the copyright owner.

ISBN 1 873844 56 5

## ACKNOWLEDGEMENTS

**Frank Garnett** of HBG Construction contributed to all of the steering group and focus group meetings and acted as main point of contact with the **Construction Health and Safety Group**

Focus group members

<b>Mark Blundy</b> <b>Clive Budge</b>	<b>Health and Safety Executive</b> <b>Interpave/PreCast Concrete Federation</b>
<b>Tony Cox</b> <b>Robert Dudgeon</b> <b>Kevin Greaves</b> <b>Neil Groves</b> <b>Chris Harris</b> <b>Lesley Hopper</b> <b>Andrew Kingscott</b> <b>Charles Melvin</b>	<b>Plastics Technology</b> <b>The Highways Agency</b> <b>Interpave/Charcon</b> <b>Leicestershire County Council</b> <b>Thyssen (Great Britain) Ltd</b> <b>WS Atkins Consultants Ltd</b> <b>Health and Safety Executive</b> <b>Construction Health and Safety Group</b>
<b>Simon Monnington</b> <b>Mike Morgan</b> <b>Tony Scawthorn</b>	<b>Health and Safety Executive</b> <b>Health and Safety Executive</b> <b>Highways and Construction</b> <b>Training Association</b>
<b>Phil Sutton</b>	<b>Durakerb</b>



The following organisations also contributed to the work:

Local Authorities	<b>Nottinghamshire County Council</b> <b>Northamptonshire County Council</b> <b>Derbyshire County Council</b> <b>Lincolnshire County Council</b> <b>Cumbria County Council</b> <b>Somerset County Council</b> <b>Durham County Council</b> <b>Warrington Borough Council</b> <b>Broxtowe Borough Council</b> <b>Harlow District Council</b>
Contractors	<b>Siac</b> <b>CTRL</b> <b>Foster Yeoman</b> <b>Sol Construction</b> <b>Thyssen (Construction) Ltd.</b> <b>Carillion</b> <b>Old House Holdings</b> <b>JDM Accord</b> <b>A.J.McCormick</b> <b>BTS Construction Ltd</b>
Training	<b>Highways and Construction</b> <b>Training Association</b> <b>Construction Industry Training</b> <b>Board</b>
Designers	<b>Nottinghamshire County Council</b> <b>Leicestershire County Council</b> <b>Durham County Council</b> <b>WS Atkins - Northamptonshire</b> <b>WS Atkins - Somerset</b> <b>WSP Consultants – Nottingham</b> <b>WSP Consultants – Hertford</b> <b>Rogers Leask Consultants-</b> <b>Derbyshire</b>
Manufacturers	<b>Marshalls</b> <b>Charcon</b> <b>Interpave</b> <b>ACCO</b> <b>Envirokerb</b> <b>Durakerb</b> <b>MB Manual Handling Systems</b>
Lifting Equipment	<b>Langtons</b> <b>Pro Grab UK</b> <b>Probst</b> <b>Al-Vac UK</b> <b>Kwik Split</b> <b>Palamatic</b>

## Table of Contents

<b>EXECUTIVE SUMMARY .....</b>	<b>7</b>
<b>1.0 INTRODUCTION .....</b>	<b>9</b>
<b>2.0 METHODS .....</b>	<b>11</b>
2.1 DESK STUDY .....	11
2.2 SITE VISITS .....	11
2.3 INTERVIEWS .....	12
2.4 EQUIPMENT TRIALS.....	12
2.5 FOCUS GROUPS .....	12
2.6 HIERARCHICAL TASK ANALYSIS .....	13
2.7 POSTURAL ANALYSIS.....	14
2.8 THE BIG PICTURE.....	15
<b>3.0 FINDINGS.....</b>	<b>16</b>
3.1 CONCRETE KERBS .....	16
3.1.1 DESIGN.....	16
3.1.2 MANUFACTURE.....	17
3.1.3 TRAINING .....	17
3.1.4 WORK ORGANISATION.....	18
3.1.5 INSTALLATION .....	19
3.1.6 MANUAL HANDLING .....	20
3.1.7 LIFTING EQUIPMENT – CLAMPS.....	20
3.1.8 LIFTING EQUIPMENT - VACUUM LIFTERS .....	21
3.1.9 REPAIR .....	22
3.1.10 REMOVAL.....	23
3.2 SLIP FORMED/ EXTRUDED KERBS.....	23
3.2.1 INSTALLATION .....	23
3.2.2 REPAIR .....	24
3.2.3 REMOVAL.....	24
3.3 PLASTIC KERBS .....	24
3.3.1 INSTALLATION .....	24
3.3.2 REPAIR .....	24
3.3.3 REMOVAL.....	24
3.4 RUBBER KERBS.....	25
3.4.1 INSTALLATION .....	25
3.4.2 REPAIR .....	25
3.4.3 REMOVAL.....	25
3.5 COMBINED DRAIN KERBS.....	25
3.5.1 INSTALLATION .....	26
3.5.2 REMOVAL.....	26
<b>4.0 CONCLUSIONS.....</b>	<b>27</b>
<b>5.0 FURTHER WORK.....</b>	<b>28</b>
<b>6.0 RECOMMENDATIONS .....</b>	<b>28</b>
<b>REFERENCES.....</b>	<b>30</b>
<b>APPENDICES.....</b>	<b>31</b>

## EXECUTIVE SUMMARY

Manual handling of concrete highway kerbs is a key contributor to the construction industry's poor record on ill health. A failure of the Construction (Design and Management) Regulations, along with other regulations that are designed to protect the workforce from exposure to work that poses a risk to their health, has meant that the subject is being given a high priority by the HSE

In order to provide information to assist the industry in tackling the problem with manual handling of concrete kerbs the Construction Health and Safety Group have sponsored Loughborough University to carry out research to investigate the problem as it exists; access alternative methods and the effect that changes will have on the industry. Loughborough University have carried out the work as part of their APaChE initiative, working with key stakeholders in the construction industry to investigate health and safety.

The investigation for the twelve month project comprised a review of kerb types and kerb lifting methods; existing research in kerb handling; a comparison of kerb handling methods; examination of the manufacturing process and kerb choice in the design process to provide training information for designers, manufacturers and operatives. Methods adopted for the research included interviews, focus group meetings, hierarchical task and postural analysis.

The designers were found to be conservative in choice of kerb detail and installation method. They did not consider site operations due in part to their lacking of site experience.

Manufacturers are beginning to take a share in the responsibility of tackling health issues. The 'we only provide what is asked for' attitude is making way for a proactive approach with organisations, who represent manufacturers, lobbying the HSE and developing guidelines for safe installation of concrete products.

National training organisations of the industry provide courses for kerb installation with an emphasis on satisfying the technical details of British Standards with a prerequisite of attendance on a manual handling course. There is a need for health aspects to be taught at all levels from director to operatives so that new initiatives at one level are not hindered by ignorance at another.

The manual handling issue is exacerbated where poor work organisation exists and bad techniques are used. Investment in new equipment or alternative material / methods will only provide small improvements unless the work organisation and techniques are given adequate consideration.

The extent and nature of risks to workers depend on whether they carry out the work as a specialist sub contractor, a ground worker, a general builders or as part of a maintenance crew. Workers were aware of the risks and appear prepared to accept them for financial gain.

Lifting equipment in the form of manual clamps, has been around for tens of years, but is slower than laying the kerbs by hand so will not be preferred if bonuses are affected. The equipment is, in most cases, an improvement on manual handling, but prolonged use would provide a risk to the workers' health.

The more recent use of vacuum lifters has reduced the risk to health, for the kerb operation itself, to an almost insignificant level, but workers who have installed kerbs by hand say they find it to be slower than laying by hand. Equipment is developing with increased use and will benefit further if manufactures were to give consideration to packing their products in a way that eased the use of vacuum devices.

The repair of kerbs has not been fully explored to date due to the reasonably low financial cost of replacement but the removal with on site milling machines has removed an area of manual handling.

Kerb/drain systems are widely used now as a lighter alternative to traditional kerbs but they are not suitable for every situation and are expensive unless a combined kerb and drainage solution are required.

The slip form method of kerb installation has been used in the UK for about 30 years but has not been fully adopted. Slip forming may now be able to offer a viable alternative with the increased pressure to remove the manual handling method. The possible development of a robust lightweight plastic kerb would benefit maintenance type operations where the use of motorised lifting equipment would not be practicable.

The construction industry is lagging behind manufacturing in tackling health issues. The manual handling of concrete kerbs in the manufacturing process was investigated 20 years ago. The industry has tended to wait until a specific operation has attracted the attention of the HSE before dealing with it (cement bags, concrete blocks, concrete kerbs) rather than tackling manual handling as a whole. This is underlined by having to import solutions from abroad with current handling equipment being developed in Germany and Denmark.

During the project it was found that pockets of the industry have been working to solve this problem on their own, often introducing good initiatives to reduce risks in their operations. But there is a lack of industry-wide cohesive support, training etc that needs to be addressed. A call for guidance, rather than regulation, would point towards the need for guidelines and tools to assist those involved with the process.

In order for the industry to tackle this problem, the manual handling of kerbs should be eliminated through:

- Designers' choice of methods and materials.
- Contractors using mechanical lifting equipment.
- Clients allowing for the cost of these actions.
- Manufacturers removing any obstacles to the adoption of technical innovations.
- Health and Safety Executive providing guidance on the change from manual to mechanical operations.
- Training organisations providing courses that embrace new methods.

In order for the construction industry to reduce the risks to health from manual handling operations in the future:

- Designers should acquire more knowledge of site operations.
- Contractors should tackle risk assessments and control without the threat of enforcement.
- Manufacturers should produce new products which consider the installers health as well as that of the end user.

## 1.0 INTRODUCTION

In 2001/02 it was estimated that 137,000 people, whose current or most recent job in the last 8 years was in the construction industry, suffered from an illness which they believed was caused or made worse by their job (Health and safety performance in the Construction Industry).

Concrete highway kerbs are used to line the majority of the roads in the UK and many other countries around the world. The majority of these will have been laid by hand as, even now, mechanical installation of kerbs in the construction industry is still in its infancy. The problem is also bigger than just new build with an estimated 4% of all kerbs replaced annually.

With the most commonly laid kerb – Designated HB2 in the British Standard BS 7263-3:2001 – weighing around 70kg, its installation by hand should have been covered by a range of legislation, e.g. the Health and Safety at work etc Act, the Management of Health and Safety at Work Regulations, the Manual Handling Operations Regulations and the Construction (Design and Management) Regulations. The failure of the CDM Regulations has been reported (Baxendale, Jones 2000) but the failure of the other regulations to address the manual handling of kerbs highlights the difficulties in regulating operations that are seen as traditional in an industry where heavy manual handling work is commonplace.



© Loughborough University

The Government and the Health and Safety Commission (HSC) Summit in 2001 set nationwide 'Revitalising' targets aimed at reducing the incident rate of cases of work-related ill health by 20% by 2010.

The continuance of manual kerb installation operations in the face of the regulations has resulted in the UK's Health and Safety Executive (HSE) placing it high on their target list for enforcement. In recent years contractors in the UK have been under pressure to comply with the regulations and hence are looking at alternative methods to install the concrete kerbs and alternative products to replace them.

The "attention of Ergonomists and Health and Safety specialists has been rather poor compared to other industries and office work. At only a few places in the world, institutions or centres have been active in this field over a long period of time." (Koningsveld and Van der Molen, 1997).

The **Construction Health and Safety Group** has provided affordable safety training for the Construction Industry since 1952 when it started with a membership of 17 representatives from the major construction companies in London.

With the membership now in excess of 500 companies it provides an extremely comprehensive range of safety training courses covering a wide range of construction related subjects.

To mark the group's 50 years jubilee they have sponsored this project which it is hoped will further their aims (see table below) and provide additional training materials to use in the group's courses to support their members needs.

**Construction Health and Safety Group – principal aims and objectives:**

- Improve occupational health in the Construction Industry.
- Foster co-operation between government, employers and those who work in the Construction Industry.
- Study the health and safety training needs of the industry.
- Provide training in response to the identified need.

In carrying out an investigation into the manual handling of concrete highway kerbs Loughborough University have used experience from their Civil and Building Engineering and Human Sciences departments.

The project forms part of Loughborough's APaChE (A Partnership for Construction Health and Safety) initiative in which the University works with key stakeholders in the construction industry and research community to investigate health and safety issues.

## 2.0 METHODS

### 2.1 DESK STUDY

Existing contacts from collaborators were established to gather information on the kerb laying operation, related research and as leads to other contacts. The next stage was to publicise the work through the CHSG meetings, University web site and by speaking to the contacts. There then followed a search of internet and library databases to begin collecting relevant information.

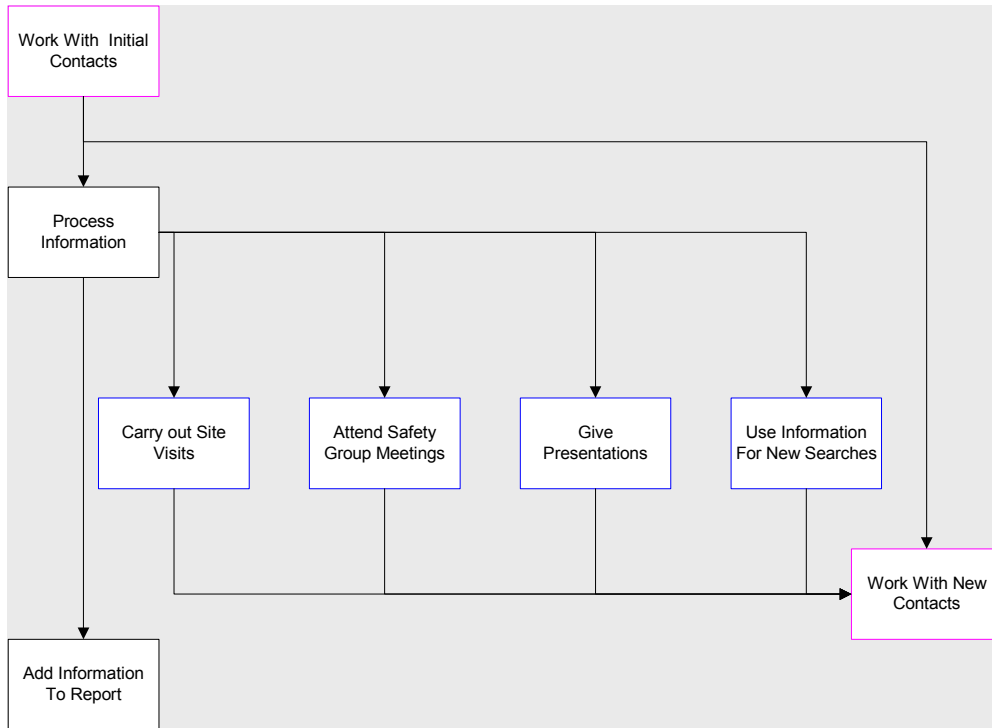


Figure 1 Research Iterative Process

Each new contact could lead to a new construction group at which further contacts could be made. This iterative process was also apparent with information searches finding keywords that could be used in further searches for information.

Once sufficient information and contacts were accrued, visits were made to observe work on site, interview operatives, attend meetings to present the initial findings and speak to key players within the industry (Local Authorities, contractors, manufacturers and designers).

### 2.2 SITE VISITS

The duration of kerb installation work is short so visits often had to be taken at short notice and on several occasions arrival on site found work had already been completed. Also, because the manual handling of kerbs, using two operatives, is flexible work, it tends to fit in with items that are critical to the completion of the contract. Therefore it was difficult to know exactly when work was to be carried out.

Where suitable work was found, the operations were observed, videoed and photographed and operatives and supervision staff informally interviewed. The video and digital photographic records were used to assist with analysis of the working operations and will provide CHSG with valuable information to assist with training.

Links with Local Authorities (Leicestershire, Nottinghamshire, Northamptonshire and Derbyshire County councils) provided access to site works, storage depots, information on

vacuum lifter procurement and experts for interviews and focus groups. Contact was also made with authorities in the North and South of England to give a broader view of the situation.

## 2.3 INTERVIEWS

The interview, unlike most other techniques, requires interpersonal skills of a high order (putting the respondent at ease, asking questions in an interested manner, noting down the responses without upsetting the conversational flow and giving support without introducing bias). At the same time the interviewer is either limited or helped by his or her own sex, apparent age and background, skin colour, accent etc. When taken seriously, interviewing is a task of daunting complexity. (Oppenheim1992).

The majority of the interviews conducted were either carried out on construction sites or over the telephone. Some informal discussions were carried out at meetings to either listen to or give presentations.

Telephone interviews could be planned with a number of questions listed beforehand but many were carried out with calls received as a response to the information on the project website. Interviews over the phone were used to test focus group questions before the meetings were carried out.

Interviewing people on site can be difficult because you do not always know who you will be talking to (Supervisor, Worker, Occupational Health) and under what conditions you will be talking to them (While work is being carried out, during a break in the work, or after work has been completed). A number of appropriate questions were prepared if the circumstances of the visit were known. Where the circumstances were not known more questions were prepared with some discarded during the interview if not considered relevant.

Detailed discussions with kerb and lifting equipment manufacturers were balanced by talking to companies investigating alternatives and specialist sub contractors.

## 2.4 EQUIPMENT TRIALS

After finding the various types of lifting equipment available for the kerb installation operation, it was intended to conduct trials to evaluate the use of each piece of equipment, and find the operatives attitudes to using them. Plans to conduct trials at the university with a group of experienced operatives and a number of different pieces of equipment were decided against because it would be difficult to relate the results to the actual practice on site.

It was therefore decided to conduct trials on site using the paired comparison method. A questionnaire was produced with rating scales to be used after the operatives had used two of the types of lifting equipment. So that each of the pieces of equipment could be compared with all of the others. Together with the questions on the use of the equipment a separate sheet included a body discomfort chart so that areas of discomfort could be recorded for each participant. However, the limited number of suitable equipment types meant that a full paired comparison study was not possible. Examples of the sheets used can be found in appendix A.

## 2.5 FOCUS GROUPS

At an early steering group meeting it was suggested that future meetings should include individuals with experience of various aspects of kerb installation. Response to this was such that it was decided to run the next meeting as a Focus Group. Focus Groups are data collection methods that permit greater access to practitioner perspective (Hide, Hastings, Gyi, Haslam, Gibb 2001).



Questions were prepared for the meeting relating to issues being considered at that time in the project. The issues, for the first focus group meeting, were the use of lifting equipment to install the concrete kerbs and the manufacture of concrete kerbs and alternatives.

Ergonomists and designers have made adaptations to extend the usefulness of the basic group discussions such as integrating activity tools to aid generation of new ideas (Langford and McDonagh 2002). The group was split into two and each half asked to place in order and comment on five lifting devices using a set of prepared information sheets (photograph, weight, cost and other uses). See Appendix B1 group comments.

It is recommended that groups should have between five and ten members (Christie, Scane and Collyer 1995). Eight members out of twelve invited attended the first meeting and five questions were used to direct the discussion.

A second Focus Group meeting was arranged to discuss design matters. The group was again split into two halves to conduct an exercise. This was to discuss the various areas where kerbs are required and which of the kerbs methods would be appropriate in each case, Appendix B2. Ten people attended and the meeting was audio taped and later fully transcribed.

The third and final group had six people in attendance to discuss training issues relating to the kerb laying operations. The group exercise asked the two groups of three to decide which group to be trained (kerb laying operatives, designers and supervisors) would benefit most the health of the operatives and why, Appendix B3. This meeting was also recorded on audio tape.

The meetings were useful in identifying themes and for opening up questions to see what was possible within the industry from different perspectives. At the second and third meeting a British Standard HB2 kerb was available with two pairs of Probst scissors clamps to promote discussion.

## 2.6 HIERARCHICAL TASK ANALYSIS

A task analysis was carried out following site visits taking elements which describe the path required to complete the operation. All of the tasks required to carry out the operation were first identified.

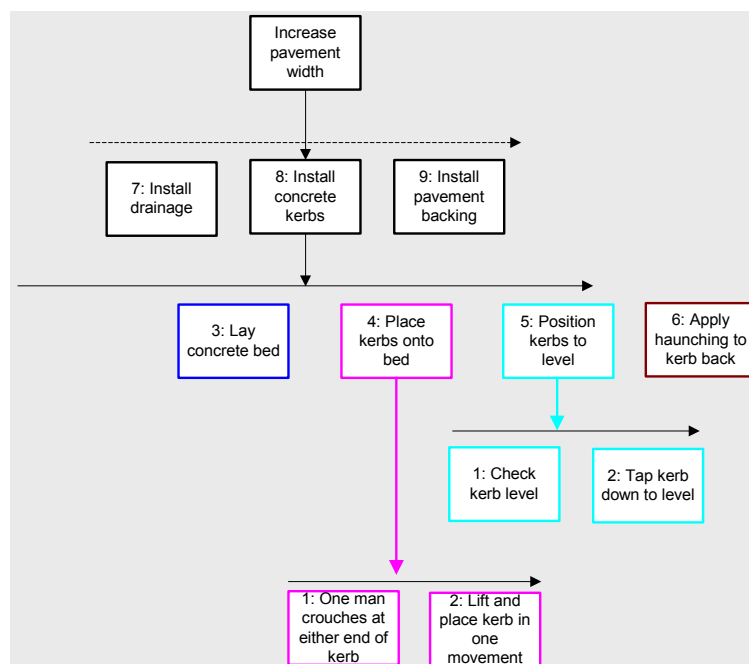


Figure 2 Hierarchical Task Analysis Example

Related tasks were grouped together and given group names which were placed in operational order. Each task was then given an identification number so that the tasks could be tabulated. In the example above 'check the kerb level' would be numbered 8.5.1.

Once tabulated, tasks where risks to health were present were identified and appropriate controls listed beside them. This is similar to carrying out a risk assessment of the work. The task analysis sheets can be seen in Appendix C.

## 2.7 POSTURAL ANALYSIS

The key postures in the kerb laying operations, see table below, were scored using the REBA (Hignett and McAtamney, 2000) tool from observing the work. The scores were then developed into action levels ranging from no action necessary to immediate action required. See table below. The use of this tool for evaluating postural loading on the body is an accepted method world wide.

Key postures of practical relevance in the workplace are:
<ol style="list-style-type: none"> <li>1. The back with its natural "S-Curve" intact</li> <li>2. The neck in its proper alignment</li> <li>3. The elbows held naturally at the sides of the body and the shoulders relaxed</li> <li>4. The wrists in line with the forearm</li> </ol>
MacLeod 2000

The REBA method uses a score for the posture of each part of the body. A score of 1 means that it is in a neutral position and scores increase to between 2 and 4 as the body part moves away from the neutral position. The scores of the trunk, neck and legs are combined to give the first score which is adjusted to account for the load. The scores for the upper and lower arms and wrists are combined to give the second score which is adjusted to account for the individuals coupling with the load. The first and second scores are then combined and adjusted for the activity of the operation to achieve a REBA score (see diagram below) which can then be used to obtain a risk level and appropriate level of action required.

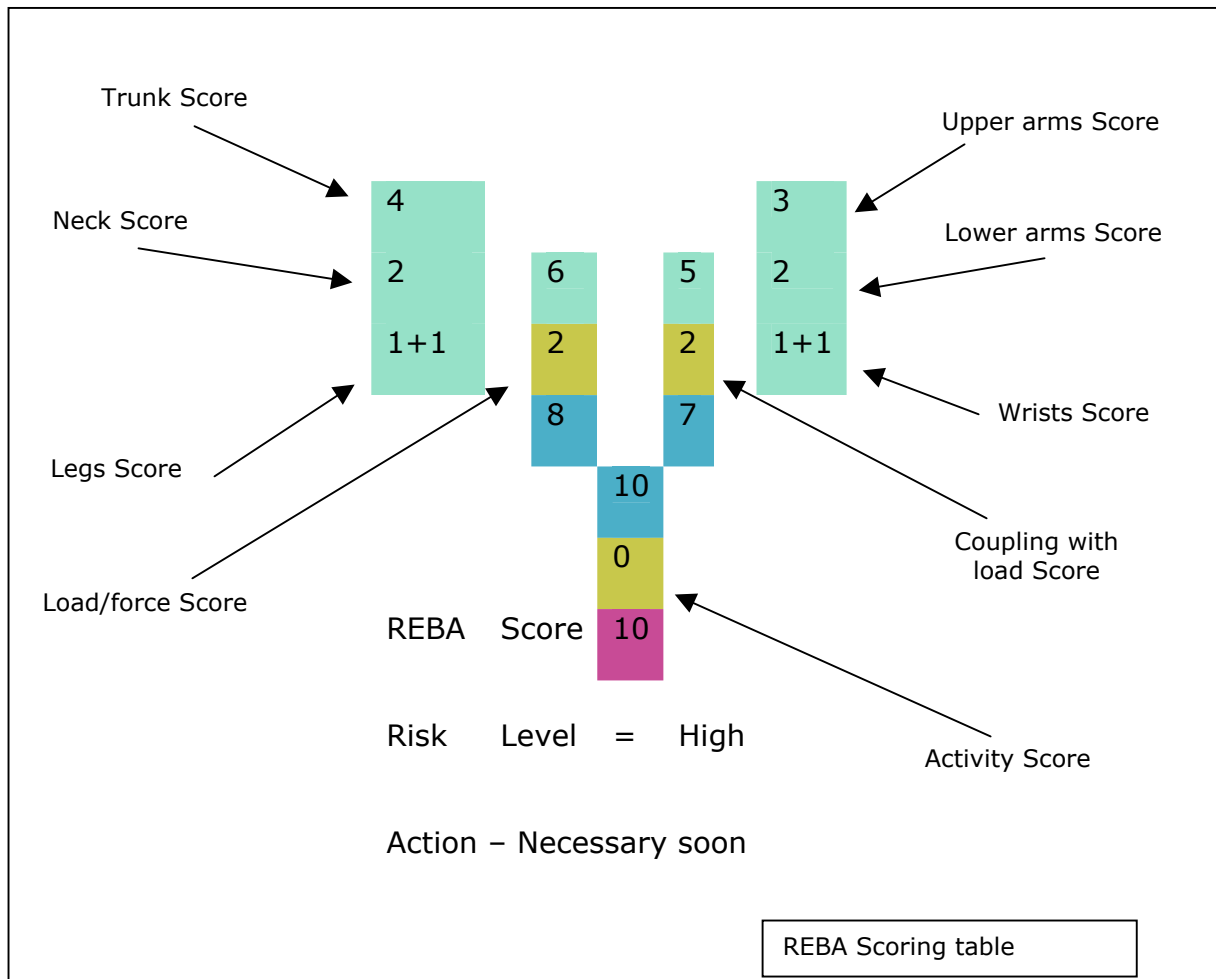
The postures measured represented the WORST adopted during the work cycle for the task assessed. The impact from repetitive work, static muscle work and the demands of rapid changes in posture are included in the score, along with the postural loading that is occurring on the body. REBA was developed to measure the impact from different task types.

REBA provides a risk rating of 1 (low) to 15 (high). It measures the posture, force and movement in dynamic tasks where manual handling may also occur.

The following risk ratings are used:

REBA SCORE	RISK LEVEL	ACTION
1	Negligible	None Necessary
2-3	Low	May be Necessary
4-7	Medium	Necessary
8-10	High	Necessary Soon
11-15	Very high	Necessary Now

The REBA scores for each of the main tasks for the various kerb operations can be seen in appendix C.



## 2.8 THE BIG PICTURE

The manual handling of the kerbs was not looked at in isolation. In order to better understand the relationship of the kerb laying operation with the various parties concerned within the construction system, the life cycle of the kerb from manufacture through to removal was determined.

At the onset of the project it was felt that looking only at manual handling and mechanical lifting aids would be of little overall benefit, so it was decided to look around the operation at the many factors that affected it (manufacture, work organisation, worker attitudes and demolition and removal).

## 3.0 FINDINGS

### 3.1 CONCRETE KERBS

#### 3.1.1 Design

The kerb provides a physical step separating the road from the footpath. It acts as a channel to assist with drainage of the road and is used to reinforce road edges where no footpaths exist.

A designer can tackle manual handling in the kerb installation operation in several ways:

- Small block pave kerb units can be used in block paved urban areas.
- Lightweight combined drain/kerb units used.
- Road widths can be extended (where possible) instead of using kerbs to reinforce road edges.
- Kerbs made from lightweight materials used.
- Requirements for healthier systems of work included in the specification/contract.



However, it was felt from the focus group meeting that designers are conservative and they feel there are no guidelines for specifying alternatives to a concrete kerb which has a British Standard.

*"Designers design to British Standards".*

A similar situation occurred with the historical use of hot rolled asphalt, the British Standard for road surfaces, which, despite initial resistance, has now largely been replaced by thin surface materials with Agrément Certification. There is also a fast track British Standard method for alternatives such as the plastic kerb, and as the alternatives become more prolific, so the designers will be under pressure to change their practice. In Local Authorities there is also an incentive to use products that are sustainable, which may lead to more specification of kerbs made from recycled materials, which could include plastics.

The CDM regulations in the UK were intended to place responsibility on the designers and clients to design out unhealthy working practices. The regulations, as previously stated, have yet to work as intended. It is now ten years since their introduction and, following reports of their lack of effectiveness, the HSE are beginning to target the designer when inspecting construction projects and take them to task with regard to the health and safety plans provided by law for each project.

In order for legislation such as the CDM regulations to work, designers require some knowledge of health issues. At the moment when a designer changes the width of a footpath they may realise that this will require a certain amount of work and resources to achieve and that these will have a financial cost. However, they most likely do not appreciate the working practices and the physical effort required and the costs to the health of the worker involved.

It was suggested, at the focus group meeting, that designers should spend more time on site to understand the working practices and how their design affects them.

*"Designers look at what they are designing but don't look at how you install it."*

*"Designers operate too much in isolation from the other processes in all aspects of construction."*

A related Loughborough APaChE project, D<sup>4</sup>h (Design for health), funded by DTI, has produced an interactive CD providing guidance for designers to reduce ill health risks for construction workers.

### 3.1.2 Manufacture

Visits to two major producers of concrete kerbs revealed that manual operations, which used to be present throughout the manufacturing operation, have been virtually eliminated. The pre cast components are lifted from the mould by vacuum devices onto pallets and then transported through curing to storage and despatch areas using forklift trucks.

Manufacturers' material safety data sheets for concrete kerbs (which are available from their web sites) state that 'manually handling the product should be avoided so far as is reasonably practical' or refers to the HSE Construction Sheet No 37 - Handling building blocks.

Representatives from the concrete kerb manufacturers at the focus group were knowledgeable in arguments against alternative materials. They appeared to have no plans to alter their product to reduce risks to installers and claimed that they had not been asked by the industry to provide anything other than the standard British Standard product. However, discussions with the Hampshire & District Construction Safety Group revealed that they carried out trials with Marshalls on the use of light weight kerbs (100mm instead of 125 mm thick). Shorter kerbs (about 500mm as opposed to 900mm long) are available and have been used in this country. A manufacturer at the key stakeholders forum reported having developed a lightweight kerb in two lengths.

From discussions with representative organisations for the concrete product it was found that the Quarry Products Association (QPA) were lobbying the HSE to coordinate discussion within the construction industry to arrive at a consensus for best practice – this led to the Key Stakeholders Forum. Interpave put together guidelines for its members for the safe installation of kerbs and flagstones. However, this was never published and is now to be replaced with new guidelines drafted by Loughborough University.

The use of kerbs made from lightweight aggregate was discussed with Lytag. They felt that this was an area yet to be explored but saw no reasons why their product shouldn't be used in this way.

Feedback from contractors has suggested that the inclusion of hand holds, lifting sockets and hollow kerbs would be useful but no evidence of these has been found.

### 3.1.3 Training

Courses for kerb laying within the UK are provided by two national bodies. The Construction Industry Training Board (CITB) and the Highways and Construction Training Association (HCTA). However, as the practice of laying kerbs by hand has not changed for decades, it is common for the techniques to be passed on from older to younger workers without further training.

CITB courses are usually attended by workers from main contractors. It is usual for the kerb installation work to be carried out by sub contractors. The HCTA operate a number of training centres that are primarily for the training of county council staff.

The courses concentrate on the technical aspects of producing the finished kerb run to line and level and may, at best, include one hour in a seven day course on aspects of use of lifting devices. There is an assumption that prerequisite manual handling instruction has been completed previously. Following attendance at the course, policing of individuals to assess that the instruction is being carried out is rare.

The construction industry in the UK is attempting to provide skills certification of workers with the Construction Skills Certification System (CSCS). Under this scheme work is to be carried out only by workers who have the appropriate certification. Although it is up and running for many common practices on larger projects it appears to be floundering with regard to specialist items of work such as kerb laying.

For training to work it needs to be carried out at all levels throughout the construction sector. Operatives, supervisors, contract managers, specification writers, designers, architects and even clients all need to be aware of the health risks that are associated with construction practices so that appropriate measures can be taken at all levels to ensure that risks are reduced to the minimum.

In some circumstances, specialist sub contractors for ground works have trained young workers in-house. They expose them to the various ground works operations (kerbs, drains, foundations and flagstones) and then keep them on in an area for which they have an aptitude. This method is preferred by employers to sending workers on an 'expensive' course to get a certificate to recognise that they can lay kerbs.

It was noted that those kerb layers who had been laying kerbs manually for many years used good techniques and smooth efficient operation with minimum postural loading. This usually occurs when they have been well trained or had suffered injury and working this way minimised the discomfort. Good techniques are usually developed with regular exposure to the work. However, if bonuses apply, the techniques are based on speed rather than benefiting their health.

National training schemes provide instruction to produce good work, thus satisfying the technical requirements of the design. If practical installation and health issues were emphasised in training this would help move workers away from concentrating on the speed of installation and to considering reducing the risks to their health.

The advent of new equipment and alternative products will also require some emphasis on health in training otherwise the benefits from investing in the new machinery will fall short of its potential. Poor use of this equipment – incorrect bed level, poor co-ordination of kerb stacks – can introduce new health risks.

### 3.1.4 Work Organisation

The organisation of the kerb installation varies from site to site. Some choose to use manual methods while others use mechanical and each of these operations will vary to suit the plan of work for each site. In the manual method, see appendix C, the stringing out of the kerbs prior to lifting onto the concrete bed can be done by site labourers instead of the specialist kerb layers. The kerbs can be strung out from a vehicle as it moves along the kerb line or pallets can be left at intervals along the kerb line and the kerbs lined up using a mechanical hand clamp. With the vacuum operations contractors are trying to find the methods that best suit their work. One variation being the method of supporting/moving the vacuum equipment as this can be done on various machines with lifting forks or trailer mounted and there have even been trials with tracked vehicles.

Contractors, put under pressure to comply with regulations, are hindered by contracts that do not specify that mechanical handling must be used and habitually go for the cheapest option which is typically installation by hand. For the contractor to consider the use of mechanical lifting equipment, the contract must be written with this in mind i.e. allowing for road closures where this is necessary to manoeuvre the equipment.

At present, designers either state mechanical lifting devices must be used or leave this to the contractor. This leads to extra work for the contractor to investigate available equipment for its suitability – balancing ability to carry the load against efficiency with laying kerbs. If lifting equipment is not specified, the contractor has to gamble that others submitting tenders are not risking a fine for carrying out manual handling against winning the work.

Also, designers will soon have to choose between traditional concrete kerbs installed with vacuum lifters against alternative kerb products.

The availability of lifting equipment is such that, if all contracts specified the use of vacuum lifters, there would not be enough pieces of equipment to go around. However, there is evidence from other similar situations (e.g. mobile elevated work platforms for steel erection) to suggest that the supply chain will respond if demand increases.

The manual handling of concrete kerbs does not usually fall on the critical path in a programme of works. This will change with the use of JCBs or the like being used to support the vacuum lifters and pallets of kerbs. If equipment is hired, it makes sense to carry out the whole operation in the shortest period of time. If space is limited, work may have to coincide with road closures programmed for other operations.

### 3.1.5 Installation

The laying of concrete kerbs is generally carried out by specialist sub contractors for large projects such as long stretches of trunk roads. For smaller jobs, where car parks and access roads are required on new developments, ground workers are used and for term maintenance work general builders and council trained ground workers are mostly used.

Ground workers, on the whole, are involved with all work at or below ground level which would include kerb laying operations, installation of drains, casting of concrete footings and also laying of flagstones and block paving. Specialist sub contractors will sometimes only install kerbs but can be involved with other work such as the laying of flagstones.



©Loughborough University

© Loughborough University

Workers interviewed were aware of the health risks but continued to put themselves at risk while financial incentives were available, aware that at some age they will have had to accrue enough money before not being physically capable of more work. It has been noted that acceptance of lifting equipment is greater where financial incentives to increase speed are not used.

With traditional methods (manual handling of concrete kerbs) the worker is at risk of injury (short and long term) as a result of lifting excessive weights in a particularly hazardous environment. Time pressures from contract deadlines and bonus schemes increase the risk. Risks are compounded by other tasks in the operation – hammering and shovelling (see REBA scores in appendix C) and by carrying out similar types of work (laying concrete flags or installing drains) when not laying kerbs.

Workers have ended up laying kerbs because of the combination of their strength, which is required to lift the kerbs, and skill because of the accurate nature of the work. Health



implications become apparent when pain and discomfort begin. The workers might then make a decision to try different lines of work or weigh up their finances against their likely working life. As workers interviewed were aware of the health risks and yet continued the practices, it appears that they have decided to accept the risks to their health for the financial reward.

Removal of bonus schemes to reduce pressure on kerb layers may be good for their health but comes as a hard knock to those who have already compromised their long term health for medium term financial gain.

Contractors are starting to look at the costs of buying or hiring vacuum lifting equipment and assessing the costs of lost days due to injuries to operatives carrying out heavy manual tasks. Loss of workers in construction due to injury is becoming more important as the number of people willing to work in construction declines.

### 3.1.6 Manual Handling

In certain circumstances small amounts of kerbs may have to be installed by hand. This should only be the case if, after carrying out risk assessments for the working operations, it is not possible to eliminate them, through design, or control them with the use of mechanical handling equipment or the use of alternative kerb materials.

In the event of manual handling being required, all workers should be trained in basic, safe, manual handling techniques and all efforts made to reduce the risks to health from the environment (eg. work not to be carried out in extreme weather conditions) and choice of personnel (eg. no workers under 18 or over 50 and must have experience of the task).

### 3.1.7 Lifting Equipment – Clamps

From early searches, two types of manual lifting clamp were found:

- Scissors clamps (one set for each of two operatives) that grip the face and back of the kerb
- Bar clamps which have a bar parallel to the kerb with two arms that clamp onto the ends of the kerb and grip when the bar is lifted up.



© Loughborough University



© Loughborough University

Following anecdotal evidence it was initially thought that clamps were provided by the employers but not used by the operatives. Site visits demonstrated that this was not the case and there were examples where regular use of clamps was evident. However, when financial bonuses were in place, the more skilled workers claimed that they found it quicker to lay kerbs by hand.

The use of the hand clamps is limited to short movements, lifting off a pallet or lifting up and onto the concrete bed, because it is difficult to walk when once lifted.



The clamps are being used less now because of the increase in the use of vacuum lifters but are still being used where it is difficult to use vacuum lifters e.g. on housing estates where the streets are tight and winding and on small maintenance work, replacing small numbers of kerbs, where it does not justify the use of mechanical lifting equipment.

The use of manual lifting clamps improves the operation of lifting providing the lift can be at waist height and allowance made for a specific user population. To grip the clamps requires some wrist deviation and prolonged use may cause discomfort. The postural loading scores (see appendix C) using the REBA tool are reduced from high and very high risk to medium risk (action necessary) for the lifting of the kerbs. The postural loading is highest on the back and legs when adjusting position to put the kerb down.

Various types of large clamps are used which are attached to site machines to lift the kerbs using a clamping operation. Remote handling increases time taken to lay the kerbs and clamps do not work well with the setting out strings.

### 3.1.8 Lifting Equipment - Vacuum Lifters

There are two main manufacturers providing vacuum lifting equipment for kerb laying operations in the UK. Both work on the basis that the machine and a pallet of kerbs are carried on the forks of a JCB or telescopic loader. The vacuum lifter has a boom along which the vacuum tube and suction plate are supported and allows considerable positional movement of the suspended kerb. The machines differ in the boom type and hand controls (one on a ring and the other a handlebar type).

As demand increases machines are becoming more readily available from plant hire operators. They are being bought by Local Authorities who carry out their own highways work and by specialist sub contractors who previously laid kerbs by hand.

Even over the period of this research project, the equipment has changed and will probably continue to change during the next few years as the increase in use provides feedback and improvements are made. For example, some difficulties have been found with the boom operation because, if this is not level, the operator has to fight against the machine as the heavy kerb is moved into position. There also are currently moves to install baffles around the engines as noise levels are in excess of 90 dB on diesel machines and ear protection must now be considered, whereas it was less likely to be required for the manual operations.



Al-Vac

© Loughborough University

Probst

© Loughborough University

All operators interviewed, who had previously laid kerbs using clamps but now used vacuum lifters, reported feeling less worn out after a day's work. There were no reports of aches and

pains to the hands after using the controls and the equipment was found to be easy to operate with a relatively short amount of training.

There is less wrist deviation from holding the controls than with the clamps and there is no supported load so that is an obvious improvement. While the handle bar operation caused slight abduction of the arms it provides a surer control of the kerb. Postural analysis of the operation using the REBA tool (Hignett and McAtamney 2000) has the postural loading at insignificant risk level with no action required (see appendix C).

There are, of course, additional costs when using mechanical lifters. Equipment must be maintained and requires fuel, replacement pads and filters. As the installation process is less flexible than two men manually handling the kerbs it will increase the costs to a contract. Depreciation and insurance also need to be considered. However, as mentioned earlier, these extra costs may be significantly reduced if the savings from not injuring workers are considered.

With new equipment, skill is still required although not so much strength. This will allow greater numbers of workers to carry out the tasks and help to prolong the working lives of existing kerb layers. Ultimately, this will reduce costs to the industry.



© Loughborough University



© Loughborough University

The packaging of the concrete kerbs was seen as an issue. Kerbs used to be delivered on wooden pallets which could be moved around a site by fork lifts. Pallets are now rarely used, having been replaced with a plastic tie that binds the kerbs together before they are covered in shrink-wrapped polythene. This change has largely been driven by sustainability concerns seeking to reduce waste. Also the order in which they are packed affects the efficiency of the mechanical lifting. Often the kerbs are back to back and every other kerb has to be turned around before it can be picked up with the profiled head of the vacuum lifters. There are also problems with kerbs falling off the stack when the plastic banding is cut. This may be an area where potential sustainability gains need to be weighed up against increased health hazards.

Small vacuum devices suspended off site machines, called Stone Magnets, can lift the kerbs but require an operative to manoeuvre the device and kerb into place.

### 3.1.9 Repair

Concrete repair is usually associated with the refurbishment of buildings from the 1960s and 1970s that had components with corroded steel reinforcement. Proprietary concrete repair work would not usually be considered for mass concrete kerbs because it would be cheaper to replace them. However, a company specialising in the repair of stone work has carried out a cost exercise comparing the cost of repairing stone kerbs in a high street situation against replacement and found the operation to be cost effective. This equation may start to favour repair more strongly as the concerns about manual handling increase.

The issue of damage to kerbs when developing housing estates was raised at the focus group meeting on design. It was suggested that when local authorities adopted the estate roads

that repair of kerbs damaged during the development of the site should be considered instead of replacement. Following the meeting it was discovered that it was possible to leave the installation of kerbs until the estate was ready for adoption. This required the use of a kerb race (form of concrete beam that the kerb is eventually bedded on) to support the edge of estate roads.

### 3.1.10 Removal

Where kerbs must be removed as part of refurbishment or renewal work, there are companies there are companies that specialise in equipment that will grind up lines of concrete kerbs – e.g. Cutakerb’s KerbsOut system - and leave the crushed concrete to form a hardcore bed for the following operations.

The operation uses milling machines specially modified to cut existing pre cast concrete kerbs prior to excavation for replacement. They are able to cut out the existing kerb 30 centimetres wide and up to 40 centimetres deep to form a perfect trench for a contractor to lay new kerbs. Not only is this operation extremely quick and environmentally friendly, dramatic cost savings can be made as it removes manual handling operations previously used.

Where fewer kerbs are to be removed which do not warrant the use of a grinding machine, the kerbs have been broken up before being removed. However, there was still evidence that maintenance work was being carried out where old kerbs were being manually handled in removal and new kerbs manually handled in installation.

## 3.2 SLIP FORMED/ EXTRUDED KERBS

### 3.2.1 Installation

A motorised vehicle that accepts concrete poured into a hopper and feeds it through a detachable profiled former to produce an extruded kerb. This equipment appears to be used globally with examples of its use in Australia, India, the USA and Ireland. Despite recorded use of this equipment for at least 30 years in the UK, it has not become widely used. Reasons for its greater use in other countries may be due to type of work (large unobstructed highways) and climates more suitable for casting concrete outside. However, with the increased technology, the equipment has and should continue to become more versatile and suitable for more complicated profiles and conditions.



© Loughborough University

© Loughborough University

The operation requires a guide wire to be set up off steel pins (set out by others). The machine then automatically follows the wire for line and level. The machine is operated from a control panel situated in an elevated position on the same side as the guide wires. From here, the concrete flow through the machine can be adjusted. The former can be lifted over any obstructions and any running adjustments can be made. The concrete flow from the

wagon needs to be regulated and a finish applied to the concrete kerb by hand trowel. These operations were carried out using three operatives.

It was reported that the machine could lay 300m of kerbs in a day with three operatives. However by, increasing the number of operatives to seven, the output could be increased to 700m. It is possible to load the machine up and take it to places inaccessible to the concrete wagon and form the kerbs.

The REBA postural loadings gave risk levels of low for the machine operator and medium for the other two operatives (see appendix C).

- loading was on the neck for the machine operator as they stood on an elevated platform on the machine and looked down at the concrete being extruded at ground level
- raising of the arms for the operator checking the concrete flow when using a shovel to move concrete in the hopper
- bending of the back for the operator with the trowel.

### 3.2.2 Repair

It would not be feasible to bring back the slip form machinery should a small section of kerb be damaged. However, as the profile of a kerb is a simple shape, it should not be difficult to construct the appropriate formwork for remedial casting.

### 3.2.3 Removal

There would be no manual handling implications with removal because the kerb as a whole could not be picked up. The CutaKerb system, which breaks up the kerb insitu, should be able to cope with removing long lengths of the slip form kerb.

## 3.3 PLASTIC KERBS

The development of a plastic kerb, by Durakerb, which is hollow and reinforced with internal ribs is currently at a testing and certification stage. The manufacturers hope to produce a component with a 9kg. weight, compared to around 70kg. for a concrete kerb, that can have an appearance to match any existing installed kerb and will be to the British Standard profile.

### 3.3.1 Installation

This kerb is being developed to be used for maintenance work. It is this type of work where the vacuum lifting equipment is difficult to use. The kerbs are of the same profile as the British Standards for concrete kerbs and would be installed in the same manner onto a concrete bed. The main difference is that, in theory, it requires three people to lift a HB2 kerb while one person should be able to lift up to three plastic kerbs.

### 3.3.2 Repair

It is claimed that minor damage to the plastic kerbs can be repaired with a heat application but more significant damage would require replacement.

### 3.3.3 Removal

It is intended to run a collection / replacement scheme so that when kerbs are replaced with new plastic ones in the future the old plastic kerbs would be taken away for recycling.



### 3.4 RUBBER KERBS

A rubber kerb produced from recycled tyres has been developed by the partnership of Harlow District Council and Rediweld (traffic management specialists) for use in positions that are susceptible to regular and heavy vehicle impact. The kerbs are of a traditional profile and for a 914 x 150mm thick x 180mm high profile the weight is reported as 19kgs, compared to around 70kg. for a concrete kerb.

#### 3.4.1 Installation

The units rely on a bolt down system for installation using three bolt-through anchors per unit. This requires more work to place the unit but there are savings with not having to excavate.



Rediweld

#### 3.4.2 Repair

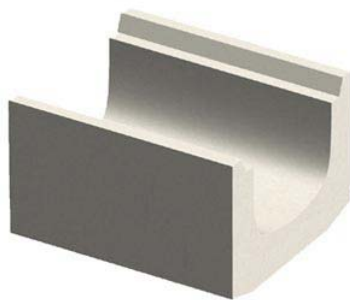
Manufacturers claim that as a flexible material, the kerb is not as susceptible to impact damage and is less likely to require repair work than conventional concrete kerbs.

#### 3.4.3 Removal

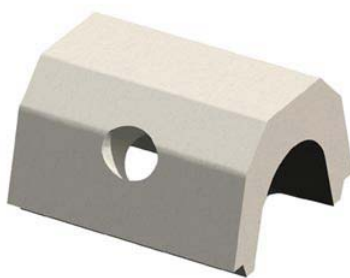
The system is designed so that it can be used for temporary traffic controls so it can be removed easily.

### 3.5 COMBINED DRAIN KERBS

The use of combined kerb and drain units has become more widespread. This has resulted in a smaller component weight which has been reduced further by the use of recycled waste materials. However, there appears to be no cost advantage due to the 'wet' manufacturing process used and it is only appropriate where drainage is required in addition to a road edge kerb.



Beany Base



Beany Top



ACO Kerbdrain

### 3.5.1 Installation

Installation for units of similar profile to concrete kerbs differs only slightly. However, larger two piece units such as the Beany Blocks require different methods. This has led to adaptors being added to vacuum lifting machines and mechanical lifting equipment being developed by installers – May Gurney.



May Gurney Installation Device

### 3.5.2 Removal

Removal for long runs is similar to concrete kerbs using the CutaKerb machinery. Small amounts would need to be broken into smaller pieces before being removed.

<b>Drain/Kerb Unit</b>	<b>Description</b>	<b>Weight in kg.</b>
ACO Kerbdrain 305	Single unit	25 – 29.5
ACO Kerbdrain 408	Single unit	32 – 35
Beany Blocks	Base	
Beany Blocks	Top	32.5
Mini Beany	Base	
Mini Beany	Top	55
Envirokerb	Single unit	16 – 16.5

## 4.0 CONCLUSIONS

the research found that installation of concrete highway kerbs by hand is widespread and includes other risk activities (e.g. hammering and shovelling) apart from the manual handling of the kerbs. As an item, a concrete kerb is a cheap commodity, mass produced to a standard profile from basic materials. Installation by hand has little impact on the overall cost of a line of kerbs.

The regulations that protect the installers from injury are not working for this operation. The Health and Safety Plans cannot have included for kerb laying operations otherwise manual handling operations would not be used as they cannot work within current guidelines.

The construction industry appears to be lagging behind manufacturing with regard to manual handling operations. Ergonomic problems in the manufacture of prefabricated concrete elements were investigated as long ago as the early 1980s (Grandjean 1983). This lack of progress is largely due to the temporary nature of construction sites and a transient workforce being difficult to regulate.

The industry seems to be reacting to enforcement, tackling sections of the problems of manual handling as they become Health and Safety Executive enforcement targets, going from cement bags to heavy blocks and now kerbs. The industry appears to be looking for guidance in a quick and easy to follow form that can help them comply with a raft of regulations that are more detailed and which they may be reluctant to tackle.

Although projects now specify lighter blocks and bags of cement to satisfy manual handling requirements, they do not address manual handling of kerbs. Workers resist complying with some restrictions because other similar operations are carried out with apparent immunity.

Where attempts have been made to tackle the problem they have sometimes failed due to lack of support from other organisational levels.

Solutions are being imported from abroad, with the vacuum lifting devices being developed in Germany and Denmark. By introducing new methods of installing concrete kerbs and kerbs made from lightweight materials the most significant of the hazards (i.e. weight of the concrete kerb) has been removed but other operations with kerb laying and carrying out similar types of work remain.

Many safety associations and individuals in the UK have been working in parallel to solve the problem. This has led to a fractured approach rather than an cohesive industry led approach to tackling the issue.

The industry is asking for guidance to use to enable them to carry out work in accordance with the regulations.

Many alternatives have been disregarded in the past because of cost. Operations such as slip form paving may now be a more attractive option as manual handling operations become less acceptable.

Although the use of hand clamps for lifting concrete kerbs is not recommended (still manual handling, trip hazards when walking and difficult to work with the string line) they may have an interim use in small maintenance work if used with lightweight kerbs.

## 5.0 FURTHER WORK

This project has concentrated on the problems and potential solutions for highway kerb laying. The work provides a foundation for further research and development on the broader issues of manual handling in construction. Key opportunities include:-

- Manufacturers' guidelines for safe installation of concrete products (kerbs and flagstones). A related project funded by Interpave, the trade body for concrete paving and kerb products, has been running consecutively with the Construction Health and Safety Group project.
- Risk assessment tool for kerb installation. A tool has been produced by Loughborough that can be used by designers and supervisors of kerb installation work to quantify the risk that a proposed installation poses and guide the revision of the process to reduce the risk. Additional work is required to validate the scoring for this tool.
- Extending the CHSG project to cover manual handling aspects of other ground works operations addressing design, management and training issues.

## 6.0 RECOMMENDATIONS

The following recommendations have been developed from this research project. The basic principles of the need to properly assess the risk for each situation and seek to eliminate, reduce, and control the residual risks still apply. These recommendations should not be seen to undermine these basic principles.

### Recommendations for Designers

1. The manual handling operation should be eliminated where ever possible through the choice of design methods and materials. (see table in Appendix 2)
2. Designers should spend more time on site in order to be aware of risks associated with their design and adopt alternative design/materials to reduce risks to installers' health.
3. Designers should examine schemes for workability and buildability. Contracts should include requirements for installation which reduce manual handling risks.

### Recommendations for Manufacturers

4. New products should be designed with consideration of the effect of the installation of the product on the installers' health.
5. Manufacturers should work with contractors and designers to remove obstacles to the adoption of technical innovations.
6. Manufacturers should be pro-active and provide advice on the safe installation of their products.

### Recommendations for Contractors

7. The manual handling of concrete kerbs should be eliminated by using mechanical lifting equipment wherever practicable.
8. Contractors should improve their knowledge of alternatives to traditional kerb details in order to identify risks to health and adopt appropriate controls when carrying out risk assessments.
9. Manual handling of concrete kerbs should only be carried out once all other options have been explored and safe handling methods should then be employed (see section 3. 1. 6).
10. Financial incentives for fast installation of kerbs should be avoided.



#### Recommendations for Training Organisations

11. Manual handling awareness training should be provided at all levels of construction organisations to ensure support is available for anyone attempting to control risks associated with manual handling tasks.
12. Training organisations should provide courses for designers and contractors in adopting appropriate methods for different kerb requirements and other related manual handling tasks.
13. Installers should receive training (at least ½ day) on vacuum lifting equipment, where used, which should include input from equipment manufacturers.

#### Recommendations for Client /Local Authorities

14. Clients should ensure that achieving their project objectives has no adverse affect on those who work on them.
15. Clients should allow for the costs of lifting equipment or alternative kerb types in new work.
16. Local Authorities should reassess adoption of roads procedures and consider accepting repairs to kerbs instead of replacement.

#### Recommendations for Health and Safety Executive

17. The Health and Safety Executive should work with construction safety organisations, clients, designers and contractors to coordinate efforts in understanding and controlling risks to health in construction work.
18. The Health and Safety Executive should provide guidance with enforcement.
19. Research into easy to use tools to aid contractors and designers with risk identification and control should be commissioned.

## REFERENCES

Baxendale, Jones 2000

Buchholz, B. et al. 1996, PATH: A work sampling-based approach to ergonomic job analysis for construction and other non-repetitive work, *Applied Ergonomics*, **27**, 177-187

Construction (Design and Management) Regulations 1994

Grandjean, E 1983, Occupational Health Aspects of Construction Work, *WHO Euro Reports and Studies 86*. World Health Organisation, Geneva

Health and Safety at work Act etc. 1974

Health and safety performance in the Construction Industry Progress since the February 2001 Summit Second report by Kevin Myers Chief Inspector of Construction, Health and Safety Executive January 2003

Hide, S. et al. 2001, Using focus group data to inform development of an accident study method for the construction industry. In M.A.Hanson (ed.) *Contemporary Ergonomics 2001*, (Taylor and Francis, London), pp153-158.

Hignett, S. and McAtamney, L. 2000, Rapid Entire Body Assessment (REBA), *Applied Ergonomics*, **31**, 202-205

Koningsveld, E.A.P. and Van der Molen, H.F. 1997, *History and future of ergonomics in building and construction*, *Ergonomics*, 40, 1025-1034

Langford, J., and McDonagh, D. 2002, What can focus groups offer us? In P.T.McCabe (ed.) *Contemporary Ergonomics 2002* (Taylor and Francis, London)

Management of Health and Safety at Work 1992

Manual Handling Operations Regulations 1992

Niskanen, T. 1992, *Accident risks and preventative measures in materials handling at construction sites*. Helsinki: Helsinki University of Technology; 72pp

Oppenheim A.N. 1992, *Questionnaire Design, Interviewing and Attitude Measurement*.

The Government and the Health and Safety Commission (HSC) Revitalising Summit 2001

## **APPENDICES**

## **Appendix 10.4**

### **Interpave kerb installation guidance**

# handling kerbs

Guide to the  
Handling of Precast  
Concrete Kerbs



**Interpave**  
THE PRECAST CONCRETE PAVING  
AND KERB ASSOCIATION



# HANDLING KERBS

## guide to the handling of precast concrete kerbs

(downloaded from <http://www.paving.org.uk>)



Published by Interpave  
The Precast Concrete Paving & Kerb  
Association  
60 Charles Street, leicester LE1 1FB

tel: 0116 253 6161  
fax: 0116 251 4568  
e-mail: [info@paving.org.uk](mailto:info@paving.org.uk)  
website; [www.paving.org.uk](http://www.paving.org.uk)

Interpave is a Product Association of the British  
Precast Concrete Federation Ltd.

© Interpave 2004

Every effort has been made to ensure that the statements made and the opinions expressed in this publication provide a safe and accurate guide; however, no liability or responsibility of any kind (including liability for negligence) can be accepted in this respect by the publishers or the authors.



## Introduction:

The Health and Safety Executive has highlighted the manual handling of Concrete Highway kerbs in their 'Construction Health and Safety Advice on HSE Priorities 2001 Onwards' document, pointing out that a total of 10,000 lost time injuries occurred during all construction work in 1999- 2000 caused by trips, slips and manual handling. In response, Interpave commissioned Loughborough University to produce specific guidelines for site handling and installation of concrete kerbs.

Throughout 2003 Loughborough University, as part of its 'ApaCHe' initiative (A Partnership for Construction Health and Safety), carried out research funded by the Construction Health and Safety Group into kerb installation. Numerous sites throughout the UK and Ireland were visited to inspect various alternative methods of manual and mechanical installation for concrete highway kerbs. Drawing on this research, Loughborough University has compiled the following guidelines for Interpave, to assist with the installation of concrete kerbs in a safe and efficient manner.

The following guidelines are intended to help with the reduction of risks resulting from installation of highway kerbs and relate to currently available equipment. They do not replace the contractor's obligations to carry out risk assessments in accordance with the Construction (Design and Management) Regulations and work should be carried out in accordance with all relevant, current legislation.

Separate guidance on the design, detailing and installation of concrete kerbs is available from Interpave.



## Context:

Concrete kerbs have been in use for around 70 years - and natural stone kerbs for much longer. However, installation of these products by hand has continued despite a plethora of regulations (including the Health and Safety at Work Act, etc., 1974, Manual Handling Operations Regulations 1992 and CDM Regulations 1994). These regulations were introduced to protect workers from risks associated with musculoskeletal disorders and work related upper limb disorders. There has been a gradual introduction of mechanical lifting devices into the UK over recent years but without supporting guidelines to reassure contactors that equipment is safe or to demonstrate how and when it should be used.










## Health and Safety Requirements:

A meeting of key stakeholders involved in all aspects of kerbs, including kerb manufacturers, contractors, local authorities, government agencies, training organisations and trade bodies, was held in December 2003. At that meeting, a timetable was agreed with the Health and Safety Executive for the industry to move from a situation where the majority of heavy kerbs (more than 20kg) are laid by hand, to one where mechanical handling is the industry norm. The following programme of actions was agreed at that key stakeholders meeting.

### Meeting the Requirements

NEW BUILD PROJECTS - LONG STRETCHES OF KERBS	
 Timescale: Immediate	Avoid any manual handling of heavy kerbs. Use mechanical handling solutions for all heavy kerb laying
NEW BUILD PROJECTS - SHORT STRETCHES OF KERBS	
 Timescale: Immediate	If no mechanical lifting equipment is immediately available, produce a time-bound action plan outlining the control measures which will be used and specify a deadline for implementation  move as soon as practicable to use of mechanical handling solutions for all heavy kerb laying
 Timescale: By end December 2004	
SPOT REPAIRS AND MAINTENANCE PROJECTS	
 Timescale: Immediate	It is recognised that much of this work is under term maintenance and that some contracts may be part-way through, so it may take some time for Clients and Contractors to make arrangements for mechanical kerb handling. If no mechanical lifting devices are immediately available, or contract terms need to be renegotiated, produce a time-bound action plan outlining the control measures to be used and specify a deadline for implementation.  Secure mechanical handling solutions for all heavy kerb laying activity
 Timescale: By end December 2004	

## Risk Assessment:



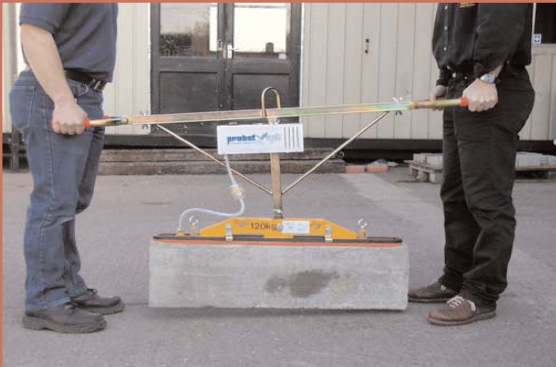
The Manual Handling Operations Regulations 1992 require the employer to carry out a risk assessment for all kerb-laying work. The HSE has proposed a Hierarchy of Controls (with preferred solutions first) to help with this, summarised as follows:

- Eliminate manual lifting of kerbs
- Total Mechanical Solutions – kerbs are always handled and laid with mechanical handling equipment
- Partial Mechanical Solutions – maximising the use of mechanical handling equipment wherever possible
- Manual Handling – in rare cases where none of the above is possible short stretches of kerbs can be laid manually. Scissor clamps allow two people to share the weight but should not be seen as an alternative to mechanical solutions.








## Lifting Equipment Summary:

The following table summarises types of lifting equipment currently available. (Table continues on following page)

	TYPE	DESCRIPTION	ILLUSTRATION
<b>MANUAL HANDLING EQUIPMENT</b>	One person manual lifting vacuum system	Battery driven vacuum lifter.	
	One Person manual lifting clamp	Simple scissor action operated by one person - (Two clamps and persons required to lift kerb)	
	Two person manual lifting clamp	Simple scissor action operated by two persons.	
	Two person vacuum lifting system	Battery driven vacuum lifter - may be used as an attachment to existing construction plant	



	TYPE	DESCRIPTION	ILLUSTRATION
<b>MECHANICAL HANDLING EQUIPMENT</b>	Mechanical grab attachment	Simple scissor attachment to an existing construction machine.	
	Hydraulic grab attachment	Hydraulically operated grab - attachment to an existing construction machine, hydraulics powered by host machine.	
	Self powered vacuum lifting attachment	Vacuum operated lifter attachment to an existing construction machine - self powered.	
	Vacuum fork lift attachment	Vacuum operated lifter attachment for a suitable fork lift or excavator fitted with forks - hydraulics powered by host machine - swining beam arm - kerbs for use carried by the equipment	
	Vacuum lifter - trailer or truck mounted	Vacuum operated self powered lifter - trailer or lorry mounted - swining boom arm - kerbs carried on board trailer or lorry	

## Manual Lifting Equipment :

Manual lifting equipment should only be used if it is not reasonably practical to use any other methods of installation. Suitability should be determined through a risk assessment of the operation. Equipment is based on either a manually operated scissor clamp or a vacuum lifter. These are available from Associate Members of Interpave.

### Selecting Manual Lifting Equipment

- Check for the appropriate manufacturer's certification / guarantees to ensure that the equipment has been designed for the intended use
- Ensure that the equipment is in good working order and not damaged
- Make sure that it will allow the worker(s) to lift and lower the load without undue bending or twisting
- Workers should be able to hold the equipment comfortably without excessive wrist deviation.

### Practical Considerations

- Ensure personnel have received training on team lifting and manual handling, and carry out the work in such a way as to reduce manual handling risks to an absolute minimum.

### Use, Maintenance and Testing of the Equipment

- Do not use for loads greater than those specified by the equipment manufacturer
- The equipment must be used, maintained and tested strictly in accordance with the equipment manufacturer's and supplier's requirements.

### Scissor Clamps

These use metal clamps to grip the product with a scissors action for lifting and can either clamp onto the ends or the sides of the kerb. Those that grip the sides are used in pairs for two-man operation with one pair per man either end of the kerb. Clamps that grip the ends can have either two handles or four handles in an H-shape (as viewed on plan), both types for two-man operation.

Although scissor clamps are low maintenance, failure of the equipment during lifting operations could cause serious injuries, and so they should be maintained in good working order. Failure of axis joints of the scissors or slippage due to worn or loose rubber grips may cause the load to drop. Wear and tear on handle grips may cause operatives' hands on the equipment to slip.

### Vacuum Lifting System

These utilise a motorised pump to generate suction through a pad that attaches to the kerb. The suction pad assembly is connected to lifting handles. It is essential to ensure that the suction pad type is suitable for the kerb type to be lifted.

Vacuum equipment may incorporate filters that require cleaning and replacement to ensure efficient running. Vacuum pads will wear and require repair or replacement from time to time. Wear and tear on handle grips may cause operatives' hands on the equipment to slip.

## **Mechanical Lifting Equipment :**

Equipment is based on mechanical or hydraulically operated clamps, or vacuum lifting systems. These are available from Associate Members of Interpave.

### **Selecting Mechanical Lifting Equipment**

- Consider the various differences between the equipment available in the context of the proposed work
- Lifting clamps/vacuum pads are available to suit different unit profiles. Care should be taken to ensure that lifting is not carried out using the wrong profiles
- Ensure that the equipment is the most appropriate for the job before purchasing or hiring. If the equipment is used inappropriately or not in accordance with the manufacturer's recommendations, accidents can occur
- Equipment continues to be developed with increased adoption by the industry and discussions with manufacturers before purchase may enable modifications to be made to suit any specific requirements.

### **Practical Considerations**

- Make sure work is appropriate for powered machines, e.g. that machinery can manoeuvre around the site
- Check with the kerb manufacturer that products will be delivered to site packed and loaded in a way that is compatible with the operational characteristics of the equipment, i.e. with drainage channels the right way up
- Operators of the equipment must complete training as laid down by the equipment supplier. Manual handling training is also required to deal with any unforeseen manual handling of kerbs and pallets.

### **Use and Maintenance of the Equipment**

- The equipment must be used, maintained and tested strictly in accordance with the equipment manufacturer's and supplier's requirements.

### **Mechanical Clamp Systems**

A simple clamping attachment to existing site plant designed for lifting. The clamping action relies on the kerb mass to activate the gripping action. Gripping is assisted by rubber blocks fixed to the clamps.

### **Hydraulic Clamp Systems**

A simple clamping attachment to existing site plant designed for lifting. The clamping action is achieved by a hydraulic device, usually powered by the host machine. Gripping may be assisted by rubber blocks fixed to the clamps.

### **Vacuum Lifters**

A simple lifting system that is either an attachment to existing site plant designed for lifting or mounted on a small lorry or trailer. Vacuum lifters utilise a motorised pump to generate suction through a pad that attaches to the kerb. The suction pad assembly is lifted and lowered by either a vacuum or hydraulic system. It is essential to ensure that the suction pad type is suitable for the kerb type to be lifted. Vacuum equipment may incorporate filters that require cleaning and replacement to ensure efficient running. Vacuum pads will wear and require repair or replacement from time to time.

## General Guidance:

It is important that work procedures are drawn up before commencement to identify any hazards. Failure to do this can result in lack of co-ordination of materials and multiple handling of product. Correct Personal Protective Clothing should be provided.

### Planning the work

- Work should be planned and coordinated to avoid unnecessary handling
- For operations where fork lift vehicles are used, kerbs should be stacked onto timber pallets. Ensure that pallets are robust as the failure of a pallet could allow kerbs to fall
- Strapping and wrapping of packs should only be removed just prior to use of the kerbs
- Care should be taken when cutting bands and/or removing wrapping to avoid kerbs falling
- Accurate placement of the concrete bed will minimise shovelling operations
- Accurate preparation of the concrete bed and any excavated trench will reduce the amount of adjustment to kerbs once laid
- Where power tools are used for cutting, these should be concrete cutters with diamond blades and water flow lubrication for cooling and dust suppression.

## Further Information:

### Publications

British Standard 7263-1:2001 - Specification for Kerbs

British Standard 7533-6:2001 - Guidance

Highways Agency Design Manual for Roads and Bridges Volume 7 Section 2 Pavement Design and Construction

Health and Safety at Work Act etc 1974

Management of Health and Safety at Work Regulations 1999

Manual Handling Operations Regulations 1992

Construction (Design and Management) Regulations 1994 (CDM)

Lifting Operations and Lifting Equipment Regulations 1998

Provision and Use of Work Equipment Regulations 1992

Loughborough University/Construction Health and Safety Group Report – Back to Design – The Manual Handling of Highway Kerbs

Loughborough University – Design 4 Health

Cumulative Trauma Disorders – Putz-Anderson

### Websites

ApaCHe – A Partnership for Construction Health and Safety – for information on associated consideration on health in construction

Construction Health and Safety Group – Training information

Ergonomics Society – for approved ergonomics consultants



# Interpave

THE PRECAST CONCRETE PAVING  
AND KERB ASSOCIATION

60 Charles Street  
Leicester LE1 1FB  
United Kingdom

e: info@paving.org.uk  
t: 0116 253 6161  
f: 0116 251 4568



[www.paving.org.uk](http://www.paving.org.uk)



PAVER SYSTEMS



INTERPAVE IS A PRODUCT ASSOCIATION  
OF THE BRITISH PRECAST CONCRETE  
FEDERATION LTD



t: 0116 253 6161  
f: 0116 251 4568  
e: info@britishprecast.org  
[www.britishprecast.org](http://www.britishprecast.org)



t: 0116 222 9840  
f: 0116 251 4568  
e: info@interlay.org.uk  
[www.interlay.org.uk](http://www.interlay.org.uk)



PUBLISHED WITH THE SUPPORT OF THE  
CONCRETE CENTRE



t: 0700 4 822 822  
e: info@concretecentre.com  
[www.concretecentre.com](http://www.concretecentre.com)

## **Appendix 10.5**

### **Interpave slab installation guidance**

# handling flags

## Guide to the Handling of Precast Concrete Flags



**Interpave**  
THE PRECAST CONCRETE PAVING  
AND KERB ASSOCIATION



# HANDLING PAVING FLAGS

guide to  
the handling of  
precast concrete paving flags

EDITION 2 – November 2005

(downloaded from <http://www.paving.org.uk>)



Published by Interpave  
The Precast Concrete Paving & Kerb  
Association  
60 Charles Street, leicester LE1 1FB

tel: 0116 253 6161  
fax: 0116 251 4568  
e-mail: [info@paving.org.uk](mailto:info@paving.org.uk)  
website: [www.paving.org.uk](http://www.paving.org.uk)

Interpave is a Product Association of the British  
Precast Concrete Federation Ltd.

© 2005 Interpave - The Precast Concrete Paving and Kerb  
Association, a Product Association of BPCF Ltd.

Every effort has been made to ensure that the  
statements made and the opinions expressed in this  
publication provide a safe and accurate guide; however,  
no liability or responsibility of any kind (including liability  
for negligence) can be accepted in this respect by the  
publishers or the authors.

## Introduction and Context:

Concrete paving flags have been in use for around 100 years - and natural stone flags for much longer. However, installation of these products by hand has continued despite a plethora of regulations (including the Health and Safety at Work Act, etc., 1974, Manual Handling Operations Regulations 1994 (as amended 2004) and CDM Regulations 1994). These regulations were introduced to protect workers from risks associated with musculoskeletal disorders and work related upper limb disorders. There has been a gradual introduction of mechanical lifting devices into the UK over recent years but without supporting guidelines to reassure contractors that equipment is safe or to demonstrate how and when it should be used. Loughborough University have assisted Interpave in the development of information in the handling of concrete flags in a safe and healthy manner.

The following guidelines are intended to help with the reduction of risks resulting from installation of concrete paving flags and are relevant for currently available equipment. They do not replace the contractor's obligations to carry out risk assessments in accordance with the Construction (Design and Management) Regulations and work should be carried out in accordance with all relevant, current legislation.

Separate guidance on the design, detailing and installation of concrete flag pavements is available from the Interpave website [www.paving.org.uk](http://www.paving.org.uk).



**Interpave**

Downloaded from <http://www.paving.org.uk>

## Health and Safety Considerations:

Each Interpave member has its own method of packaging but it is common for paving flags to be stacked vertically. The large type D (900 x 600mm) units are just banded. All other sized flags are firstly banded to ensure integrity then some are, in addition, sausage or shrink wrapped. Around 80% of packs are supplied palletised.

Flags can be divided into three main categories: Standard, Small Element and Decorative. Specific manufacturers should be contacted for detailed information on particular Decorative flags. Standard and Small Element concrete paving flags are produced in accordance with British/European Standard BS EN 1339 7263:Part 1:2001. Traditionally the range of sizes has remained consistent and the following units are recognised as the British Standard preferred sizes. As a guide to calculating individual weights of different size paving units a density of 2300kg/m<sup>2</sup> is used here.

Designation	Nominal Size mm	Thickness mm	Weight kg
A	600 x 450	50 or 63	32 or 39
B	600 x 600	50 or 63	43 or 52
C	600 x 750	50 or 63	53 or 65
D	600 x 900	50 or 63	64 or 78
E (small element)	450 x 450	50 or 70	23 or 33
F (small element)	400 x 400	50 or 65	19 or 23
G (small element)	300 x 300	50 or 60	11 or 13

## **Risk Assessment:**

The Manual Handling Operations Regulations 1992 (as amended 2004) apply to all construction work. They set out a framework for employers to tackle the risks from manual handling. Under these regulations, if employers cannot avoid manual handling where there is a risk of injury, they must assess their manual handling operations and take steps to reduce the risk of injury to the lowest level reasonably practicable. When deciding what needs to be done, you may find it useful to use the following hierarchy of control measures. You will need to show that you have used solutions from the top of the hierarchy in preference to solutions lower down.

The Hierarchy of Controls is as follows:

- Elimination - eliminate manual lifting of heavy flags during the design stage.
- Total mechanical solution - Ensure flags are always handled and laid mechanically ( e.g. with vacuum lifters, mechanical grabs, etc). This is the preferred solution for the majority of new build and many refurbishment works.
- Partial Mechanical Solution - ensure that the maximum possible amount of the process of handling flags is done mechanically ( e.g. using mechanical solutions to get the flags near to their final position such as off-loading using a hoist). The risk from manual handling may be reduced by using smaller/lighter flags and/or block paving.
- Manual handling - in rare cases where none of the above solutions is possible smaller areas of flags may be laid manually. Workers should be trained in lifting safely. The use of lighter weight flags, or devices which allow two people to share the lift will further reduce the risk of injury.



## **Precautions:**

All of those involved in the specification, manufacture, supply and installation of flags can help to reduce the risk from manual handling.

### **Designers, Planning Supervisors and Clients**

The design and planning stage should consider:

- Solutions that eliminate repetitive manual handling.
- Flags that are compatible with mechanical handling solutions.
- Identifying the risk during the lifetime of the product including issues relating to maintenance and repair.
- Planning the work to allow the maximum number of flags to be laid at one time to realise the economies of scale and promote the practicability of mechanical handling.

### **Manufacturers and suppliers**

Flag manufacturers will need to:

- Supply flags in a format compatible with commonly used mechanical handling equipment.
- Ensure flags can be removed from the pack without the need to handle them manually.
- Clearly mark pack weights and component weights.
- Ensure, where possible, pack sizes are below 1 tonne to allow handling by a wide range of commonly used site equipment.
- Safe storage and secure transportation.



## **Contractors:**

Contractors need to plan the work to ensure risk is kept to an acceptable level. This might involve the following actions:

Rethinking the phasing of flag installation to maximise the number of flags being laid at one time by mechanical means.

Lay direct from the pack rather than double handling.

Use machinery capable of handling both packs and individual flags.

Provide a safe storage and secure transportation of flags.




Ensure that workers are trained in a safe use of mechanical lifting equipment.

Provide training in the safe lifting techniques for works involved with flag laying.

Consider use of alternative smaller flag units or block paving in certain circumstances.

## Mechanical Lifting Equipment Summary:

The following table summarises types of lifting equipment currently available.

	TYPE	DESCRIPTION	ILLUSTRATION
<b>MECHANICAL HANDLING EQUIPMENT</b>	Self powered vacuum lifting attachment	Vacuum operated lifter attachment to an existing construction machine, self powered	
	Vacuum fork lift attachment	Vacuum operated lifter attachment for a suitable fork lift or excavator fitted with forks <ul style="list-style-type: none"> <li>- hydraulics powered by host machine</li> <li>- swinging beam arm</li> <li>- flags for use carried by the equipment</li> </ul>	
	Vacuum lifter - trailer or truck mounted	Vacuum operated self powered lifter <ul style="list-style-type: none"> <li>- trailer or lorry mounted</li> <li>- swinging boom arm</li> <li>- flags carried on board trailer or lorry</li> </ul>	

## Lifting Equipment:

Equipment is usually based upon vacuum lifting systems. Manual lifting equipment should only be used if it is not reasonably practical to use any other methods of installation. Suitability should be determined through a risk assessment of the operation. These are available from Associate Members of Interpave.

### Selecting Lifting Equipment

- Consider the various differences between equipment available in the context of the proposed work.
- Check for the appropriate manufacturer's certification / guarantees to ensure that the equipment has been designed for the intended use.
- Ensure that the equipment is in good working order and not damaged.
- Vacuum lifting equipment vacuum pads are available to suit different flag sizes and surface profiles. Ensure that the lifting vacuum heads are suitable for and compatible with the flags to be lifted.
- Ensure that the equipment is the most appropriate for the job before purchasing or hiring. If the equipment is used inappropriately or not in accordance with manufacturers recommendations, accidents can occur.
- For manual lifting equipment, make sure that it will allow the worker(s) to lift and lower the load without undue bending or twisting and to hold the equipment comfortably without excessive wrist deviation.
- Equipment continues to be developed with increased adoption by the industry and discussions with the equipment manufacturers before purchase may enable modifications to be made to suit any specific requirements.

### Practical Considerations

- Make sure work is appropriate for powered machines, e.g. that the machinery can manoeuvre around the site.
- Check with the flag manufacturer that products can be delivered to site packed and loaded in a way that is compatible with the operational characteristics of the equipment.
- Operators of the equipment must complete training as laid down by the equipment supplier. Manual handling training is also required to deal with any unforeseen manual handling of flags and pallets.
- When manually handling ensure personnel have received training on team lifting and manual handling, and carry out the work in such a way as to reduce manual handling risks to an absolute minimum

### **Scissor Clamps**

A simple clamping attachment to existing site plant designed for lifting. The clamping action relies on the kerbmass to activate the gripping action. Gripping is assisted by rubber blocks fixed to the clamps.

Although scissor clamps are low maintenance, failure of the equipment during lifting operations could cause serious injuries, and so they should be maintained in good working order. Failure of axis joints of the scissors or slippage due to worn or loose rubber grips may cause the load to drop. Wear and tear on handle grips may cause operatives' hands on the equipment to slip.

### **Vacuum Lifters**



A simple lifting system that is either an attachment to existing site plant designed for lifting or mounted on a small lorry or trailer. Vacuum lifters utilise a motorised pump to generate suction through a pad that attaches to the flag. The suction pad assembly is lifted and lowered by either a vacuum or hydraulic system. It is essential to ensure that the suction pad type is suitable for the flag type to be lifted.

Vacuum equipment may incorporate filters that require cleaning and replacement to ensure efficient running. Vacuum pads will wear and require repair or replacement from time to time.

Ensure that handle grips are firmly located and in good condition. Wear and tear on handle grips may cause operatives' hands on the equipment to slip.

## Manual Lifting Equipment Summary:

The following table summarises types of lifting equipment currently available.

	TYPE	DESCRIPTION	ILLUSTRATION
MANUAL HANDLING EQUIPMENT	One person manual lifting vacuum system	Battery driven vacuum lifter.	
	Two person manual lifting clamp	Simple scissor action operated by two persons.	
	Two person vacuum lifting system	Battery driven vacuum lifter - may be used as an attachment to existing construction plant	

## General Guidance:

It is important that work procedures are drawn up before commencement to identify any hazards. Failure to do this can result in lack of coordination of materials and multiply handling of product. Correct Personal Protective Equipment should be provided.

### Planning the work

- Work should be planned and coordinated to avoid unnecessary handling.
- For operations where fork lift vehicles are used, flags should be stacked onto timber pallets. Ensure the pallets are robust as failure of a pallet could allow flags to fall.
- Strapping and wrapping of packs should only be removed just prior to the use of the flags.
- Care should be taken when cutting bands and/or removing wrapping to avoid flags falling.
- Where power tools are used for cutting, they should be concrete cutters with diamond blades and water flow lubrication cooling and dust suppression.

### Return to Work

Employers should consider how to manage workers who have suffered a manual handling injury, in particular their return to work. For some lower back injuries staying mobile can assist recovery. Good management would include reviewing the risk assessment and obtaining medical advice. Further information is available on the *HSE Back Pain and Sickness absence* web pages.

## Further information:

### Publications

- BS EN 1339:2003, *Concrete Paving Flags - Requirements and Test Methods*
- BS 7533:Part 4, *Code of practice for the construction of pavements of precast concrete flags or natural stone slabs*
- Highways Agency. *Design Manual for Roads and Bridges: Volume 7, Section 2: Pavement Design and Construction.*
- *Health and Safety at Work Act etc.* 1974.
- *Management of Health and Safety at Work Regulations.* 1999.
- *Manual Handling Operations Regulations.* 1992 (as amended 2004).
- *Construction (Design and Management) Regulations.* 1994 (CDM).
- *Lifting Operations and Lifting Equipment Regulations.* 1998.
- *Provision and Use of Work Equipment Regulations.* 1992.
- Loughborough University – *Design 4 Health.*
- *Cumulative Trauma Disorders.* Putz-Anderson.
- HSG 149 - *Backs to the Future, safe manual handling in construction*
- HSE leaflet MISC 383, *the Manual Handling Assessment Chart*
- HSE booklet L23 - *Manual Handling; The Manual Handling Operations Regulations 1992 (as amended)*
- Leaflet INDG 143 (rev 2) *Getting to Grips with Manual Handling*
- INDG 398 - *Are you making the best use of lifting and handling aids?*

### Websites

- ApaCHe – A Partnership for Construction Health and Safety – for information on associated consideration on health in construction
- Construction Health and Safety Group – Training information
- Ergonomics Society – for approved ergonomics consultants
- <http://www.hse.gov.uk/msd/backpain/index.htm>.
- <http://www.hse.gov.uk/sicknessabsence/index.htm>