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National Occupational
Health and Safety Commission

THE ROLE OF DESIGN ISSUES IN WORK-RELATED INJURIES IN AUSTRALIA 1997–2002

CANBERRA
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NATIONAL OCCUPATIONAL HEALTH AND SAFETY COMMISSION

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FOREWORD

In seeking to achieve Australian workplaces free from injury and disease, the National Occupational Health and Safety Commission (NOHSC) works to lead and coordinate national efforts to prevent workplace death, injury and disease. We seek to achieve our mission through the quality and relevance of information we provide and to influence the activities of all parties with roles in improving Australia's occupational health and safety (OHS) performance.

In seeking to improve Australia's OHS performance, NOHSC works to:

- support and add value to efforts in the jurisdictions to tailor approaches to prevention improvement;
- facilitate, through strategic alliances, the development and implementation of better approaches to achieving improved prevention outcomes; and
- integrate the needs of small business into its work.

On 24 May 2002, the Workplace Relations Ministers' Council endorsed the release of the NOHSC *National OHS Strategy 2002-2012*. The Strategy was developed by the members of NOHSC and reflects their agreement to share responsibility for continuously improving Australia's performance in work related health and safety.

There are five initial national priority areas for action to achieve short-term and long-term improvements.

The priorities are:

- reduce high incidence/severity risks;
- improve the capacity of business operators and workers to manage OHS effectively;
- prevent occupational disease more effectively;
- eliminate hazards at the design stage; and
- strengthen the capacity of government to influence OHS outcomes.

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Appointment of the Project Team

In August 2003, the National Occupational Health and Safety Commission (NOHSC) released a select tender document regarding the analysis/research of data on the incidence of design-related workplace fatalities and injuries in Australia for the period 1997–2002. A project group led by Flinders University was awarded the contract in September 2003. The members of the project group were:

- Dr Tim Driscoll (ELMATOM Pty Ltd);
- Associate Professor James Harrison (Director, Research Centre for Injury Studies, Flinders University); and
- Mr Wayne Harvey of Flinders Consulting P/L who conducted the financial management of the project.

Work was also contributed by Clare Bradley and Rachel Newson (research officers at the Research Centre for Injury Studies, Flinders University).

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- Qstats, Queensland;
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- Workplace Standards, Tasmania;
- Victorian WorkCover Authority; and
- WorkCover WA

EXECUTIVE SUMMARY

This report presents the results of a project that investigated the role of design issues in work-related injury.

In recent years there has been increasing interest in and focus on the contribution of design to occupational health and safety. This is reflected in design (Eliminate hazards at the design stage) being one of the five priorities under the *National OHS Strategy 2002-2012*.

In August 2003, the National Occupational Health and Safety Commission (NOHSC) commissioned research into the incidence of design-related workplace fatalities and injuries in Australia for the period 1997–2002.

Key objectives for this preliminary phase of the project were to provide:

- an understanding of the contribution of design to workplace injuries and fatalities and the nature and extent of these in the period 1997–2002; and
- a comparative analysis of fatalities to the 1989–1992 study (identifying emerging issues, changes to baseline etc).

The concept of design-relatedness is not well conceptualised or practically applied in the literature and therefore no existing definitions or approaches could be adopted. In addition, limited data were a constraint. The focus of the research was on workplace incidents, with work-related incidents involving motor vehicle, aircraft or train crashes, and medical misadventure, being excluded. Serious and fatal injuries were examined in preference to less serious injuries.

1.1 Results

1.1.1 Fatalities analysis

The National Coroners Information System (NCIS) was the data source for fatal injuries. Deaths resulting from workplace injuries on or between 1 July 2000 and 30 June 2002 were included. Seventy-seven (37%) of the 210 identified workplace fatalities definitely or probably had design-related issues involved. In another 29 (14%), the circumstances were suggestive that design issues were involved.

Design-related issues were definitely or probably involved in at least half of the incidents in the mining, transport, agriculture, construction, trade and manufacturing industries.

Design-related issues were most prominent in the *machinery and fixed plant* group, and *mobile plant and transport* group, but varied considerably between different specific agency types.

1.1.2 Comparison to the 1989-1992 study

The role of design issues in work-related fatalities involving *machinery and fixed plant* during 1989–1992 had been examined previously as part of the second work-related fatalities study. This published information was compared to the data in the current study. The major difference between the two data sets was the proportion of incidents with identified design issues. Overall, 90% of the incidents involving *machinery and fixed plant* in the current analysis appeared to be due in part to design issues. Only two incidents in the *machinery and fixed plant* agency group did not have definite or probable design involvement. In contrast, design issues involved 54% of the *machinery and fixed plant* involved in incidents in the 1989-1992 study.

1.1.3 Injuries analysis

The source of workers' compensation data is the National Data Set For Compensation-Based Statistics (NDS). The NDS is compensation-based data collected by NOHSC from all states and territories.

Information was received for 2 705 compensable cases that met the final selection criteria. Only serious and fatal injuries were included. On the basis of the text descriptions, design issues appeared to contribute to at least 30% of these. The proportion varied considerably depending on the agency type involved. Most categories had at least 15% involvement, however the highest proportion of incidents involved:

- cutting, slicing and sawing machinery (78%);
- crushing, pressing, rolling machinery (67%);
- filling and bottling/packaging plant (32%);
- workshop and worksite tools and equipment (32%); and
- garden and outdoor powered equipment (27%).

1.2 Summary and conclusions

The analysis has provided several useful outcomes:

- knowledge of the patterns of circumstances leading to design-related injury;
- information about the extent of design involvement and an approximate ranking across various types of machinery, plant and equipment; and
- an indicative comparison with information on design involvement in work-related fatalities ten years ago.

The main finding from the study is that design continues to be a significant contributor to work-related serious injury in Australia. This is the case with a wide variety of machinery, plant and equipment, although the extent of involvement varies between them. Limitations of the data sources mean that the design contribution identified in this analysis is likely to be underestimated.

Most of the main design problems are old issues, with guarding the most prominent example. Other identified problems were:

- poorly situated controls;
- inadequate interlock safety systems;
- absent or inadequate rollover protective structures and/or associated seat belts;
- inadequate fall protection; and
- failed hydraulic lifting systems.

These issues appear to provide a lot of scope and opportunity for prevention activities.

Limitations in the available data sources also meant that the potential contribution of the design of systems, processes and buildings to work-related injury was beyond the scope of the current analysis. This is another reason why the estimates presented in this report are likely to be underestimates of the true situation.

There appears to have been a substantial decrease in the number of fatal incidents involving *machinery and fixed plant* in the decade between 1992 and 2002, probably primarily since 2000, but data issues may explain part of this.

When interpreting the results of this study, the nature and source of the raw data must be kept in mind. Both the NCIS and workers' compensation data were not collected primarily for prevention

purposes in general, nor to consider design issues in particular. The NCIS information was provided by police, OHS officers and/or Coroners, and the workers' compensation text descriptions were provided by the injured worker or the relevant employer, not by an impartial investigating officer. The available information may be expected to under or over emphasise factors related to design in some incidents, although underestimation seems more likely. Adding this to the problem that 'design-relatedness' is inherently an imprecise concept, the results of the analysis can only be considered indicative. They clearly indicate that design is an important contributing factor in work-related serious injury, and the study provides a reasonable estimate of the extent of involvement, but the precise contribution is not known.

1. INTRODUCTION

1.1 Background

There are many potential contributing factors to any work-related incident that results in injury. These include aspects or characteristics of the systems of work, the equipment and materials used, the environment and the worker. Each of these has been the subject of prevention initiatives. Whenever possible, the use of passive safety measures is preferred as a means of control. Passive safety measures are those that function without the need for input by workers. Examples include:

- guarding on machinery;
- safety interlock systems; and
- earth leakage devices (also known as residual current devices).

Passive safety measures can be designed to decrease the likelihood of an incident occurring (e.g. guarding on machinery), decrease the likelihood or severity of an injury resulting from an incident (e.g. Roll-Over Protective Structures on mobile equipment; residual current devices), or even to decrease the consequences of an injury that has occurred (e.g. a safety alarm system allowing early localisation and treatment of an injured person).

These are preferred because they do not require the actions or cooperation of workers, and function regardless of whether unforeseen events occur, or workers or others are using the equipment as intended.

Most passive safety measures work because they are designed into the equipment, building, or system of work. For this reason, in recent years there has been increasing interest in and focus on the contribution of design to occupational health and safety (OHS). This is reflected in design being one of five priorities under the *National OHS Strategy 2002-2012*: Eliminate hazards at the design stage[1].

This project supports the design priority by providing an assessment, on a qualitative and quantitative basis, of the contribution of design to the occurrence of fatal and non-fatal work-related injuries in Australia. To establish an appropriate baseline measure and a methodology to compare measures in the future, further work will consider possible target measures relevant and appropriate to monitoring design issues.

'Design' can be interpreted narrowly or broadly, as can the question of whether some particular aspect of design can be considered to be 'related' to a particular event or type of injury case. A narrow interpretation would focus on types of cases in which design contributed strongly and directly to the outcome, in ways that are likely to be detectable with reasonable assurance on a case-by-case basis.

A broad interpretation could extend beyond this to include the contributions of design to work-related injury and fatalities in contexts in which this cannot be assessed on a case-by-case basis; that is, considering design as a risk factor for injury, determined by means of population studies and summarised in terms of attributable risk. It could also extend to consider aspects of design, and the relationship of design to injury, which are more abstract and less direct, such as comfort and aesthetics as factors amenable to design and which can influence matters such as the usage of personal protective equipment; design as a factor influencing the likelihood of human errors of particular types; and the design of safety training programs.

The primary advantage of a narrow interpretation is easier identification of the main physical design aspects of an incident. The main disadvantage is that this will encompass a smaller part of the total scope of 'design-related', work-related injury than might prove to be achievable by a

broader, but less certain approach. The approach adopted in this analysis is the narrower interpretation.

1.2 Scope of the project

The main areas to be addressed in this phase of the project were identifying the extent to which design issues were involved in work-related injuries, and the main types of design problems (see Appendix 6, Objectives 1, 2 and part of Objective 4). The limitations of the available data sources and the higher importance given to more serious injuries resulted in serious and fatal injuries being examined in preference to less serious injuries.

The consideration of the development of one or more targets and any baseline measurement against which such a target could be compared, and detailed description and consideration of examples, were deferred to later stages of the project.

The current report includes the analysis of data from the National Coroners Information System (NCIS) and the workers' compensation system. Comparison is also to be made to a report on fatalities associated with design issues involving *machinery and fixed plant* from a work-related fatalities study covering the period 1989-1992[2].

2. METHODS

This section presents a summary of methods used in this phase of the study. A detailed description of the methods is at Appendix 1.

2.1 Definitions

2.1.1 Work-related

Only work-related cases were considered in this study. The definition of *work-relatedness* is that adopted by the NCIS, which was developed in close consultation with NOHSC. A work-related case is:

> "A person who was fatally injured as a result of, or who died of a fatal condition caused by, exposure to their own or others' work activity or work factors; or who was fatally injured whilst travelling to or from work." *

This definition includes workers in workplaces, persons driving for work purposes, persons driving to or from work (commuters), and bystanders. Only persons dying directly or indirectly as a result of injury were included. (Indirect injury covers situations such as someone dying as a result of a pulmonary embolus or sepsis while hospitalised after major injury.)

This definition was applied to cases identified in the NCIS as being work-related. Injury cases included in workers' compensation authority data sets were accepted as being work-related.

* The full NCIS definition of *work-relatedness* is available at: http://www.vifp.monash.edu.au/ncis/.

2.1.2 Design-related

An injury was defined as a design-related case if:

- any aspect of the construction of equipment, plant, tools or structure involved in the incident made a meaningful contribution to the occurrence of the injury-causing incident and/or to the occurrence of fatal injury resulting from the incident; and
- it was realistic to expect that this factor could have been modified to avoid the incident or the subsequent fatal injury.

Certain groups of cases were excluded from the current analysis for one or more reasons. These included groups:

- where relevant design issues were already addressed by specific authorities and did not fall within the scope of OHS design as envisaged for this project; and/or
- where the available data sources were unlikely to contain information regarding design issues for these types of cases.

These groups were persons injured as a result of:

- motor vehicle incidents involving road vehicles on public roads;
- aircraft crashes;
- train crashes; or
- medical misadventure.

2.2 Fatal injuries

The primary source of information for fatal injuries was the NCIS. The NCIS is a national system of information and supporting infrastructure designed to provide prompt access to national coronial data to support the work of Coroners and others interested in the prevention of injury and disease. It is important in the current project because it is the only source that covers all work-related incidents (although only fatal ones) regardless of the employment status of the injured person and the setting of the incident. It is the only accessible source likely to have detailed information on many of the deaths of interest.

Cases were eligible for inclusion if the death occurred on or between 1 July 2000 and 30 June 2002. Queensland cases could not be included because information on these cases has only recently been included in the NCIS and was not available to researchers at the time this study was conducted.

All relevant fields from the various NCIS forms were requested, as well as the police description of circumstances. The police description consisted of one or more entries describing the particulars of the fatally injured person, the circumstances leading to their death and other information related to the person, the subsequent investigation of circumstances and various other factors. The extent, detail and usefulness of the descriptions vary considerably between jurisdictions, and between cases within the same jurisdiction.

2.2.1 Identifying work-related deaths

The NCIS has a specific variable that identifies deaths as being work-related or not. In addition to this *Work-relatedness* variable, the *Activity* variable also provides information on work-relatedness by describing the activity of the person at the time of the incident. The categories related to work are ‘working’, ‘commuting’ and ‘working or commuting’. For an individual case, the relationship to work indicated by the codes for the *Activity* and *Work-relatedness* variables would usually be expected to match, although legitimate exceptions can occur. For this analysis, the group of cases for which detailed information was sought comprised any death that was identified as work-related

by either the *Work-relatedness* variable or the *Activity* variable. No detailed attempt was made to use other information in the NCIS to identify other work-related cases (this is considered in the Discussion).

2.2.2 Identifying circumstances involving design issues

The police description was the main source of information used to identify cases with design-related issues. Other information, such as the Coroner's Finding on the NCIS website, was used where available and appropriate.

Cases were coded as 'Definitely', 'Probably', 'Possibly', 'Unknown' and 'Not' design-related. For example, incidents would be coded as design-related if someone fell from a height and there were no railings to prevent a fall; if someone was electrocuted by domestic current on a circuit without an earth leakage device; if a tractor or bulldozer operator was killed if there was no roll-over protection device or cabin and the machinery rolled over, or the operator was struck by a heavy object while operating the machinery; or if someone was caught in the moving parts of machinery that could have been guarded and/or protected by a cut-off safety system. The difference between 'Definite', 'Probable' and 'Possible' codes was primarily due to different levels of available information about the circumstances. 'Unknown' was usually used when there was little or no information available. 'Not' was used when there was sufficient information to rule out design as an issue (e.g. a police officer shot by a fugitive), although even for some of these cases it could be argued that a design-related prevention approach might have been possible. Specific examples of the way the coding was applied are provided in Appendix 2.

This analysis considered design issues to have occurred if design had definitely or probably made a significant contribution to the incident and its fatal outcome. This means that the number/proportion of deaths identified as involving design issues must be considered to be an underestimate of the true situation. For some analyses, results for cases coded as possible design issues are also presented. For those cases identified as definitely, probably or possibly being related to design, the main apparent design problems were recorded.

Three coders (TD, CB and RN) were involved in the coding of design-relatedness for NCIS cases. One coder (TD) coded all 210 cases. All cases were also coded by at least one other coder, and 95 cases were coded by all three coders (a fourth investigator did not perform coding but did the formal comparison of the independent codes – this will be presented in the Phase 3 report). All coding was done using a blinded approach. That is, no coder was aware of the code assigned by the other coder(s) at the time the coding was performed . Cases coded by the second and third coders were a random sample of the total cases. Assigned codes were then compared. For the purposes of the comparison, and of the analysis presented in this report, 'Definite' and 'Probable' codes were considered to identify 'Design-related' cases, whereas 'Possible', 'Unknown' and 'Not' combined into a second, 'Other', category. Major discrepancies (i.e. coded as 'Definite' or 'Probable' by at least one coder and 'Possible', 'Unknown' or 'Not' by at least one coder) were discussed by the involved coders, and an agreed final code assigned where possible. In two cases, final agreement could not be reached. These cases were given a final code of 'Unknown". Agreement at the two-category level between TD's codes and the codes assigned by the relevant other coder was 83% (see Appendix 3 for more details).

The results were compared to a consideration of design issues in incidents leading to fatal injuries involving machinery and fixed plant that were identified in the 1989-1992 work-related fatalities study.

2.3 Workers' compensation data

Workers' compensation information was the data source used to examine the role of design in non-fatal injuries. Information was requested from all states and territories, as well as Comcare and Seacare, for the period 1 July 1997 to 30 June 2002.

Only incidents that resulted in 'serious' injury were included. Serious injury is defined in this study as injuries that were fatal or resulted in total and permanent disability (that is, cases with a National Data Set (NDS)[3] severity code of 1 or 2).

An agency of injury/disease was excluded if it was considered:

- unlikely that design issues could be identified in any available narrative information;
- unlikely that the agency would result in major injury; and/or
- design issues were likely to be considered by other sectors/authorities and/or the issues were not likely to be primarily or predominantly OHS issues.

Workers' compensation information used in this analysis was coded according to the Type of Occurrence Classification System (TOOCS)[4]. The 'Breakdown agency' is defined as "the object, substance, or circumstance that was principally involved in, or most closely associated with, the breakdown event". The 'Breakdown event' is defined as "the point at which things started to go wrong and which ultimately led to the most serious injury or disease"[4]. Breakdown agencies were restricted to:

- all machinery and mainly fixed plant (TOOCS 2.1 Group 1)[4];
- self-propelled plant, semi-portable plant and other mobile plant (from Group 2);
- all powered equipment, tools and appliances (Group 3); and
- ladders, mobile ramps and stairways and scaffolding (from Group 4).

See Appendix 4 for more detail.

'Vehicle accidents' (TOOCS 2.1 Mechanism code 92)[4] not already excluded by the agency criteria were excluded if the injured person was in a standard road vehicle (car, truck, motorcycle or bicycle).

Useable information was received from the Australian Capital Territory, Comcare, Queensland, South Australia, Tasmania and Victoria. Victorian data were only a subset of the relevant claims in that state, as claims from self-insurers were not included since they do not provide the Victorian WorkCover Authority with descriptions. Western Australia also provided information for one year, but this could not be used because text descriptions were not available.

Cases that did not meet the selection criteria, and duplicate cases, were deleted. Files from different jurisdictions were analysed separately and the results then combined. Only combined data are presented in this report.

2.3.1 Identifying circumstances involving design issues

As with the consideration of design issues with NCIS fatalities data, the intention was to identify any circumstance in which design factors had contributed in some meaningful way to the occurrence of the injuries. Incidents that involved design issues could only be identified in the workers' compensation data using the text descriptions. A large number of cases had no text description or no description of circumstances (e.g. the text just listed the injury). In addition, many of the descriptions did not contain enough information to adequately assess possible contribution of design issues.

This approach to coding meant that the final coding could only either identify that a design issue had (definitely or probably) contributed, or record this assessment as indeterminate. It is possible that in some cases design issues appeared to have been involved when in fact they were not, but on balance it is likely that the presented results are an underestimate of the proportion of cases for which design issues were important, rather than being the actual proportion that involved design issues. One person (TD) performed all the coding of workers' compensation data.

Cases were not analysed separately in terms of fatal and serious non-fatal injury, as not all data sets separately identified these cases. However, fatal injuries only comprised about 1% of the cases based on NDS[3] data for all jurisdictions.

3. RESULTS

3.1 Fatalities

Four hundred and eighty-four (484) work-related cases were identified for the two-year period ending June 30 2002. Of these, 274 (57%) were excluded because they were medical misadventure, motor vehicle or plane incidents. This left 210 work-related deaths within the scope of the current study, virtually all of which had occurred in some type of formal workplace.

Seventy-seven (37%) of the 210 workplace deaths definitely or probably had design-related issues involved. One of these fatalities was a bystander death. In another 29 (14%), the circumstances were suggestive that design issues were involved, but there was not enough information to conclude that design was definitely or probably involved. For 43 deaths (20%), it was not possible to determine if design issues were or were not involved, due to little or no information available in police description or Coroner's Findings (41 deaths) or because it was difficult to decide for theoretical reasons if the circumstances met the definition of design-related (two deaths). For the remaining 61 deaths (29%), design issues were unlikely to have been involved. These percentages were similar for each of the two years of available data (Table 1 and Table A5.1 in Appendix 5).

3.1.1 Industry

The highest number of workplace fatalities were in the agriculture, construction, forestry and fishing, transport, manufacturing, trades and cultural and recreational services industries. Design-related issues were definitely or probably involved in at least half of the incidents in the mining, transport, agriculture, construction, trade and manufacturing industries (Table 2).

Table 1: Design-related involvement in fatal workplace incidents. Australia (excluding Queensland), 2000-01 and 2001-02. Number and per cent.

	2000-01		2001-02		Total	
	Number	**%**	**Number**	**%**	**Number**	**%**
'Workplace' cases	103	100.0	107	100.0	210	100.0
Design-related:						
Definite	16	15.5	18	16.8	34	16.2
Probable	19	18.4	24	22.4	43	20.5
Total definite and probable design-related	**35**	**34.0**	**42**	**39.3**	**77**	**36.7**
Possible	14	13.6	15	14.0	29	13.8
Total definite, probable and possible design-related	**49**	**47.6**	**57**	**53.3**	**106**	**50.5**
Not known	22	21.4	21	19.6	43	20.5
Not design-related	32	31.1	29	27.1	61	29.0

Table 2: Industry identified for working persons fatally injured in workplace incidents. By design-related involvement. Australia (excluding Queensland), 2000-01 and 2001-02. Number and per cent.

	Definite/Probable Design-related		Possible Design-related		Total fatalities	
Industry	**Number**	**%**	**Number**	**%**	**Number**	**%**
Agriculture, Forestry and Fishing	28	38.4	10	13.7	73	100.0
Agriculture	25	52.1	8	16.7	48	100.0
Services to Agriculture; Hunting and Trapping / Forestry and Logging / Commercial Fishing	3	12.0	2	8.0	25	100.0
Construction	20	46.5	7	16.3	43	100.0
Transport and Storage	8	40.0	6	30.0	20	100.0
Manufacturing	7	43.8	3	18.8	16	100.0
Wholesale Trade / Retail Trade	7	50.0	1	7.1	14	100.0
Cultural and Recreational Services	2	14.3	0	..	14	100.0
Mining	3	50.0	1	16.7	6	100.0
Health and Community Services	1	20.0	0	0.0	5	100.0
Accommodation, Cafes and Restaurants	0	..	0	..	4	100.0
Finance and Insurance / Property and Business Services	0	..	0	..	3	100.0
Government Administration and Defence	0	..	1	100.0	1	100.0
Not known	0	..	0	..	4	100.0
Bystander	1	14.3	0	..	7	100.0
TOTAL	**77**	**36.7**	**29**	**13.8**	**210**	**100.0**

3.1.2 Agency of injury

The most commonly involved agency groups were *mobile plant and transport*, *environmental* agencies and *machinery and fixed plant*. Design-related issues were most prominent in the m*achinery and fixed plant* group and *mobile plant and transport* group, but varied considerably between different specific agency types (Table 3).

3.1.3 Types of design issues

There were a wide range of design issues evident in the fatal incidents, but there were also some features common to a number of incidents. The most common scenarios involved:

- problems with rollover protective structures (ROPS) and/or associated seat belts;
- inadequate guarding;
- lack of residual current devices;
- inadequate fall protection;
- failed hydraulic lifting systems;
- brake problems on mobile plant or vehicles; and
- inadequate protection mechanisms on mobile plant and vehicles (such as enclosed cabins) (Table 4).

3.1.3.1 Problems with rollover protective structures and/or associated seat belts

Typical problems involving ROPS and/or seat belts involved persons falling out of tractors, often when the tractor rolled over, and being struck by the tractor. In some instances there was no ROPS, and in some the ROPS appeared to be present but the person was still struck by the tractor or received fatal injuries when they were thrown out. Seat belts were rarely mentioned. This meant that, although seat belts were obviously not being worn at the time of the incident, it was not clear whether they were fitted and not used, or not fitted.

3.1.3.2 Inadequate guarding

Guarding was a major design issue, usually because guarding was absent or inadequate. Three of the incidents involved clothing being caught in an auger, and others involved contact with moving parts in fixed equipment (e.g. a water pump conveyor, a potato bin tipper). In some cases it was hard to separate the guarding issue from the broader design issue of in-built safety processes, such as safety inter-locks and fail-safe systems. Three incidents involved the deceased person being caught in inadequately protected presses or crushers, and another involved being caught by parts of an automated dairy.

Table 3: Agency group identified for working persons and bystanders fatally injured in workplace incidents. By design-related involvement. Australia (excluding Queensland), 2000-01 and 2001-02. Number and per cent.

Agency	Definite and probable Design-related		Possible Design-related		Total fatalities	
	Number	%	Number	%	Number	%
Crushing, pressing, rolling machinery	4	100.0	0	..	4	100.0
Conveyors and lifting plant	12	92.3	1	7.7	13	100.0
Electrical installation	6	85.7	1	14.3	7	100.0
Other plant and equipment	2	66.7	1	33.3	3	100.0
Machinery and (mainly) fixed plant	**24**	**88.9**	**3**	**11.1**	**27**	**100.0**
Self-propelled plant	11	64.7	1	5.9	17	100.0
Semi-portable plant	1	100.0	0	..	1	100.0
Other mobile plant	14	60.9	4	17.4	23	100.0
Road transport	11	44.0	8	32.0	26	100.0
Rail transport	0	..	0	..	2	100.0
Water transport	0	..	1	10.0	10	100.0
Mobile plant and transport	**37**	**47.4**	**14**	**17.9**	**78**	**100.0**
Workshop and worksite tools and equipment	2	100.0	0	..	2	100.0
Kitchen and domestic equipment	1	100.0	0	..	1	100.0
Office and electronic equipment	1	100.0	0	..	1	100.0
Garden and outdoor powered equipment (includes weapons)	0	..	2	28.6	7	100.0
Other powered equipment, tools and appliances	1	100.0	0	..	1	100.0
Powered equipment, tools and appliances	**5**	**41.7**	**2**	**16.7**	**12**	**100.0**
Handtools, non-powered, edged (includes knives)	0	..	0	..	8	100.0
Other handtools	0	..	1	100.0	1	
Fastening, packing and packaging equipment	1	50.0	0	..	2	100.0
Furniture and fittings	0	..	0	..	1	100.0
Ladders, mobile ramps and stairways, and scaffolding	2	20.0	1	10.0	10	100.0
Other non-powered equipment	2	25.0	1	12.5	8	100.0

Agency	Definite and probable Design-related		Possible Design-related		Total fatalities	
	Number	%	Number	%	Number	%
Non-powered handtools, appliances and equipment	**5**	**16.7**	**3**	**10.0**	**30**	**100.0**
Chemicals and chemical products	**0**	**..**	**0**	**..**	**1**	**100.0**
Materials and substances	**2**	**16.7**	**0**	**0.0**	**12**	**100.0**
Outdoor environment	3	10.0	7	23.3	30	100.0
Indoor environment	1	100.0	0	100.0	1	100.0
Underground environment	0	..	0	..	1	100.0
Environmental agencies	**4**	**12.5**	**7**	**21.9**	**32**	**100.0**
Live four-legged animals	0	..	0	..	6	100.0
Other live animals	0	..	0	..	4	100.0
Human agencies	0	..	0	..	3	100.0
Animal, human and biological agencies	**0**	**..**	**0**	**..**	**13**	**100.0**
Other and unspecified agencies	**0**	**..**	**0**	**..**	**5**	**100.0**
TOTAL	**77**	**36.7**	**29**	**13.8**	**210**	**100.0**

Table 4: Design-related problems in fatal workplace incidents. By certainty of design involvement. Australia (excluding Queensland), 1 July 2000 to 30 June 2002. Number and per cent.

Category	Definite/probable		Possible		Total	
	Number	%	Number	%	Number	%
ROPS/seat belts	13	16.9	0	..	13	12.3
Guarding	11	14.3	0	..	11	10.4
RCD	9	11.7	0	..	9	8.5
Fall protection	6	7.8	4	13.8	10	9.4
Hydraulics	6	7.8	1	3.4	7	6.6
Overhead protection (cabin, etc)	5	6.5	1	3.4	6	5.7
Roof material	2	2.6	4	13.8	6	2.8
Brakes	2	2.6	3	10.3	5	4.7
All-terrain vehicles	2	2.6	1	3.4	3	2.8
Building construction	2	2.6	1	3.4	3	5.7

Safety systems	2	2.6	0	..	2	2.8
Vehicle blind spots	1	1.3	2	6.9	3	2.8
Stacking	1	1.3	1	3.4	2	0.9
Over-luffing	1	1.3	1	3.4	2	1.9
Controls	1	1.3	0	..	1	1.9
Lighting	1	1.3	0	..	1	1.9
Other	12	15.6	10	34.5	22	0.9
						20.8
Total	**77**	**100.0**	**29**	**100.0**	**106**	**100.0**

3.1.3.3 Lack of residual current devices

Nine workers were electrocuted in circumstances where it appeared that residual current devices were not present and that the incident would not have been fatal if such a device was present. It was difficult in some cases to be sure that the residual current device was not present and that the incident would have been prevented by its presence, and for two cases the Coroner explicitly mentioned it.

3.1.3.4 Inadequate fall protection

Six incidents involved people falling from structures, due in part to inadequate fall protection. Two of these incidents involved people falling from scaffolding, and another two involved falling from structures on a construction site, although limited information on these incidents precluded a detailed understanding of the circumstances. A fifth incident involved someone falling from a windmill platform, and a sixth involved a fall while loading a truck. Another four incidents involved similar falls, but the limited information available meant that they were classed as 'possible' cases rather than 'definite' or 'probable'. Three of these were falls from trucks during loading or unloading.

3.1.3.5 Failed hydraulic lifting systems

Six incidents occurred when persons maintaining or repairing the raised part of a vehicle or mobile equipment were crushed following failure of the hydraulics holding up the raised part. These incidents involved the raised cabin of a semi-trailer, the raised tray of a tip truck (two incidents), the lifting arms of a front-end loader, the raised blade of a bulldozer, and a bobcat.

3.1.3.6 Inadequate overhead protection mechanisms on mobile plant and vehicles

Five incidents involved persons being crushed by falling objects while operating a vehicle. Three of these persons were miners, and in one of these incidents the Coroner specifically stated that the design of the vehicle forced the miner to step out of the protective canopy of the machine into a dangerous situation.

3.2 Comparison to 1989-1992 fatalities study

Information from the work-related fatalities study (1989-1992)[2] was analysed to examine the role of design issues in fatalities involving *machinery and fixed plant*. The results of that analysis have been described in detail elsewhere[2]. In brief, 233 deaths occurred in 225 fatal incidents involving 238 different items of *machinery and fixed plant* (some incidents involved more than one item of *machinery and fixed plant*). (Note that the 1989-1992 study included Queensland deaths, whereas the more recent information did not.) Conveyors and lifting plant were the most commonly involved agencies, accounting for 68% of the incidents. Half of the incidents were found to have at least one significant design issue.

In the current analysis, there were 27 fatal incidents involving *machinery and fixed plant*. However, seven of these involved high or low tension wiring, which were excluded from the 1989-1992 analysis[2], leaving 20 fatal incidents in the current analysis to be compared to 225 incidents in 1989-1992 study[2].

3.2.1 Machinery and plant type

The distribution of the types of *machinery and fixed plant* was similar in the two data sets, with:

- conveyors and lifting plant dominating (65% in the current analysis and 68% in 1989-1992)2;
- forklifts were, proportionally, less involved in the current analysis than they were in 1989-19922, but the number of incidents in the current analysis was not high, so the differences might be due to random factors; and
- crushing equipment proportionally much more likely to be involved in the current analysis compared to the 1989-1992 study2 (Table 5).

3.2.2 Industry

Transport and storage and manufacturing were the main two industries used in both analyses. The proportion of deaths of workers employed in the transport and storage industry was found to be higher in the recent study than in the 1989-1992 analysis[2]. Persons employed in the mining industry comprised 8% of fatally injured persons in the 1989-1992 analysis[2], but none of the 19 deaths of workers involved *machinery and fixed plant* in the current analysis (Table 6).

3.2.3 Presence of design issues

The major difference between the two data sets was the proportion of incidents with identified design issues. Overall, 90% of the incidents involving machinery and fixed plant in the current analysis appeared to be due in part to design issues. Only two incidents in the machinery and fixed plant agency group did not have definite or probable design involvement. These incidents involved a forklift truck and an industrial drier, and were considered to have had possible design involvement. In contrast, design issues involved 54% of the machinery and fixed plant incidents in 1989-1992 study[2] (Table 7).

Table 5: Comparison of two studies conducted into design-related involvement in fatal work-related incidents involving machinery and (mainly) fixed plant. Prevalence of involved machinery. Study 1: WRFS2 1989 to 1992 – Australia. Study 2: 2000-01 to 2001-02 – Australia (excluding Queensland). Number and per cent.

Machinery and fixed plant	This study		WRFS 2	
	Number	%	Number[2]	%
Cutting	0	..	18	7.6
Crushing	4	20.0	9	3.8
Heating	0	..	10	4.2
Cooling	0	..	9	3.8
Conveyors and lifting plant				
Forklifts	3	15.0	50	21.0
Cranes	3	15.0	44	18.5
Hoists	3	15.0	29	12.2
Conveyor belts	1	5.0	15	6.3
Power transfer	0	..	5	2.1
Other lifting plant	3	15.0	18	7.6
Total conveyors and lifting plant	**13**	**65.0**	**161**	**67.6**
Turbines	0	..	9	3.8
Radiation	0	..	0	..
Bottling	0	..	0	..
Other	3	15.0	22	9.2
Total	**20**	**100.0**	**238**	**100.0**

1. Incidents involving high or low-tension wiring have been excluded.

2. There were 233 deaths, but 238 items of machinery and (mainly) fixed plant were involved in those deaths. Note that these numbers include Queensland deaths, whereas the recent study excludes Queensland deaths.

Table 6: **Comparison of two studies conducted into fatal work-related incidents involving machinery and (mainly) fixed plant[1]. By industry. Study 1: WRFS2 1989 to 1992 – Australia. Study 2: 2000-01 to 2001-02 – Australia (excluding Queensland). Number and per cent.**

	Study 2: 2000-01 to 2001-02 n = 19 [2]		Study 1: WRFS2 1989 to 1992 n = 221	
	Fatalities		**Design-related**	
Industry	**Number**	**% of total fatalities**	**Number**	**% of total fatalities**
Manufacturing	7	36.8	66	29.9
Transport and storage	4	21.1	28	12.7
Wholesale trade / Retail trade	3	15.8	21	9.5
Construction	3	15.8	38	17.2
Agriculture, forestry and fishing	2	10.5	24	10.9
Cultural and recreational services	0	..	5	2.3
Government administration and defence	0	..	4	1.8
Mining	0	..	18	8.1
Finance and insurance / Property and business services	0	..	6	2.7
Electricity, gas and water supply	0	..	9	4.1
Not known	0	..	2	0.9
TOTAL	**19**	**100.0**	**221**	**100.0**

1. Incidents involving high or low-tension wiring have been excluded.
2. One incident involved a bystander and so no industry was coded.

Table 7: Design-related involvement in fatal work-related incidents involving machinery and fixed plant[1]. Australia, 1989 to 1992 and Australia (excluding Queensland), 1 July 2000 to 30 June 2002. Number and per cent[2].

Machinery and fixed plant	This study		WRFS 2	
	Number	% design-related	Number	% design-related
Cutting	0	..	18	94.4
Crushing	4	100.0	9	88.9
Heating	0	..	10	60.0
Cooling	0	..	9	33.3
Conveyors and lifting plant				
Forklifts	3	66.7	50	36.0
Cranes	3	100.0	44	36.4
Hoists	3	100.0	29	58.6
Conveyor belts	1	100.0	15	80.0
Power transfer	0	..	5	80.0
Other lifting plant	3	100.0	18	66.7
Total conveyors and lifting plant	**13**	**92.3**	**161**	**49.1**
Turbines	0	..	9	33.3
Radiation	0	..	0	..
Bottling	0	..	0	..
Other	2	66.7	22	59.1
Total	**20**	**90.0**	**238**	**54.2**

1. Incidents involving high or low-tension wiring have been excluded.
2. Percentages are the percentage of incidents involving each type of machinery and fixed plant that involved design issues.

3.2.4 Types of design issues

For the 18 incidents where design-related issues were identified in the current analysis:

- guarding was an important issue in eight incidents; and
- safety systems were a problem in two incidents.

The other issues occurred in only one incident each:

- rollover protective structures and seat belts;
- the strength of roofing material;
- overhead protection on a forklift;
- poorly secured vehicle on a hoist;
- a crane without over-luffing devices hitting overhead power lines;
- an unstable industrial vacuum cleaner; and
- exposed crane cabling combined with safety harness construction.

In one incident, the exact design issue could not be identified.

The main design issues identified in incidents involving *machinery and fixed plant* in the 1989-1992 study were[2]:

- guarding could be removed or rendered inoperative;
- no guarding of area designed around work space or equipment;
- controls in a position which did not allow adequate viewing of machinery;
- positioning of controls allowed inadvertent activation by operator during maintenance or other activities on the equipment;
- equipment not designed to 'fail safe';
- equipment able to function with inappropriate attachments;
- blind spots on manoeuvrable equipment;
- equipment able to function when nearing overhead wires (lack of over-luffing devices);
- reliance of equipment on one mechanism which, if it failed, had catastrophic consequences; and
- seatbelts not designed into equipment.

3.3 Workers' compensation information

Information was received for 2,705 cases that met the final selection criteria (as described in Section 2: Methods). On the basis of the text descriptions, design issues appeared to contribute to at least 30% of these. The proportion of design-related issues varied considerably depending on the agency type involved. Most categories had at least 15% involvement, but the highest proportions of design involvement were:

- Cutting, slicing and sawing machinery (78%);
- Crushing, pressing, rolling machinery (67%);
- Filling and bottling/packaging plant (32%);
- Workshop and worksite tools and equipment (32%); and
- Garden and outdoor powered equipment (27%) (Table 8).

Table 8: Design-related involvement in compensated injuries. Selected Australian compensation schemes, 1997–1998 to 2001–2002. Number and per cent.

Code[1]	Category[1]	All cases		Design–related	
		Number	%[2]	Number	%[3]
GROUP 1	MACHINERY AND (MAINLY) FIXED PLANT				
11	Cutting, slicing, sawing machinery	523	19.3	475	90.8
12	Crushing, pressing, rolling machinery	159	5.9	115	72.3
13	Heating, cooking, baking equipment	59	2.2	23	39.0
14	Cooling, refrigeration plant and equipment	19	0.7	4	21.1
15	Conveyors and lifting plant	326	12.1	108	33.1
16	Electrical installation	73	2.7	21	28.8
17	Radiation based equipment	4	0.1	1	25.0
18	Filling and bottling/packaging plant	28	1.0	11	39.3
19	Other plant and machinery	218	8.1	102	46.8
	Total machinery and fixed plant	**1,409**	**52.1**	**860**	**61.0**
GROUP 2	MOBILE PLANT AND TRANSPORT				
21	Self-propelled plant	113	4.2	17	15.0
22	Semi-portable plant	89	3.3	25	28.1
23	Other mobile plant	265	9.8	42	15.8
	Total mobile plant and transport	**467**	**17.3**	**84**	**18.0**
GROUP 3	POWERED EQUIPMENT, TOOLS/APPLIANCES				
31	Workshop and worksite tools and equipment	206	7.6	105	51.0
32	Kitchen and domestic equipment	156	5.8	33	21.2
33	Office and electronic equipment	110	4.1	1	0.9
34	Garden and outdoor powered equipment	56	2.1	28	50.0
35	Pressure based equipment not covered elsewhere	49	1.8	8	16.3
39	Other powered equipment, tools and appliances	27	1.0	11	40.7
	Total powered equipment, tools	604	22.3	186	30.8
GROUP 4	NON-POWERED HANDTOOLS, etc.				
46	Ladders, mobile ramps and stairways, and scaffolding	225	8.3	18	8.0
TOTAL		**2,705**	**100.0**	**1,148**	**42.4**

1. TOOCS 2.1 code and category
2. Percentage of all cases.
3. Percentage of cases involving that type of agency for which design appeared to contribute.

3.3.1 Types of design issues

The main identifiable design issues involved:

- inadequate guarding;
- poorly situated control devices;
- inadequate interlock safety systems;
- sticking drills; and
- equipment failure.

3.3.1.1 Inadequate guarding

The most common scenario was the injured worker coming into contact with sharp blades, rollers or pressing apparatus due to guarding which was missing, inadequate or had been removed. Another common occurrence involved a worker's hand being caught in moving parts of a conveyor. A minority of these incidents were identified as occurring during maintenance. Many incidents involved clothing or gloves being caught in rotating parts, resulting in the hand or arm of the worker coming into contact with the machinery. This was the most common circumstance involving augers and machinery with rollers.

Examples where there was a clear failure of guarding, but where guarding was not specifically mentioned, included:

- *Positioning material-guillotine activated — cut mid finger;*
- *Amputation — finger caught in feed belt circular saw;*
- *Checking core size & machine activated — crush right finger;*
- *Hit moving saw blade with hand — amputation left thumb;*
- *While cutting timber on the circular saw the timber snagged and kicked forcing the right hand onto the saw cutting surface; and*
- *Running timber through circular saw/amputation left index finger/s.*

Examples where failure of guarding was specifically mentioned included:

- *Operating machinery — left ring finger got caught in the machine. The machine was not guarded;*
- *Compound fracture and large wound right arm. Cleaning sieve in cellar — removed guards from sieve and proceeded to hose sieve from the side. Rotation of machine (sieve) which gripped hand followed by arm.*

Examples where clothing was caught in moving parts were:

- *Mesh glove caught in rollers of quill machine;*
- *Drilling a pole, drill bit caught leather glove — fracture left little finger/s;*
- *Using picking tool on sorting table, glove got caught in picker — amputated finger/amputation right index finger/s;*
- *Cutting timber to length using a circular saw — shorts were caught up in power saw blade, pulling the saw towards the leg — leg was cut by power saw blade.*

3.3.1.2 Poorly situated control devices

Despite most descriptions being very brief, a number of them clearly described persons inadvertently hitting a button or foot control that started the equipment. This resulted in the worker being cut, crushed or otherwise injured, with the injuries typically involving the fingers or hands. Examples included:

- *Bumped 'on' button on machine and jammed right finger — crushed;*
- *Accidentally turned on mixer injuring finger as a result/cut left ring finger/s;*
- *Clearing punch, foot slipped off chair, activated machine peddle — fracture left middle finger/s;*
- *Scooping bottles off bin. While in lifter — accidentally hitting lever causing the machine to lift, which twisted his head;*
- *Setting a machine — accidentally knocked inching button with elbow — tip of finger caught in form tool as machine inched over.*

3.3.1.3 Interlock safety systems

A considerable number of the descriptions identified incidents where the worker was injured because their fingers or hand had been in or on plant or equipment that had started inadvertently (as described above) or unexpectedly. Most of these cases involved fixed plant or equipment for which it could be reasonably expected that some form of interlock safety system would be appropriate and practical. One example was as follows:

- *Running machinery — machine dropping materials onto belt drive — carton moved away from sensor which restarted the belt drive. Jammed hand at the end between rollers.*

3.3.1.4 Sticking drills

A considerable number of incidents involved the worker operating a powered drill or powered hand-held saw. Examples included:

- *Using electric drill and it jammed, twisting wrist and causing chuck key to hit wrist — chipped bone in right wrist;*
- *Drilling a 63mm hole through 16mm particle board to take a waste pipe. The 63mm hole saw grabbed, stopped momentarily and the drill spun. When the drill spun it smacked into right thumb.*

3.3.1.5 Equipment failure

A relatively small number of incidents involved clear failure of equipment. Descriptions of these included:

- *Hydraulic hose blew hot oil into both eyes and face — burn;*
- *Hydraulics on machinery failed, disc dropped onto foot and toes;*
- *Scaffolding gave way, crashed into window pane.*

3.3.1.6 Other problems

Many of the descriptions were very similar. Typical examples for common types of incidents are described above. However, there were also examples of a smaller number of almost identical incidents with a clear design contribution and presumably a relatively straightforward design solution. An example of this was three cases that had descriptions of incidents in which the injured worker was folding an irrigation boom and had part of their fingers, hand or arm caught in the hinged area:

- *Performing normal work duties folding up the boom of a spray rig — amputation right middle finger/s;*
- *Folding up spray boom. Last fold moved suddenly — caught arm in fold/fracture right wrist/s;*
- *Folding up the extension end of a boom spray — amputation left little finger/s.*

The vast majority of descriptions of incidents involving ladders and scaffolding did not allow an appropriate assessment of the contribution of design to be made. Such incidents were coded as 'Unknown' design-relatedness. The description of circumstances typically stated that the person 'fell from a ladder', 'slipped off a ladder', 'slipped on the step of a ladder', 'slipped on scaffolding', 'fell when the ladder slipped' or 'fell when the ladder collapsed'. These included:

- *Climbing down a ladder going from one level to another, stopped and slipped and fell approximately three feet on landing;*
- *Picking oranges near top of ladder. Foot slipped on ladder rung — over balanced because I had a full bag. Fell to the ground hitting leg on ladder on the way down; and*
- *Climbing scaffolding to plaster wall. Foot slipped while climbing scaffolding.*

In some instances, the description did indicate that design issues were involved to some extent:

- *Fell off scaffold while spray painting ceiling when safety bar gave way;* and
- *Standing on scaffold, when scaffold gave way causing him to fall onto concrete floor.*

4. DISCUSSION

4.1 General Issues

4.1.1 Identification and classification of design issues

Few publications consider in detail the role of design issues in work-related incidents, although some have included design issues as a small component of a broader analysis of the contributing factors in work-related injury. As a result there were no approaches identified that could be adopted for this study.

For this study, a pragmatic approach to the identification of design issues was adopted. The task involved using the available data, which had not been collected or recorded with the aim of describing aspects of design that may have been important to the occurrence of the incident. The approach used was in part impeded by the data limitations. It involved including cases if aspects of the design of machinery, plant, equipment or structures had clearly contributed to the occurrence of the fatal or serious incident and/or to the sustaining of fatal injuries as a result of the incident, and where such aspects could reasonably be expected to be preventable with current technology.

For many circumstances, deciding whether design issues were involved, and identifying the type of issue, was straightforward. However, this was not always the case. The main cause of this difficulty was the lack of detailed information about the incident circumstances. For example, there have been many instances of workers being hit by forklift trucks where issues of line of sight, warning lights, alarms or environmental lighting have been found to be important. All of these factors can be considered design problems. However, if the only relevant available part of a description is that 'a pedestrian worker was hit by a forklift truck', there is not enough information to be confident that design played a role. In a small number of cases, there was adequate information about the circumstances, but difficulties arose because of uncertainty regarding whether design should have been considered to play an important part in the incident.

Even where design issues were considered to have contributed, the identification of the relevant design issue was not always straightforward. A classification scheme was developed during this project, but was sometimes difficult to apply because a number of different design approaches might have prevented the problem. Only the apparent primary design issue was identified, although in some instances it was likely that more than one design issue contributed.

Finally, when interpreting the results of this study, the nature and source of the raw data must be kept in mind. Both the NCIS and workers' compensation data were not collected primarily for prevention purposes in general, nor to consider design issues in particular. The NCIS information was provided by police, OHS officers and/or Coroners, and the workers' compensation text descriptions were provided by the injured worker or the relevant employer, not by an impartial investigating officer. The available information may be expected to under or overemphasise factors related to design in some incidents, although underestimation seems more likely. Adding this to the problem that 'design-relatedness' is inherently an imprecise concept, the results of the analysis can only be considered indicative. They clearly indicate that design is an important contributing factor in work-related serious injury, and the study provides a reasonable estimate of the extent of involvement, but the precise contribution is not known.

4.1.2 Types of design issues involved in work-related injuries

The main design issues identified for fatal work-related incidents were problems with rollover protective structures and/or associated seat belts; inadequate guarding; lack of residual current devices; inadequate fall protection; failed hydraulic lifting systems; and inadequate protection mechanisms (such as enclosed cabins) on mobile plant and vehicles.

For serious non-fatal injuries, as described by workers' compensation data, guarding was overwhelmingly the major problem identified. Guarding problems occurred particularly in incidents involving cutting, slicing and sawing machinery; crushing, pressing and rolling machinery; conveyors and lifting plant; other plant and equipment; and powered tools and equipment. Some overlap with guarding problems included poorly-situated controls and inadequate interlock safety systems.

Other design issues identified included generic issues such as drills and other powered tools sticking in the material on which they were being used and then wrenching the hand of the worker. There were also examples of failure of various types of powered or non-powered equipment, and some interesting instances of a specific type of incident involving the same item of equipment and the same design issue (e.g. the irrigator booms mentioned in the Results).

Incidents involving all-terrain vehicles showed the intersection between design and usage. All-terrain vehicles on farms are commonly used in purposes for which they were not specifically designed. This gap between design and use sometimes contributes to the incident occurring, and it could be argued that it is reasonable to expect that the designers and manufacturers anticipate such use.

4.1.3 The scope of design issues

The identification of design issues in work-related incidents leading to serious injury in this study cannot be expected to include the full range of circumstances in which design contributes to such incidents. For most fatal incidents involving issues with the physical design of machinery, plant and equipment, reasonably detailed descriptions by the police and/or Coroner should provide the type of information necessary to assess the role of design. Workers' compensation data descriptions sometimes provide the required level of detail. However, even detailed information may not allow the identification or assessment of the role of the design of systems, process and buildings unless it is collected with these issues in mind. Nevertheless, the design of systems, process and buildings can be expected to contribute to some incidents resulting in work-related injury.

Limitations in the available data sources meant that these potential design factors were beyond the scope of the current analysis. This is another reason why the estimates of design-relatedness presented in this report must be considered to be underestimates of the true situation.

4.1.4 Multiple contributing factors

The methodological approach taken in this study falls between an amalgamated case series and a population-based study. For the analysis of NCIS data in particular, there was commonly sufficient information to confidently conclude that design did (or did not) make a meaningful contribution to the death. This does not necessarily mean design was the only such contributing factor, nor even that it was the most important factor. Indeed, in most work-related injury deaths there are several important factors involved. However, cases were only classified as design-related if the available information strongly suggested that the incident would not have occurred, or would not have had its fatal outcome, if the design issue had not been present. The information does not prove that tackling design issues is the most cost-effective prevention approach (although the arguments were presented in the Introduction as to why it might be). What it does show is that design is an important contributing factor to serious work-related injury in Australia.

4.2 Fatalities

4.2.1 Identification of work-related deaths

Work-related deaths in the NCIS were identified using the two most relevant NCIS variables. One of these specifically identifies the work-relatedness of the case and one identifies the activity of the person at the time of the fatal incident. These variables could be expected to identify all work-related deaths, whether involving workers, commuters or bystanders. However, the NCIS is only in its third year of operation, and quality control and checking procedures are still being developed, so some errors in the coding may be expected. Following exclusion of the medical misadventure, motor vehicle and aircraft incident deaths, the deaths identified as work-related on the basis of the *Work-relatedness* and *Activity* variables were checked, and the circumstances compared to the work-related definition used by the NCIS and adopted for the current study. This resulted in seven cases being excluded.

The NCIS was not searched comprehensively for other work-related deaths that had not already been identified using the two variables mentioned above. However, it is unlikely there were many such deaths, especially of workers. Also, it is unlikely that such deaths would have involved machinery, fixed or mobile plant or powered equipment, and unlikely that the circumstances would have preferentially involved, or not involved, design issues. Deaths involving bystanders might be less well covered, because the connection to work can be harder to identify. This is also the case for commuting deaths, because of a lack of information about the purpose of a vehicle journey, but this is not an issue for this study since motor vehicle incidents were excluded.

4.2.2 Identifying circumstances in which design issues were involved

The intention was to identify any circumstance in which design factors had contributed to the fatal injuries. This identification can be very difficult. In particular, it is difficult to exclude design as a possible factor, since it is possible to imagine design-related interventions that would prevent almost any death. Many of these interventions might not, currently at least, be considered to be practical or realistic. The identification becomes even more difficult when the available information is limited, as was the case with many of the incidents. Even when there was a lot of information in the police description of circumstance, this information did not always address design issues, or did not cover areas that allow design issues to be considered.

However, all cases were independently coded by at least two coders, and 45% were coded by all three coders. The agreement of independent coding at the two-category level (design definitely/probably involved versus design possibly/unknown or not involved) was high, and discrepancies were discussed to reach, wherever possible, an agreed final code as to the

involvement of design. Given the various factors impacting on consideration of the role of design, complete agreement on every case cannot be expected. However, the comparison of independent codes showed that the overall proportion of cases deemed to have 'Definitely' or 'Probably' involved design issues was similar between coders, and very close when the 'Possible' category was included (see Appendix 3).

4.3 Comparison to 1989-1992 fatalities study

Data on recent work-related fatalities involving machinery and fixed plant were compared to data on similar fatalities that occurred during the four-year period 1989 to 1992[2]. In both analyses the proportion of incidents involving *machinery and fixed plant,* to which design issues contributed, was high. Allowing for the small number of cases in the recent time period, the greater role of design in these cases is clear. Nearly all recent fatal work-related incidents involving machinery and fixed plant included some sort of significant design issue.

Presuming this difference reflects the true situation, rather than arising from methodological problems, an explanation for this finding may be that in the ten years between the period covered by the 1989-1992 study[2] and the current analysis, there has been improvement in the control of many workplace hazards associated with the use of mechanical equipment and fixed plant, without a proportionately similar improvement in the control of design issues. Many of the non design-related circumstances leading to work-related fatal injury would therefore now occur much less frequently, and design-related issues would be identified in a greater proportion of the fatal incidents. This does not mean that design-related problems are more common. In fact, they may well be less common yet still significantly be involved in a greater proportion of the work-related fatal incidents.

The types of design issues identified in the 1989-1992 analysis[2] of *machinery and fixed plant* incidents were very similar to the design issues identified for all the workplace fatalities included in the current analysis. Not all of these issues were identified in the *machinery and fixed plant* fatal incidents in the current analysis (described above). The low number of such incidents in the current analysis makes direct comparison difficult, and much more detailed information was available for incidents considered in the 1989-1992 analysis[2]

Nevertheless, guarding was clearly the main design issue in *machinery and fixed plant* for both the 1989-1992 study[2] and the current analysis. In the current analysis, guarding accounted for 44% of design problems in incidents involving *machinery and fixed plant*. In the 1989-1992 study[2], where more than one design problem was sometimes identified in the same incident, guarding accounted for 38% of design problems and featured in 23% of the *machinery and fixed plant* fatalities.

Several methodological issues need to be considered in any comparison such as the one undertaken here. These include the definitions used, the application of the definitions, and the comparability of the two study groups. Importantly, the definition of design issues, and of work-relatedness, was similar in both studies, but the application of these definitions also needs to be considered. It is hard to assess the agreement in the application of these definitions, as the required information from the 1989-1992 study[2] was not available, and it was not possible to reassess all the 1989-1992 cases[2]. For most cases, the investigators in the earlier study had access to much more detailed information regarding the circumstances than was available for the current analysis. This may have allowed them to more easily identify non-design issues, or rule out design issues, in the earlier study than was possible in the current analysis. However, it seems that more comprehensive information would be more likely, rather than less likely, to allow important design issues to be identified. In addition, reasonable consistency between the two studies in the application of the design issues definition can be expected, because the coder who assessed the design-relatedness in all cases in the current study also directed the 1989-1992 study[2].

The earlier period covered the whole of Australia, whereas the more recent analysis excluded Queensland data. Industries or activities that are preferentially based in Queensland will therefore

not be appropriately represented in the current data. Labour Force data[5] do not suggest the industry distribution in Queensland is (or was during the 1989-1992 period) significantly different to that in the rest of Australia, but there is little information on the distribution of more specific activities or tasks within each industry.

A major difference between the two studies is the number of work-related deaths involving *machinery and fixed plant*. In the 1989-1992 study[2], there were 233 deaths over four years, or approximately 60 per year. Excluding Queensland deaths, as was necessary for the analysis of NCIS data, there were approximately 50 deaths per year. In comparison, the analysis of recent data identified only 20 deaths involving *machinery and fixed plant* in two years, or 10 deaths per year. The reasons for this apparent five-fold improvement are not clear. The two main possible explanations appear to be that there really has been a large drop in work-related fatalities involving *machinery and fixed plant*, or that such deaths were under-recognised by the NCIS.

As mentioned earlier, the NCIS was not comprehensively searched for work-related deaths that were not identified as such by the W*ork-relatedness* or A*ctivity* variables. However, the variable identifying the main involved object was inspected for all cases in the NCIS, and no other cases suggestive of being work-related were identified. Only five per cent of cases were still 'Open' (that is, the coronial process was not completed), and very few of these did not have a definitive code for *Work-relatedness, Activity* and *Primary object*.

Data from the NDS also suggest much of the drop may be real. Using NDS[3] data available through the NOHSC website via the National Occupational Statistics Interactive (NOSI)[6], information on accepted workers' compensation claims for fatal injury and non-fatal injury requiring 10 or more days off work and for which *machinery and fixed plant* was coded as the *Breakdown* agency was obtained for each year from 1994–1995 to 2000–2001 inclusive (the most recent time period for which NOSI[6] data are available).

These data show that *machinery and fixed plant* comprised a very stable proportion of claims for serious, non-fatal injuries over the period, ranging from 6.6% to 7.3% of all serious injuries claims. For fatal injuries, the proportions were somewhat less stable, as might be expected with the much smaller numbers involved, but still only ranged from 5.0% to 9.9% up to 1999–2000, and averaged 6.6%. However, for 2000–2001, *machinery and fixed plant* fatalities only comprised 3.4% of all fatal injury claims. This was 11 deaths for the whole of Australia, compared to an average of 29 (range 26 to 34) for the previous six years (Table 10). Of the 27 deaths identified in the NCIS as involving *machinery and fixed plant* (including those involving high or low tension wiring, as these are included in the NDS[3] information), nine were in 2000–2001 and 18 in 2001–2002.

An analysis of unpublished NDS data provides more detailed information on compensated claims for fatal injury involving *machinery and fixed plant* for all of Australia, excluding Queensland, from 1991–1992 to 2001–2002. This shows much lower numbers of deaths in 2000–2001 (12) and 2001–2002 (11) compared to earlier years (average = 23; range = 18 to 30). Most of the difference was in the 'Electrical installation' category (Table 11). Such a sharp drop in numbers is suggestive of a change in coding practice or coverage in the workers' compensation system. However, the similar drop seen in the NCIS suggests that at least part of the decline may be real.

In summary, under-recognition of cases in the NCIS does not seem likely to be the main explanation for the apparent large drop in the annual number of work-related deaths involving *machinery and fixed plant*, although it is likely that a small number of relevant cases were missed. Considered together, the NCIS and NDS data suggest that 2000–2001 was an unusual year in terms of the low number of recorded work-related deaths involving *machinery and fixed plant*. The NDS data also suggest that 2001–2002 had a similarly low number of such deaths. Such a dramatic drop seems strange, and no clear explanation for it is apparent.

Table 9: Compensated claims for injury – those with machinery and fixed plant as the Breakdown agency versus all breakdown agencies. Serious non-fatal[1] and fatal injuries. Australia, 1994–1995 to 2000–2001. Number and per cent.

Year	Non-fatal			Fatal		
	Machinery and plant	All agencies	%[2]	Machinery and plant	All agencies	%[2]
1994–1995	7,353	105,231	7.0	27	429	6.3
1995–1996	7,096	106,146	6.7	24	409	5.9
1996–1997	6,827	103,889	6.6	21	418	5.0
1997–1998	6,602	97,325	6.8	30	401	7.5
1998–1999	6,369	87,567	7.3	34	372	9.1
1999–2000	6,459	92,915	7.0	26	262	9.9
2000–2001	7,495	105,636	7.1	11	319	3.4
1994–1995 to 1999–2000	8,034	116,452	6.9	28.8	435	6.6

1. Injuries resulting in 10 days or more off work.
2. Machinery and plant claims as a percentage of all claims.

Table 10: Compensated claims for fatal injury where machinery and fixed plant was the Breakdown agency. Australia (excluding Queensland), 1991–1992 to 1999–2000 versus 1 July 2000 to 30 June 2002. Number.

Machinery and (mainly) fixed plant	1991-92 to 1999-00: average deaths per year	2000-01	2001-02	2000-01 c/w previous years[1]	2001-02 c/w previous years[2]
Cutting	0.9	0	0	-0.9	-0.9
Crushing	1.6	1	1	-0.6	-0.6
Heating	1.0	1	1	0.0	0.0
Cooling	0.2	0	0	-0.2	-0.2
Conveyors and lifting plant					
Forklifts	3.9	4	3	0.1	-0.9
Cranes	1.7	1	3	-0.7	1.3
Hoists	0.7	0	1	-0.7	0.3
Conveyor belts	0.8	0	0	-0.8	-0.8
Power transfer	0.4	0	1	-0.4	0.6
Other lifting plant	1.3	0	1	-1.3	-0.3
Total conveyors and lifting plant	**8.8**	**5**	**9**	**-3.8**	**0.2**
Electrical installation	8.8	4	0	-4.8	-8.8

Radiation	0.0	0	0	0.0	0.0
Bottling	0.0	0	0	0.0	0.0
Other	2.1	1	0	-1.1	-2.1
Total	**23.3**	**12**	**11**	**-11.3**	**-12.3**

1. Number of deaths in 2000–2001 compared to the average number of deaths each year from 1991–1992 to 1999–2000.
2. Number of deaths in 2001–2002 compared to the average number of deaths each year from 1991–1992 to 1999–2000.

4.4 Workers' compensation information

4.4.1 Interpretation of the design-related proportion

The approach to coding meant that, for virtually all workers' compensation cases, the final coding could only either identify that a design issue had definitely or probably contributed, or record this assessment as indeterminate. As mentioned in the earlier, although it is possible that in some cases design issues appeared to have been involved when in fact they were not, on balance it is likely that the presented results are an underestimate of the proportion of cases for which design issues were important, rather than being the actual proportion that involved design issues.

4.4.2 Representativeness of compensation information

Useable workers' compensation information was not available from all states and territories, mainly because text descriptions of the circumstances were not available. Information was provided for just over 2,700 cases that met the eligibility criteria for the study (i.e. involved the selected breakdown agencies). This was only 15% of the total number of cases in Australia that met the eligibility criteria for the years covered by the analysis, but 70% of the expected cases for the included jurisdictions and breakdown agencies (based on a separate NOHSC extract of NDS[3] data covering those years).

The cases included in this analysis cannot be assumed to be representative of workers' compensation claims for the whole of Australia. In addition, workers' compensation data do not cover all work-related injury, with particular industries and tasks likely to be under-represented because they have a higher proportion of self-employed persons. The implications for the results of the study are uncertain.

Of the three included jurisdictions with more than 400 cases, the percentage involving design issues was fairly similar for most broad categories — 41%, 48% and 55% for machinery and plant; 6%, 4% and 21% for mobile plant; 12%, 12% and 18% for powered equipment and tools; and 26%, 32% and 38% overall. This suggests that the involvement of design issues in incidents concerning particular types of equipment is similar, regardless of the jurisdiction. However, the uses and types of equipment will be directly related to the type of work activities being undertaken (and perhaps, therefore, the occupation of the worker), and these can be expected to vary considerably between jurisdictions. Therefore, the overall involvement of design issues in a particular jurisdiction can also be expected to vary considerably, even if the role of design in incidents of the same type is very similar. This implies that the proportion of design issues is most usefully presented separately for specific agency groups, where possible.

Equipment use and type can also be related to employment status, since certain occupations have a higher proportion of self-employed persons than others. Factors such as equipment age and level of maintenance might well be different for self-employed versus employed persons. Equipment age and level of maintenance can be directly related to the likelihood of design being involved in injury-causing incidents. Therefore, for a given agency type, the proportional involvement of design issues may vary with employment arrangement. To the extent that this

occurs, workers' compensation data may not adequately represent design-related injury incidents in self-employed persons, since self-employed persons are not usually covered by the workers' compensation system in Australia. However, equipment is likely to be older, and maintenance poorer, if used by self-employed persons, due to financial restraints compared with businesses with employees. This means the involvement of self-employed persons is unlikely to be less than it is for employees (represented by the workers' compensation data). Therefore, workers' compensation data probably underestimates, rather than overestimates, the proportion of cases in the entire workforce in which design issues are involved.

These factors suggest that, for a particular type of machinery, plant or powered equipment:

- the workers' compensation data included in this study probably provides a reasonable representation of the involvement of design issues in incidents leading to compensable injury in Australia; and
- workers' compensation data may not adequately represent design involvement in injury-causing incidents for self-employed workers, but is likely to be an underestimate rather than an overestimate.

4.4.3 Usefulness of text descriptions

The usefulness of the available text descriptions varied considerably between and within jurisdictions. Most descriptions consisted of a few phrases describing briefly what happened and/or what was being done at the time of the injury. Even the most comprehensive description was little more than two short sentences. Many contained no useful information at all. This made identifying or excluding the contribution of design issues very difficult.

Some descriptions did explicitly identify design issues. In others, there was enough information in the descriptions, especially when combined with coded information describing the Nature, Bodily location, Mechanism and/or Breakdown agency, to accept that there were design issues involved. However, in many cases, there was insufficient information to make an assessment. As stated in the Methods, this meant that the identified proportion of cases involving design issues are probably an underestimate. The extent to which the stated proportions understate the true results is likely to vary with the Breakdown agency.

Given these problems with the text descriptions, it was surprising how many cases clearly indicated problems with design. As mentioned above, the results of the analysis of workers' compensation data clearly identified some significant design issues, with guarding being the predominant problem. Guarding issues are likely to be more obvious to the persons reporting the incident, and easier for the reader to identify, than many other design issues. For example, an incident involving someone's hand being caught in a bench saw is likely to be described, even in a brief description, in such a way that design can clearly be identified as an issue (e.g. 'Using bench saw, hand pulled into saw blade by wood'). In contrast, incidents in which someone falls from a ladder, or is hit by a forklift truck, may well have important design–related issues, but a brief text description is unlikely to identify or exclude such issues (e.g. 'fell from ladder'; 'forklift ran over foot'). Therefore, it is not surprising that design issues identified in this analysis should preferentially involve guarding. Notwithstanding this, other design issues were identified, despite the limitations of the available data.

4.4.4 Coding problems

The selection of cases was based on the recorded Breakdown agency. The Breakdown agency is the '*object, substance, or circumstance that was principally involved in, or most closely associated with, the breakdown event'*, and so would be expected to be machinery, plant or equipment. It was clear from some descriptions that this was not always the case, either because an *environmental* agency was viewed as the most important agency, because the coding was wrong, and/or because more than one type of machinery, plant or equipment was involved in the same incident.

Most of the identified coding problems arose because an *environmental* agency (e.g. a slippery surface) was coded as the Breakdown agency in incidents in which machinery, plant or equipment was meaningfully involved. For example, 'Getting out of a forklift — slipped on slippery step' was coded as TOOCS code 713: '*Wet, oily or icy traffic and ground surfaces'* in one case. Coding the forklift truck as the Breakdown agency would probably be more correct (although this might change depending on the specific circumstances of the incident), and the forklift truck code was used for other cases that appeared very similar to this one.

There were many other examples of similar types of incidents being coded to different breakdown agencies. No attempt was made to correct the codes in the data provided by the jurisdictions. It is likely that a small proportion of cases involving the agencies of interest in this analysis were excluded because they were assigned a different Breakdown agency code. However, the proportion of such cases is likely to be small. More importantly, there is no reason to suspect that the involvement of design issues in such cases is less likely than in the correctly coded cases, and therefore no reason to suspect that the identified proportion of cases involving design issues is an overestimate.

Despite the text descriptions being brief, those with adequate detail were able to provide some useful insights into incidents leading to work-related injury. This study suggests that analysis of these text descriptions could make a useful contribution to the prevention of work-related injury by providing an understanding of the circumstances leading to work-related injury.

5. SUMMARY AND CONCLUSIONS

This report presents a consideration of the role of design issues in serious work-related injury. The concept of design-relatedness is not well conceptualised or practically applied in the literature and therefore there were no existing definitions or approaches that could be adopted. In addition limited data constrained the approaches that might be used. Therefore, a pragmatic approach was adopted. The focus was on workplace incidents, with work-related incidents involving motor vehicles, aircraft or train crashes and medical misadventure being excluded.

- The resulting analysis has provided several useful outcomes:
- knowledge of the patterns of circumstances leading to design-related injury;
- information about the extent of design involvement and an approximate ranking across various types of machinery, plant and equipment; and

an indicative comparison with information on design involvement in work-related fatalities ten years ago.

The main finding from the study is that design continues to be a significant contributor to work-related serious injury in Australia. This is the case with a wide variety of machinery, plant and equipment, although the extent of involvement varies between them. Limitations of the data sources mean that the percentage involvement identified in this analysis are likely to be underestimates and to be imprecise.

Most of the main design problems are old issues, with guarding the most prominent example. Other identified problems were poorly situated controls; inadequate interlock safety systems; absent or inadequate rollover protective structures and/or associated seat belts; inadequate fall protection; failed hydraulic lifting systems; and inadequate protection mechanisms (such as enclosed cabins) on mobile plant and vehicles. These appear to provide a lot of scope and opportunity for prevention activities.

Limitations in the available data sources also meant that the potential contribution of the design of systems, processes and buildings to work-related injury was beyond the scope of the current

analysis. This is another reason why the estimates of design-relatedness presented in this report are likely to be underestimates of the true situation.

There appears to have been a substantial decrease in the number of fatal incidents involving *machinery and fixed plant* in the decade between 1992 and 2002, probably primarily since 2000, but data issues may explain part of this.

The next component of the study will provide more detail on the type of design problems and the settings in which they occurred, primarily based on the information available in the NCIS. The various possible definitions of design-relatedness, and how such definitions might be applied, will be investigated. Possible development and use of baseline and target values will be examined. Finally, ways to improve the use of existing data sources will be considered. Possibilities include:

- developing a design attributable risk for specific agencies or occupations, which could then be applied to routinely collected existing mass data sources such as workers' compensation data, national deaths data and hospital admissions data;
- the use of automated analytical text searching systems to identify design issues in available text data from workers' compensation sources; and
- improvements in current data sources, such as the use of a nationally consistent form and procedures for investigating incidents resulting in work-related fatal and serious non-fatal injury.

6. REFERENCES

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APPENDIX 1
DETAILED DESCRIPTION OF METHODS

Definitions

Work-related

Only work-related cases were considered in this study. The definition of *work-relatedness* is that adopted by the NCIS, which was developed in close consultation with NOHSC. In brief, a work-related case is *A person who was fatally injured as a result of, or who died of a fatal condition caused by, exposure to their own or others' work activity or work factors; or who was fatally injured whilst travelling to or from work*.[1] This definition includes workers in workplaces, persons driving for work purposes, persons driving to or from work (commuters), and bystanders. Only persons dying directly or indirectly as a result of injury were included. (Indirect injury covers situations such as someone dying as a result of a pulmonary embolus or sepsis while hospitalised after major injury.)

This definition was applied to cases identified in the NCIS as being work-related. Cases included in workers' compensation authority data sets were accepted as being work-related.

Design-related

An injury was defined as a design-related case if any aspect of the construction of equipment, plant, tools or structure involved in the incident made a meaningful contribution to the occurrence of the injury-causing incident and/or to the occurrence of fatal injury resulting from the incident, and it was realistic to expect that this factor could have been modified to avoid the incident or the subsequent fatal injury.

Certain groups of cases were excluded from the current analysis for one or more reasons. These were if relevant design issues can be expected to already be addressed by specific authorities, they were considered not to fall within the scope of OHS design issues as envisaged for this project, and/or the available data sources were unlikely to contain information regarding design issues for these types of cases. These groups were persons who were injured as a result of:

- motor vehicle incidents involving road vehicles on public roads;
- aircraft crashes;
- train crashes; or
- medical misadventure.

Fatal injuries

The primary source of information for fatal injuries was the NCIS. The NCIS is a national system of information and supporting infrastructure designed to provide prompt access to coronial data from all coronial jurisdictions in Australia, to support the work of Coroners and others interested in the prevention of injury and disease. The NCIS has been developed for Coroners, and is managed, by the Monash University National Centre for Coronial Information (MUNCCI). The NCIS is important in the current project because it is the only source that covers all work-related incidents (although only fatal ones) regardless of the employment status of the injured person and the setting of the incident, and the only accessible source likely to have detailed information on many of the deaths of interest.

[1] The full NCIS definition of *work-relatedness* is available at: http://www.vifp.monash.edu.au/ncis/.

Only injury deaths were of relevance to the analysis of NCIS data. Such deaths should be identified as being 'External Cause' deaths in the *Case Type* variable of the NCIS. This classification of Case Type occurs at the time of notification of the case to the NCIS, and at the completion of the coronial process. Occasionally, deaths that could appropriately be considered as being due to injury are classified initially as 'Natural Cause'. Also, cases that are still 'Open' (that is, the coronial process is not completed) may have an erroneous, incomplete or missing code for *Case Type*. Therefore, only definite Natural Cause cases were excluded in the initial data request. Suicides were excluded from the scope of this study.

NCIS cases were eligible for inclusion if the death occurred on or between 1 July 2000 and 30 June 2002. This two-year period was chosen because 1 July 2000 is the earliest date of death for cases included in the NCIS, and to allow time for the coronial process to have been completed for the vast majority of cases. Only limited information is available on a case in the NCIS until the coronial investigation process is completed and the status of the case is formally changed from Open to Closed in the NCIS. Also, 2001-2002 is the baseline year for NOHSC's OHS Strategy[2]. Queensland cases could not be included because information on these cases has only recently been included in the NCIS and it was not available to investigators at the time this study was conducted.

Therefore, potential injury cases were identified in the NCIS by obtaining information on all cases with a:

- date of notification on or between 1/7/2000 and 30/6/2002;
- EXCEPT those with:
- Case type at completion = 'Natural Cause';
- OR
- Intent at completion = 'Deliberate self-harm'.

All relevant fields from the various NCIS forms were requested, as well as the police description of circumstances. Information for fields that have numeric codes was requested in numeric form, but the provided data used the category labels rather than the associated codes. The police description consists of one or more entries describing the particulars of the fatally injured person, the circumstances leading to their death, and other information related to the discovery of the injured or deceased person, the subsequent investigation of circumstances, and various other factors. The extent, detail and usefulness of the descriptions vary considerably between jurisdictions, and between cases within the same jurisdiction.

The information was provided in two Excel files, one for 2000–2001 deaths and another for 2001–2002 deaths. These files contained all the data except the police description of circumstances. The police descriptions were supplied in flat files that were converted into Word files. The 2000–2001 descriptions were supplied in a single flat file that was later converted into seven Word files, one for each of the jurisdictions except Queensland. The 2001–2002 descriptions were supplied in seven flat files, again one for each of the jurisdictions except Queensland. This information was extracted by MUNCCI in early October 2003. Cases described as 'Open' or 'Closed' refer to the *Case Status* at the time the data were extracted. For some cases, other information was obtained directly from the NCIS website by the investigators. This information included the Coroner's Finding, although this was often not available through the website or did not contain any useful information.

The Excel files were cleaned, unnecessary fields deleted and some new fields created on the basis of the original information provided. Duplicate cases (e.g. those where the incident had occurred in one jurisdiction but the death had occurred in another, and for which both jurisdictions had a file)

[2] National Occupational Health and Safety Commission. *National OHS Strategy 2002-2012*. Canberra: NOHSC, 2002. Available at: http://www.nohsc.gov.au/nationalstrategy/Strategy2sep.pdf.

were deleted. Cleaning included comparing dates of incident, death and notification looking for anomalies (e.g. the incident could not occur after the death, and notification could not occur before the death). Identified anomalies were resolved where possible by inspecting the relevant NCIS file on the web site and reading any attached files or other information.

Identifying work-related deaths

The NCIS has two specific variables that identify deaths as being work-related or not. The variables are *Work-relatedness* and *Activity*. As noted above, the relevant definition of work-related is broad. The definition, as currently applied by the NCIS coders, includes medical misadventure cases. However, home duties deaths are not included.

In addition to the *Work-relatedness* variable, the *Activity* variable also provides information on work-relatedness, as it describes the activity of the person at the time of the incident. The categories related to work are 'working', 'commuting', and 'working or commuting'. For an individual case, the relationship to work indicated by the codes for the *Activity* and *Work-relatedness* variables would usually be expected to match, although legitimate exceptions can occur.

The group of cases for which detailed information was sought comprised any death that was identified as work-related by either the *Work-relatedness* or the *Activity* variable. No detailed attempt was made to use other information in the NCIS to identify other work-related cases (This is considered in the Discussion). The *work-relatedness* of particular deaths could only be assessed if sufficient information was available. This resulted in a small number of cases identified by NCIS codes as being work-related subsequently being excluded because they were considered not to have been work-related, even if design issues may have been involved.

Identifying circumstances involving design issues

The police description was the main source of information used to identify cases with design-related issues. The Coroner's Finding, and other information on the NCIS web site, was used where available and appropriate.

Cases were coded as 'Definitely', 'Probably', 'Possibly', 'Unknown' and 'Not' design-related. For example, incidents would be coded as design-related if someone fell from a height and there were no railings to prevent a fall; if someone was electrocuted by domestic current on a circuit without an earth leakage device; if a tractor or bulldozer operator was killed if there was no roll-over protection device or cabin and the machinery rolled over, or the operator was struck by a heavy object while operating the machinery; or if someone was caught in the moving parts of machinery that could have been guarded and/or protected by a cut-off safety system. The difference between 'Definite', 'Probable' and 'Possible' codes was primarily due to different levels of available information about the circumstances. 'Unknown' was usually used when there was little or no information available. 'Not' was used when there was sufficient information to rule out design as an issue (e.g. a police officer shot by a fugitive), although even for some of these cases it could be argued that a design-related prevention approach might have been possible. Specific examples of the way the coding was applied are provided in Appendix 2.

This analysis considered design issues to have occurred if design had definitely or probably made a significant contribution to the incident and its fatal outcome. This means that the number/proportion of deaths identified as involving design issues must be considered to be an underestimate of the true situation. For some analyses, results for cases coded as possible design issues are also presented. For those cases identified as definitely, probably or possibly being related to design, the main apparent design problems were recorded.

Three coders were involved in the coding of design-relatedness for NCIS cases. One coder (TD) coded all 210 cases. All cases were also coded by at least one other coder, and 95 cases were coded by all three coders (a fourth investigator did not perform coding but did the formal

comparison of the independent codes – this will be presented in the Phase 3 report). All coding was done using a blinded approach. That is, no coder was aware of the code assigned by the other coder(s) at the time the coding was performed. Cases coded by the second and third coders were a random sample of the total cases. Assigned codes were then compared. For the purposes of the comparison, and of the analysis presented in this report, 'Definite' and 'Probable' codes were considered to identify 'Design-related' cases, whereas 'Possible', 'Unknown' and 'Not' combined into a second, 'Other', category. Major discrepancies (i.e. coded as 'Definite' or 'Probable' by at least one coder and 'Possible', 'Unknown' or 'Not' by at least one coder) were discussed by the involved coders, and an agreed final code assigned where possible. In two cases, final agreement could not be reached. These cases were given a final code of 'Unknown'. Agreement at the two-category level between TD's codes and the codes assigned by the relevant other coder was 83% (see Appendix 3 for more details).

For those cases identified as definitely, probably or possibly being related to design, the main apparent design problems were recorded.

The results were compared to a consideration of design issues in incidents leading to fatal injuries involving machinery and fixed plant that were identified in the 1989-1992 work-related fatalities study.

Workers' compensation data

Workers' compensation information was the data source used to examine the role of design in non-fatal injuries. Information was requested from all states and territories, as well as Comcare and Seacare, for the years 1997–1998 to 2001–2002 inclusive.

Since there are over 100 000 compensation claims for injury each year in Australia, an approach was required to restrict the cases to be examined. The applied restrictions involved the Severity of the injury, the Breakdown agency, and the Mechanism.

Only incidents that resulted in 'serious' injuries were included, which in this study was defined as injuries that were fatal or resulted in total and permanent disability (that is, cases with a National Data Set (NDS) severity code of 1 or 2).

An agency was excluded if it was considered:

- unlikely that design issues could be identified in any available narrative information;
- unlikely that the agency would result in major injury; and/or
- design issues were considered by other sectors/authorities and/or the issues were not primarily or predominantly OHS issues.

Workers' compensation information used in this analysis was coded according to the Type of Occurrence Classification System[3]. The 'Breakdown agency' is defined as *the object, substance, or circumstance that was principally involved in, or most closely associated with, the breakdown event*. The 'breakdown event' is defined as *the point at which things started to go wrong and which ultimately led to the most serious injury or disease.*[4] Breakdown agencies included in the analysis were restricted to:

- all machinery and mainly fixed plant (TOOCS 2.1 Group 1);
- self-propelled plant, semi-portable plant and other mobile plant (from Group 2);
- all powered equipment, tools and appliances (Group 3); and
- ladders, mobile ramps and stairways, and scaffolding (from Group 4) (see Appendix 4 for more detail).

[3] National Occupational Health and Safety Commission. Type of Occurrence Classification System. Revised Edition 2.1. Canberra: NOHSC, 2002.

Other agencies were initially included in the data request, but the text descriptions for these agencies contained such little information regarding the possible involvement of design factors that a reasonable assessment of the role of design could not be made. Therefore, incidents in which these agencies were coded as the Breakdown agency were not included in the main analysis (see Appendix 4). These excluded agencies were:

- rail transport, air transport, water transport and other transport (from Group 2);
- chemicals and chemical products (Group 5); and
- environmental agencies (Group 7).

'Vehicle accidents' (TOOCS 2.1 Mechanism code 92) not already excluded by the agency criteria were excluded if the injured person was in a standard road vehicle (car, truck, motorcycle, bicycle).

Useable information was received from the Australian Capital Territory, Comcare, Queensland, South Australia, Tasmania and Victoria. Victorian data were only a subset of the relevant claims in that state, because claims from self-insurers were not included since self-insurers do not provide the Victorian WorkCover Authority with descriptions. Western Australia also provided information for one year, but this could not be used because text descriptions were not available.

The initial data request from compensation authorities was for information on all claims completed any time from (and including) 1997–1998 to 2001–2002. However, this was later modified to all claims first recorded/lodged within that time period. Of the six schemes that were able to supply data, four provided information on claims lodged in that time period, and one provided information on claims with an intimation date. (The 'intimation date' is defined as the date of registration of the worker's application for compensation in the insurer's computer system after the application is lodged with the insurer.) One jurisdiction provided information on claims completed in the time period (although only 16% of the claims (1% of all the claims included in the analysis) were lodged prior to 1 July 1997).

The requested information was unit record data covering the Nature, Location, Mechanism, Breakdown agency, Agency of injury and text description for each claim. Coded data were requested.

Cases that did not meet the selection criteria, and duplicate cases, were deleted. Files from different jurisdictions were analysed separately and the results then combined. Only combined data are presented in this report.

Identifying circumstances involving design issues

As with the fatalities data, the intention was to identify any circumstance in which design factors had contributed in some meaningful way to the occurrence of the injuries. Incidents that involved design issues could only be identified in the workers' compensation data using the text descriptions. A minority of cases had no text description or no description of circumstances (e.g. the text just listed the injury). Many of the descriptions did not contain information to adequately assess the possible contribution of design to the injury.

This approach to coding meant that the final coding could only either identify that a design issue had (definitely or probably) contributed, or record this assessment as indeterminate. It is possible that in some cases design issues appeared to have been involved when in fact they were not, but on balance it is likely that the presented results are an underestimate of the proportion of cases for which design issues were important, rather than being the actual proportion that involved design issues. One person (TD) performed all the coding of workers' compensation data.

Cases were not analysed separately in terms of fatal and serious non-fatal injury, as not all data sets separately identified these cases. However, fatal injuries only comprised about 1% of the cases (based on NDS data for all jurisdictions).

Other potential sources of data on injuries related to design issues

There were several data sources initially considered but that were not able to be included. This was because the data were not available at the time, not available in an appropriate format, and/or not suitable for a consideration of design issues. The main examples of these data sources are considered briefly here. Some may prove useful for the next phase of the study and, if appropriate and relevant, will be included there.

Occupational health and safety authority investigation reports

Each state and territory collects information on incidents leading to serious non-fatal, and fatal, work-related injury. This information is in the form of brief notification reports and OHS inspectors' reports. The notifications and the OHS inspectors' incident reports could prove a useful and detailed source of information on the involvement of design issues in work-related injury. These could serve either as a basic data source of information on serious non-fatal injury, or as a supplement to fatal cases of interest identified through the NCIS. The OHS investigation reports should not be subject to coverage issues based on employment status or variations due to changes in legislation, although certain types of incidents (such as those occurring on public roads; and those covered by other regulatory authorities such as a air safety, marine safety and mining safety authorities) are often not covered.

Unfortunately, for this study, useable information from these data sources was not available. Only three jurisdictions were able to provide some information, and two of these only covered fatal injuries. In addition, all the information was brief, often providing only a short summary of the circumstances. Specific investigation reports may have been available for some of the incidents. However, the data would not have been available in time for inclusion in this analysis, and probably would not have provided a broad enough coverage.

National Hospital Morbidity Database

The National Hospital Morbidity Database is a "…collection of electronic confidentialised summary records for admitted patients separated in public and private hospitals in Australia"[4]. That is, it is a database where all the hospital admissions and discharges are collected. It is coordinated by the Australian Institute of Health and Welfare. An annual summary report is published by the AIHW[5]. There are approximately 20,000 hospital admissions for work-related injuries in Australia each year. Design-related incidents are very difficult to identify. Identification relies on the assumption that involvement of particular circumstances, as recorded by the External Cause code, implies that design was, or might have been, a causal factor. The limitations of this are similar to those that apply to NDS data without text descriptions of the incident, but are more severe. This is because the External Cause classification provides less specific categories than do the classifications underlying the NDS (an exception is land transport vehicles). The National Hospital Morbidity Database is not subject to coverage issues such as exclusion based on employment status or variations due to changes in legislation. In the future, it may be possible to investigate a sample of hospitalised cases to develop attributable fractions regarding design for certain combinations of External Cause and Diagnosis codes. These attributable fractions could then be applied to the routinely collected National Hospital Morbidity data.

Australian Bureau of Statistics surveys

The Australian Bureau of Statistics (ABS) conducts a number of surveys that directly or indirectly address OHS. However, ABS surveys are unlikely to provide useful information on design issues

[4] Australian Institute of Health and Welfare. National Hospital Morbidity Database. Canberra: AIHW, 2002. Available at: http://www.aihw.gov.au/hospitaldata/morbidity.html#nhmd1.

[5] Australian Institute of Health and Welfare. Australian Hospital Statistics 2001–02. Canberra: AIHW, 2003.

in work-related injury. In particular, the most recent National Health Survey appears to contain little, if any, information on the involvement of design in work-related injury[6, 7].

Other regulatory authorities

For certain industries or circumstances, major incidents resulting in work-related injury are covered by regulatory authorities (or other authorities) other than jurisdictional OHS authorities. These include mining, air safety, marine safety and road safety (or police) authorities. Reports from these authorities are often detailed, and for many incidents are likely to contain information on design issues where these are relevant. However, the reports still appear to be paper-based or hard to access electronically. They are likely to provide good coverage for fatal incidents within the sphere of interest of the authority, and increasingly poor coverage and less detailed information with decreasing severity of injury.

For this study, detailed information was obtained from the Department of Minerals Resources regarding a limited number of mining fatality cases in New South Wales. The number of cases was too small to be included in this analysis, but relevant aspects of this information should be appropriate for inclusion in the next analysis. Similarly, information identified on the websites of various OHS and industry enterprises, particularly mining, may be of use in the next phase, but were not appropriate for inclusion in this phase of the analysis.

[6] Australian Bureau of Statistics. *National Health Survey: Injuries, Australia*. Canberra: ABS, 2003. Cat no 4384.0.

[7] Australian Bureau of Statistics. *National Health Survey - Summary of Results, Australia*. Canberra: ABS, 2002. Cat no 4364.0.

APPENDIX 2
EXAMPLES OF WORK-RELATED CASES AND THE ASSESSMENT OF DESIGN-RELATEDNESS

This section presents examples of the circumstances involved in incidents considered in the study. The purpose of this information is to provide an understanding of the available information and the way in which the definitions were applied.

The descriptions for fatal incidents are taken from the police notification report or the Coroner's Finding in the NCIS. For non-fatal incidents, the descriptions come from the text descriptions of cases supplied by workers' compensation authorities. For both fatal and non-fatal incidents, the exact wording of the descriptions is shown, apart from some minor editing to ensure no identifying information was included.

Fatal incidents: identified in the NCIS

Definite

Case 1: Design issue identified as a problem with hydraulics.

From the Coroner's Finding:

"On {date}, {injured person}, a self-employed mechanic, was fatally injured after becoming trapped between the body and lifting frame of a Caterpillar front-end loader. The loader was located on the property of {place}. The deceased had worked on equipment at this location over a number of years. One of the tasks to be undertaken to repair the equipment was the removal and replacement of one pressure hose to the lift arm. The bucket of the equipment was tilted forward and resting on its front edge when the pressure hose was disconnected. The bucket and support arms have then dropped trapping the deceased between the frame and body of the equipment. Contributing factors were that no supports were used in the preparation of the removal of the hydraulic pressure hose and the wheels were not chocked to stop the equipment from moving backwards or forwards."

Case 2: Design issue identified as a problem with fall protection (although other design issues appear to also have been involved).

From the Coroner's Finding:

"On {date}, {injured person}, a {age} farmer, left his house at about {time} to perform various farm duties on his {size} hectare property. When he did not return for lunch, a search was conducted and he was found deceased at about 5.00pm at the base of a windmill. The deceased had received fatal injuries as a result of falling or being knocked from the platform of a windmill stand. The platform was approximately 7.5 metres from the ground. The weather on the day was hot with a blustery north wind. It appears that the deceased had greased the head of the windmill and on release of the wind vain, has fallen or been knocked by the wind vain from the work platform of the windmill.

Comments: It is suggested that the Victorian WorkCover Authority, Manufacturing Industry Group, conduct a project on the design and manufacture of windmills to ensure that they are compliant with Section 3 & 4 of the OHS (Plant Regulations) 1995. The aim of the project would be to reduce the risk of fall from height by modification of equipment (e.g. Remote greasing points to eliminate the need to access for greasing purposes) and for the Farm Safety Branch to publicise the dangers of working from windmills and the risks involved when working at height."

Case 3: Design issue identified as a problem with guarding.

From the Coroner's Finding:

The deceased was present while her parents were involved in the milking of cows. The dairy is a conventional herringbone set up designed for 30 cows per side but had been commissioned at 20 cows a side. To enable cows to walk through after being milked a hydraulically operated bail/ feeder arrangement had been installed. Four fail safe "up and down" control stations were strategically located in the milking pit. The bail/feeder assembly can be raised or lowered from each of these control stations two at each side. Movement is only obtained while the operator in the pit maintains pressure on the directional button (fail safe).

When 20 cows on either side had been milked {name} the deceased's father has activated the "up" button. Unbeknown to him, the deceased who had momentarily before been seated safely away from the herringbone structure as she had previously been warned by her mother of the dangers in dairies. The deceased has climbed up the steps on the North Eastern end and was in the walking area.

Her head has become trapped between the main structure and the bail assembly as it was being raised. Appropriate signs and guards have now been fitted.

Probable

Case 4: Design issue identified as a problem with rollover protection and/or seat belts (although other design issues may well also have been involved).

From the police notification report to the Coroner:

"The deceased was a profiling machine operator for {company}. Deceased had been employed by the company since {date}.....At about {time} the crew began profiling sections of the road. After one section the deceased moved the machine about 100 metres south to a second position where he commenced to profile a section of the road. Profiling involves digging up the road and mixing the road material with cement. This process is completed by the profiling machine operated by the deceased.....Witnesses state that the deceased had commenced one run on the second section of the road and was reversing the machine in order to make a second run. For unknown reasons the machine continued in reverse over an embankment on the eastern side of the road (same side of road as the machine was working on) the deceased stood up as the machine was moving toward the edge of the embankment then attempted to jump to safety as it rolled over. The deceased was unable to jump clear and the machine rolled on top of him. The embankment is approximately 3 metres high."

Case 5: Design issue identified as probable lack of overhead protection (cabin, etc).

From the police notification report to the Coroner:

"{date} the deceased attended his workplace, {place}. The deceased had been employed at the location as a forklift driver since {date}. At about {time} on {date} a witness heard a loud crash and the continual sound of a horn coming from the warehouse..... The witness has gone to investigate and has found the deceased seated in his fork lift with the protective cage compressing against the head of the deceased. On top of the protective cage was a metal packing crate containing what appeared to be galvanised pipe. The crate was approximately four to five metres long being square in section measuring approximately 40cm square, and having a gross mass of 1.212kg….."

Case 6: Design issue identified as probable lack of a residual current device.

From the police notification report to the Coroner:

"Electrician electrocuted {date} after cutting a wire working on a roof."

Possible

Case 7: Design issue identified as a possible problem with the braking system.

From the police notification report to the Coroner:

"The deceased is the owner of a property located at the above premises. On the {date and time} the deceased was in paddock located on the west side of his property. He was using his tractor to carry bale of silage from one paddock to another, the bale was on rear carry bars. He got off the tractor to cut the string on the bail, he was then getting back onto the tractor when it started moving, presumably by a cow pushing the bale. This caused the tractor to move forward on a slight incline heading towards the creek. In an attempt to get back onto the tractor the rear wheel rolled over the left hand side of the deceased's head and chest. The tractor weighed approximately 2 ton and the bale of silage approximately 350 kg....."

Case 8: Design issue identified as a possible problem with building design and construction.

From the police notification report to the Coroner:

"The deceased is a plumber and was hired by {name} to replace a pipe in the rear yard of {place}. The job was only going to take a few hours and he informed {name} that he would do the job on the afternoon of the {date}, once he finished work. {name} attended at the address at {time} on the {date} to check on the progress of the job. When he arrived he found the deceased face down, under a slab of brick and concrete wall that he had been digging under. The part of the wall that fell was an extension to an existing wall and did not have any reinforcement. It appeared to have broken away from the rest of the wall."

Unknown

Case 9:

From the police notification report to the Coroner:

"Deceased was fighting a grass fire at the above location alone in a CFA 'Quick Attack' unit. After the vehicle ran out of water the deceased, armed with a 20 litre knapsack, approached a large tractor towing a large plough cutting a fire break, presumably to request/ direct the driver in his activities. Due to a change of wind, visibility became limited and the deceased mistakenly moved into the path of the plough which is much wider than the tractor towing it and became entangled in the four widest trailing discs. The deceased was then dragged 75 to 80 metres before being 'released' causing apparently massive injuries."

Case 10:

From the Coroner's Finding:

On {date and time} the deceased was located lying face down on a concrete path at {place}. He had been working at this address as a roof tiler with his employer {name} and colleague {name}….Statements from {the injured person's} colleagues indicate that he had been working on the roof directly above where he was found just prior to him being located. {name} heard a "bang like the gutter had broke", and upon looking in the direction of the noise has seen the deceased on the ground. The house they had all been working on was a single level brick veneer dwelling. It was undergoing extensive renovations and the area where the deceased has fallen from was an addition to the existing structure. As the pitch of the roof was less than 30 degrees, perimeter fall protection was not required as per the regulations. On the day of the incident, there were carpenters also working at the site. The deceased had just finished his apprenticeship…. At the time of the incident, the deceased had almost completed his tasks for the day and was nearing the end of the pointing phase in the roofing process which is the application of cement mixed with oxide (a colour) over the bedding….. Although the evidence is not clear, it appears the deceased has most likely lost balance whilst working on the roof and fallen approximately 3 metres receiving fatal injuries as a result of the fall. Workcover investigators believe the most likely scenario is that the deceased was standing on the second gable roof, stretching over to the third gable towards the spouting when he has lost his balance. There were no breaches of the OHS Act 1985 in this incident and no prosecution was sought. The Code of Practice for the safe work on roofs excluded villa constructions at the time of the incident. I recommend that the Code of Practice include villa constructions as fall protection should be applicable to all building sites to prevent further deaths of this nature."

Not design-related

Case 11

From the police notification report to the Coroner:

The deceased was in a paddock assisting a neighbour clean up timber which was being felled by an excavator (pushing down trees). At the above time the deceased walked under a 15 metre tall tree which was being pushed over and subsequently struck him on the head causing what appeared to be instant death.

Case 12:

From the police notification report to the Coroner:

At approximately {time and date} the first race at {place} racecourse commenced for the day. The start appears to have been normal and after the horses have travelled approximately 450 metres horse {name} has run into the inside running rail and then fallen over, dislodging the rider {name}. {He} has also impacted the running rail and upright, suffering multiple head and chest injuries.

Non-Fatal incidents: identified in from workers' compensation data

Design-related

Crushed tip of finger when using guillotine — amputation of finger.

Laceration left thumb — cotton caught hand in winding machine.

Fell off scaffold causing head injuries and multiple fractures.

Design-relatedness not known

Back, neck, r/shoulder and r/ankle. Allegedly fell off tractor.

Strain right arm and back. Physical handling object strain back.

Descending from roof top down ladder when slipped. L1 vertebrae fracture — back & left wrist.

APPENDIX 3: BROAD COMPARISON OF INDEPENDENT CODING OF DESIGN-RELATEDNESS

Three coders were involved in the coding of design-relatedness for NCIS cases. One coder (TD) coded all 210 cases. All cases were also coded by at least one other coder, and 95 cases were coded by all three coders (a fourth investigator did not perform coding but did the formal comparison of the independent codes – this will be presented in the Phase 3 report). All coding was done using a blinded approach. That is, no coder was aware of the code assigned by the other coder(s)). Cases coded by the second and third coders were a random sample of the total cases. Assigned codes were then compared. For the purposes of the comparison, and of the analysis presented in this report, 'Definite' and 'Probable' codes were considered to identify 'Design-related' cases, whereas 'Possible', 'Unknown' and 'Not' combined into a second, 'Other', category. Major discrepancies (i.e. coded as 'Definite' or 'Probable' by at least one coder and 'Possible', 'Unknown' or 'Not' by at least one coder) were discussed by the involved coders, and an agreed final code assigned where possible. In two cases, final agreement could not be reached. These cases were given a final code of 'Unknown".

The agreement of independent coding at the two-category level (design definitely/probably involved versus design possibly/unknown or not involved) was high (83%)[8], and discrepancies were discussed to reach wherever possible an agreed final code as to the involvement of design. Given the various factors impacting on consideration of the role of design, complete agreement on every case cannot be expected. However, the comparison of independent codes showed that the overall proportion of cases deemed to have 'Definitely' or 'Probably' involved design issues was similar between coders, and very close when the 'Possible' category was included (Tables A3.1 and A3.2).

Table A3.1: Coding of design-relatedness for fatal workplace incidents. By coder and overall. Australia (excluding Queensland), 1 July 2000 to 30 June 2002. Number and per cent.

Assigned code	Coder 1		Coder 2		Coder 3		Final agreed code	
	Number	%	Number	%	Number	%	Number	%
Definite	36	17.1	44	29.1	26	16.9	34	16.2
Probable	52	24.8	19	12.6	24	15.6	43	20.5
Possible	20	9.5	17	11.3	28	18.2	29	13.8
Unknown	40	19.0	37	24.5	22	14.3	43	20.5
Not	62	29.5	34	22.5	54	35.1	61	29.0
Total	**210**	**100.0**	**151**	**100.0**	**154**	**100.0**	**210**	**100.0**
Definite / probable	88	41.9	63	41.7	50	32.5	77	36.7
Possible / unknown	60	28.6	54	35.8	50	32.5	72	34.3
Not	62	29.5	34	22.5	54	35.1	61	29.0
Total	**210**	**100.0**	**151**	**100.0**	**154**	**100.0**	**210**	**100.0**
Def / prob / poss	108	51.4	80	53.0	78	50.6	106	50.5
Unknown	40	19.0	37	24.5	22	14.3	43	20.5
Other	62	29.5	34	22.5	54	35.1	61	29.0
	210	**100.0**	**151**	**100.0**	**154**	**100.0**	**210**	**100.0**

[8] Kappa statistics are not presented here. A detailed consideration of agreement between coders will be presented in the Phase 3 report.

Table A3.2: Comparison at the two-category level of independent coding of design-relatedness for fatal workplace incidents. Main coder versus other coders[1]. Australia (excluding Queensland), 1 July 2000 to 30 June 2002. Number and per cent.

		Other coders	
Coder 1	Design-related[2]	Other[3]	Total[4]
Design-related[2]	59	25	84
Other[3]	10	106	116
Total	69	131	200

1. One coder (TD) coded all cases. All cases were then independently (blindly) coded by one of two other coders.
2. Cases coded as 'Definite' or 'Probable'.
3. Cases coded as 'Possible', 'Unknown' or 'Not'. This includes two cases where the final classification could not be agreed.
4. Ten cases that were coded by both coders 2 and 3 for training purposes at the beginning of the coding process have not been included.

   Agreement = (59 + 106) / 200 = 83%

APPENDIX 4: INCLUSION AND EXCLUSION OF BREAKDOWN AGENCIES FOR WORKERS' COMPENSATION DATA[1]

	Category code and description	Requested	Analysis
GROUP 1	MACHINERY AND (MAINLY) FIXED PLANT		
11	Cutting, slicing, sawing machinery	IN	IN
12	Crushing, pressing, rolling machinery	IN	IN
13	Heating, cooking, baking equipment	IN	IN
14	Cooling, refrigeration plant and equipment	IN	IN
15	Conveyors and lifting plant	IN	IN
16	Electrical installation	IN	IN
17	Radiation based equipment	IN	IN
18	Filling and bottling/packaging plant	IN	IN
19	Other plant and machinery	IN	IN
GROUP 2	MOBILE PLANT AND TRANSPORT		
21	Self-propelled plant	IN	IN
22	Semi-portable plant	IN	IN
23	Other mobile plant	IN	IN
24	Road transport	OUT	OUT
25	Rail transport	IN	OUT
26	Air transport	OUT	OUT
27	Water transport	IN	OUT
29	Other transport	IN	OUT
GROUP 3	POWERED EQUIPMENT, TOOLS AND APPLIANCES		
31	Workshop and worksite tools and equipment	IN	IN
32	Kitchen and domestic equipment	IN	IN
33	Office and electronic equipment	IN	IN
34	Garden and outdoor powered equipment	IN	IN
35	Pressure based equipment not covered elsewhere	IN	IN
39	Other powered equipment, tools and appliances	IN	IN
GROUP 4	NON-POWERED HANDTOOLS, APPLIANCES AND EQUIPMENT		
41	Handtools, non-powered, edged	OUT	OUT
42	Other handtools	OUT	OUT
43	Fastening, packing and packaging equipment	OUT	OUT
44	Furniture and fittings	OUT	OUT
45	Other utensils	OUT	OUT
46	Ladders, mobile ramps and stairways, and scaffolding	IN	IN

	Category code and description	Requested	Analysis
49	Other non-powered equipment	OUT	OUT
GROUP 5	CHEMICALS AND CHEMICAL PRODUCTS		
51	Nominated chemicals	IN	OUT
52	Other basic chemicals	IN	OUT
53	Chemical products	IN	OUT
GROUP 6	MATERIALS AND SUBSTANCES		
61	Non-metallic minerals and substances	OUT	OUT
62	Other materials and objects	OUT	OUT
63	Other substances	OUT	OUT
GROUP 7	ENVIRONMENTAL AGENCIES		
71	Outdoor environment	IN	OUT
72	Indoor environment	IN	OUT
73/74	Underground environment	IN	OUT
GROUP 8	ANIMAL, HUMAN AND BIOLOGICAL AGENCIES		
81	Live four-legged animals	OUT	OUT
82	Other live animals	OUT	OUT
83	Non-living animals	OUT	OUT
84	Human agencies	OUT	OUT
85	Biological agencies	OUT	OUT
GROUP 9	OTHER AND UNSPECIFIED AGENCIES		
91	Non-physical agencies	OUT	OUT
99	Other and unspecified agencies	OUT	OUT

1. Breakdown agencies included and excluded from the requested data and the analysed data. Workers' compensation data. TOOCS 2.1 classification.

APPENDIX 5: ADDITIONAL RESULTS

Table A5.1: **Design-related involvement in fatal workplace incidents.** Australia (excluding Queensland), 1 July 2000 to 30 June 2002. Number and per cent.

	NUMBER			%		
	2000–2001	**2001–2002**	**Total**	**2000–2001**	**2001–2002**	**Total**
Original cases	3403	3064	6467			
In-range	3312	2841	6153	97.3	92.7	95.1
In-range from other data set	33	-33	0			
Total In-range	3345	2808	6153			
NCIS Work = work	235	224	459	7.0	8.0	7.5
NCIS Activity = work (excludes Work = work)	14	20	34	0.4	0.7	0.6
Total possible work-related cases	249	244	493	7.4	8.7	8.0
Not work	4	3	7			
Duplicate cases	0	2	2			
Total work-related cases	245	239	484	7.3	8.5	7.9
Medical misadventure	42	29	71	17.1	12.1	14.7
Total truly work-related cases	203	210	413	82.9	87.9	85.3
Motor vehicle incident	97	96	193	39.6	40.2	39.9
Plane crash	3	7	10	1.2	2.9	2.1
Total work-related cases excluded	100	103	203	49.3	49.0	49.2
Remaining work-related cases	103	107	210	50.7	51.0	50.8
Design-related						
Definite	16	18	34	15.5	16.8	16.2
Probable	19	24	43	18.4	22.4	20.5
Total definite or probable design-related	35	42	77	34.0	39.3	36.7
Possible	14	15	29	13.6	14.0	13.8
Total definite, probable	49	57	106	47.6	53.3	50.5

	NUMBER			%		
	2000–2001	**2001–2002**	**Total**	**2000–2001**	**2001–2002**	**Total**
or possible design-related						
Not known	22	21	43	21.4	19.6	20.5
Not design-related	32	29	61	31.1	27.1	29.0

APPENDIX 6: PROJECT REQUIREMENTS

The initial project plan had seven objectives. These were to undertake national data collection and analysis that will:

- provide an understanding of the contribution of design to workplace injuries and fatalities and the nature and extent of these in the period 1997–2002;
- provide a comparative analysis of fatalities to the 1989–1992 study (identifying emerging issues, changes to baseline etc);
- support the effective measurement, monitoring and evaluation of the safe design program on a national basis by providing a benchmark over the life of the National OHS Strategy 2002–2012;
- provide examples of poor design issues to inform a targeted national approach to intervention;
- determine/analyse the contribution of poor procurement practices on injuries/fatalities;
- compare Australian data by key industry/design product with international data to establish/understand issues and identify any better practice solutions; and
- inform data collection requirements for future design analysis/benchmarking.

GLOSSARY

ABS	Australian Bureau of Statistics
AIHW	Australian Institute of Health and Welfare
MUNCCI	Monash University National Centre for Coronial Information
NCIS	National Coroners Information System
NDS	National Data Set for Compensation-Based Statistics
NHMD	National Hospital Morbidity Database
NOHSC	National Occupational Health and Safety Commission
TOOCS	Type Of Occurrence Classification System
WRFS 2	Second work-related fatalities study, 1989-1992