Concrete slump

Project report

July 2009
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Introduction

This project was undertaken as an initial scoping exercise to examine a key aspect of concreting. The aim of the project was to gather information in relation to the commercial construction industry’s current use of a default concrete slump value of 80 mm during concreting activities and its impact on musculoskeletal injury risks.

The *slump test* is a method used to determine the consistency of concrete and to check its uniformity from batch to batch. The consistency, or stiffness, of the concrete shows the fluidity of the concrete indicating how much water has been used in the mix, and is often measured by concrete slump. The stiffness of the concrete mix is often matched to the requirements for the finished product. All concrete mixes are a combination of aggregate (gravel and/or sand), cement and water in varying proportions. The concrete mixture and the ratios of ingredients affect the workability of the end product and the concrete’s final strength (water/cement ratio).

In terms of workability only, the higher the slump value, the higher the amount of water and as a result the mixture is more fluid for working the concrete and finishing. The construction industry perceives that higher slump values require less muscular effort to manipulate. The usefulness of the *slump test* as a predictor of concrete strength is controversial (Popovics 1994); (Mitteleacher 1992) and the shrinkage has traditionally been perceived by the industry as affecting the integrity and quality of the concrete.

Australian Standard 0102.3.1-1998 *Methods of testing concrete* specify a process for the slump test. The slump cone is filled with fresh concrete in layers, tamping between each to remove voids. The concrete is levelled off with the top of the cone. On removing the cone, the slump is measured (photo sequence 1.). A number of companies undertake specialised slump testing.

**Photo 1 (sequence)**

| Slump cone | Tamping procedure | Removing cone | Height measurement |

There are a number of manual tasks associated with the workability of concrete which affect concreting activities. For the purpose of this project, three tasks were assessed, namely raking, screeding, and edging.
Background

In late 2007 the Concrete Industry Association Queensland (CIAQ) established an industry working party. Workplace Health and Safety Queensland (WHSQ) was also represented on this industry working party.

The purpose of the working party was to instigate an industry change from a default slump value of 80 mm to 100 mm for commercial flat work. This was driven by industry concerns regarding the musculoskeletal injury risks associated with lower slump values.

In July 2008 the Construction Industry Sector Standing Committee (ISSC) received a letter from the CIAQ seeking endorsement for pursuing this issue. The ISSC requested a WHSQ Principal Advisor Ergonomics to assess the musculoskeletal injury risks associated with an 80 mm slump value in the commercial construction setting.

Literature review

A review of the literature indicated that there were few studies which specifically addressed the musculoskeletal injury risks associated with various slump values.

One article of significant interest regarding slump values was found in the newsletter Lifeline from the Laborers’ Health and Safety Fund of North America (LHSFNA)\(^1\). It highlighted the increased body stressing risks with lower slump values and it also provided a link to a range of tipsheets\(^2\) specifically targeting concreting activities. These tipsheets were developed collaboratively using a grant from the National Institute for Occupational Safety and Health (NIOSH). In summary, the article discussed the need to target upstream obligation holders for example owners, architects, designers and builders to design for higher slump concrete.

By its very nature, construction work is ergonomically hazardous (Schneider and Susi, 1994). Many studies have identified that construction work involves numerous awkward and sustained working postures, repetitive forward and backward bending and twisting of the back, sudden unexpected muscle strains, heavy lifting and carrying, the operation of heavy machinery, power tools, cluttered work surfaces and temperature extremes (Schneider, 2001; Buchholz, 1996; Lipscomb, 1997; Spielholz, Wiker and Silverstein, 1998; Hasten, Lea and Johnstone, 1996; Lappalainen et al, 1998; and Heuer, 1996).

Schneider, et al (1998) showed in their review of over 13 000 job analyses undertaken by the United States Department of Labor that:

- construction work is more physically demanding than other occupations, in particular with regard to strength required to lift loads
- more than 30 per cent of construction occupations were rated as heavy or very heavy jobs, compared with only about 9 per cent of non-construction occupations.

Koningsveld and Van der Molen (1997) identified that the overall energetic workload of many construction workers was found to exceed the international accepted limit of 30 per cent of VO\(_{2}\)\(_{\text{max}}\). VO\(_{2}\)\(_{\text{max}}\) is a measure of maximum rate of oxygen uptake.

Concreters

Concreters are exposed to a range of musculoskeletal disorders due to the number of high physical demand manual tasks. Pouring and finishing concrete requires a great deal of strength in the lower back, legs, and upper body (Schneider and Susi, 1994). Smoothing the surface using the screeding...
tool, rake or straight edge trowel is a strenuous task and the worker must adopt awkward, bent postures when performing these tasks.

An internet search of relevant information including that published by occupational health and safety regulators and industry bodies was conducted. The construction industry worldwide has a vast number of publications, safety information, manuals, guides and standards. This information provides a varied list of possible countermeasures related to injury risk in the construction industry, both in regard to mechanism of injury and disease and by different trades and activities. There is, however, a paucity of information and guidance material targeting specific manual tasks and the use of higher order risk controls in the construction industry. The solutions offered are invariably general in nature and relate to work methods intended to cope with existing equipment and processes. Changes to the design, equipment and processes are rarely suggested.

**Review of Queensland workers compensation claims data**

The high risk of musculoskeletal injury in the construction industry is well recognised with musculoskeletal disorders (MSD) accounting for 55 per cent of non-fatal injury claims. The majority of MSD claims are due to muscular stress while lifting, carrying, putting down or handling objects.\(^3\) Occupations most commonly affected by MSDs are:

- construction assistants
- labourers and other workers providing manual labour
- carpenters
- general electricians
- plumbers
- painters and decorators.

Concreters are broadly captured under the classifications of *construction assistants* and *labourers and other workers providing manual labour*.

The existing data and literature highlight that construction workers are at significant risk of musculoskeletal injury, specifically related to the tasks they perform. The data does not allow scrutiny of specific tasks.

**Limitations of the assessment**

There were a number of assessment limitations which impacted on the project:

- Difficulties organising access to work sites during large pours.
- The default slump value has a ± 15 mm range.
- No control over the slump values of the pour on the day.
- Inability to isolate the manual task risk factors (direct stressors) i.e. force to move the concrete cannot be assessed without recognising the risks from the working postures and the duration.
- The assessment was conducted on site. It was not a controlled environment and therefore there was no ability to control other variables.
- Time with the workers for consultation was difficult due to their work demands.
- The location of the screeding activities occurring on site was hazardous for the assessor to make the measurements. Not only was access to the workers difficult, but the wet concrete was slippery and balance difficult.

\(^3\) QLD Workers compensation claims data 2003-04 and 2005-06

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Project activities

Consultation

Dr Burgess-Limerick’s (Associate Professor University of Queensland; Certified Professional Ergonomist (CPE) with the Human Factors and Ergonomics Society of Australia) advice on research design and methodology indicated that a research study on slump values would need significant resources in terms of time and money. He highlighted the difficulty in applying the laboratory findings to actual concreting activities. For example, using a force gauge in the laboratory to measure the force required to work wet concrete at varying slump values did not take into consideration other risk factors such as posture and the impact on the body when performing concreting tasks.

Industry representatives and the WHSQ construction inspectors reported that based on their experience:
- lower slump values increased the physical demands of the tasks associated with concreting
- lower slump values made the operation of the concrete pump more difficult
- lower slump values compromised the quality of the finish when mechanical aids are used
- higher slump values could be specified during the design phase, as the specifications will depend on a number of variables in the design of the structure and the material used.

It was also highlighted that since architects and engineers are not routinely on site during the construction phase, there may be little awareness of the issues or opportunity for these stakeholders to address the manual tasks related implications of the specifications, particularly once the construction has commenced.

A Queensland Department of Main Roads representative indicated that they had identified the need for workers to work with higher slump values. He reported that this department had already moved to using concrete with a 100 mm slump value.

Ergonomics assessment

Preliminary site visits to both large and small construction sites were undertaken by WHSQ to gain an understanding of the normal range of concreting activities and environments. Subsequently, two commercial construction site visits were undertaken on 17 December 2008 and 2 February 2009 for the purpose of undertaking an ergonomic assessment of commercial concreting manual tasks (Appendix 1.1).
Three tasks were assessed: raking, screeding, and edging.

Photo 2  The tasks of raking (worker on left) and screeding (worker on the right) aim to spread, level and smooth the concrete.

Photo 3  Edging (worker on the left) is a finishing task and is done to further compact the surface concrete and achieve a smooth finish.

Ergonomic assessment tools
Risk factor model
The risk factor model used was the model outlined in the Queensland Government *Manual Tasks Code of Practice 2000*. The direct stressors which impact on the body and have the potential to cause injury are:

- forceful exertions
- working postures (awkward and static)
- repetition and duration
- vibration.
Task analysis
A task analysis was done for each of the three tasks (Appendix 1.2). This analysis highlighted the presence of the direct stressors working postures and duration in addition to forceful exertions. These direct stressors impact on the level of musculoskeletal injury risk associated with the concreting tasks assessed.

Manual Tasks Risk Assessment tool (ManTRA)
The Manual Tasks Risk Assessment tool (ManTRA) was chosen as it was originally developed to assess manual task compliance with the Queensland Government Manual Tasks Code of Practice 2000. This assessment involved video taping the selected manual tasks and analysing them using the ManTRA tool4 (Appendix 2).

Risk factors were identified for the three tasks. Numerical ratings were allocated to obtain risk scores for exertion, awkwardness and a final cumulative risk score, which included repetition, duration and vibration risk factors. Tasks were considered to be high risk for any body region if the exertion risk factor score was 5 or greater, the sum of exertion and awkwardness is 8 or greater or the cumulative risk score was 15 or greater.

Findings
The information obtained on 17 December 2008 was used for the assessment as it was deemed to be representative of the work. The slump value at the time of the assessment (averaged over 19 samples between 6:30 am and 11:00 am) was 93.16 mm. This value supported the workers’ estimation of the slump value being at the high end of the permissible range on the day of the assessment and that it was an easier day for that reason.

Table 1: Summary ManTRA scores for raking, screeding and edging

<table>
<thead>
<tr>
<th>Task</th>
<th>Body part</th>
<th>Exertion</th>
<th>Sum of exertion and awkwardness</th>
<th>Cumulative risk</th>
</tr>
</thead>
<tbody>
<tr>
<td>Raking</td>
<td>Back</td>
<td>5</td>
<td>8</td>
<td>17</td>
</tr>
<tr>
<td></td>
<td>Neck/shoulder</td>
<td>5</td>
<td>8</td>
<td>17</td>
</tr>
<tr>
<td></td>
<td>Arm/wrist/hand</td>
<td>5</td>
<td>8</td>
<td>17</td>
</tr>
<tr>
<td></td>
<td>Lower limbs</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Back</td>
<td>4</td>
<td>8</td>
<td>16</td>
</tr>
<tr>
<td></td>
<td>Neck/shoulder</td>
<td>5</td>
<td>9</td>
<td>18</td>
</tr>
<tr>
<td></td>
<td>Arm/wrist/hand</td>
<td>5</td>
<td>9</td>
<td>18</td>
</tr>
<tr>
<td></td>
<td>Lower limbs</td>
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<td></td>
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<tr>
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<td>Back</td>
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<td>9</td>
<td>17</td>
</tr>
<tr>
<td></td>
<td>Neck/shoulder</td>
<td>5</td>
<td>10</td>
<td>19</td>
</tr>
<tr>
<td></td>
<td>Arm/wrist/hand</td>
<td>5</td>
<td>10</td>
<td>19</td>
</tr>
</tbody>
</table>

Each of the selected tasks had exertion scores of 5 for at least two body parts, sum of exertion and awkwardness scores 8 or greater for at least two body parts and cumulative risk scores of 15 or greater for at least three body parts. Each of the three tasks had cumulative risk scores of 15 or greater for at least three body parts. The body parts that were found to have higher risk were the back, knees, shoulders/neck and wrists/forearms. This is consistent with the WorkCover data for the

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4 ManTRA V2.0, Burgess-Limerick et al 2004

Workplace Health and Safety Queensland, Department of Justice and Attorney-General
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general construction industry. These scores for each relevant body part are summarised in Table 1 above.

These scores indicate that remedial action is required for all three tasks. The exertion and combined exertion and awkwardness scores indicate that both the risk factors of forceful exertion and working postures must be targeted when developing suitable controls.

Administrative controls such as reducing the time that workers are performing the tasks would reduce their exposure to the task (and marginally reduce the cumulative risk scores), but it would not affect the exertion or sum of exertion and awkwardness scores.

With each of the three tasks assessed, workers are required to exert force in awkward and sustained working postures. ManTRA highlighted the significance not only of forceful exertions but also the other direct stressors, namely working postures and duration. It is these combined risk factors which impact on the level of risk of musculoskeletal injury associated with the concreting tasks assessed.

**Discussion**

The information gathered as part of this project supports the suggestion that lower slump values contribute to the force requirements of concreting tasks.

The other direct risk factors associated with concreting tasks include working postures and duration. Although the tasks did not meet the WHSQ Manual Tasks Code of Practice 2000 definition of repetition, the tasks were performed throughout the day at a high frequency rate. These direct risk factors are due to a number of contributing and modifying risk factors which include work area design:

- engineering specifications
- the design of the structure
- the size of the pour
- the location of pour
- the work area (mesh, wet concrete, protruding steel and other materials)
- concrete additives for example water reducing admixtures
- environmental conditions for example heat and wind
- tool use for example rakes, screeds and trowels
- mechanical aids available/being used
- organisational factors for example, the number of staff; pace of work, hours of work; rest breaks, training, and
- individual worker factors for example skills and experience.

**Design**

The engineering specifications and design of the structure have a significant influence on the manual task risk factors. As such, the manual task implications should be considered during the design and planning phases.

Current design-induced hazards relevant to concreting activities require alternative/innovative design based solutions.

**Workplace Health and Safety Act 1995**

The *Workplace Health and Safety Act 1995* places obligations on designers of structures. A safe design approach begins in the conceptual and planning stages with an emphasis on making choices about design, materials used and methods of manufacture or construction to enhance the finished structure. A designer needs to consider how safety can be best achieved in each of the lifecycle stages.
Manual Tasks Code of Practice 2000

The Manual Tasks Advisory Standard 2000 (MTCOP) states that ergonomic principles need to be considered in design and outlines a number of risk factors that should be considered when managing the risk of musculoskeletal injury. Design controls which either eliminate or minimise the risk are preferred.

Possible design controls include:

- redesigning the structural specifications to reduce/eliminate the use of concrete slabs in their current form (e.g. precast)
- using additional plasticiser (Schneider and Susi, 1994) to make the concrete flow more easily:
- using of self levelling concrete
- using higher slump values similarly to make the concrete flow more easily
- introducing a coating material over the concrete which provides the smooth level finish required
- designing the work area to reduce the need for workers to walk and work on steel mesh and in wet concrete
- designing the work area to allow mechanical aids to be used and moved safely during the concreting activities
- designing the structure in such a way that the size of the pour is reduced
- using higher slump values to allow for increased use of mechanical aids, and
- redesigning the hand tools used such as rakes, bull floats and edging trowels for improved ease of grip and working postures, particularly the wrist, knees, hips and spine.

Mechanical aids

The use of mechanical aids impact adversely on the quality of the concrete finish with lower slump values. This means there is a reliance on workers to manually provide a quality finish. The use of mechanical aids (which also assist workers in addressing the other direct risk factors) are preferred for higher slump value applications where the quality of the finish is not essential to the job.

There are a range of solutions which include increased mechanisation of the tasks. Mechanical aids available include:

- vibrating needle
- power rake
- motorised screed
- roller screed
- walk behind laser screed
- helicopter.

Administrative controls

Administrative controls mainly reduce the time that workers are exposed to the risk and are not as effective as design controls. They include:

- work organisation, for example, job rotation, structured rest breaks, reduced working hours or increased staffing
- task specific training
- policies and procedures
- preventative maintenance programs
- personal protective equipment.
Summary

- The literature indicates that concreting is a high risk task in relation to musculoskeletal disorders.
- Anecdotal information provided by workers and management in the concreting industry, WHSQ construction inspectors and industry representatives indicates that lower slump values (80 mm) contribute to the force required when performing the concreting tasks.
- Observation and assessment of concreting tasks identified that workers are exposed to the manual task direct stressors of forceful exertions, awkward and static working postures and long durations. The contributing and modifying risk factors are work area design, hand tools, nature of the load, load handling, work organisation and individual factors.
- The exertion and awkwardness score obtained via ManTRA indicated that the combined risk factors required remedial action.
- There are a significant number and range of controls available. However, the ability to use mechanical aids is impacted on by the work area design, for example, accessibility, floor surface, manoeuvrability on site and the finishing requirements. Therefore administrative controls remain the predominant type of controls used by the industry.

The activities discussed in this report represent a scoping exercise for the purpose of providing information and recommendations targeting the musculoskeletal injury risks associated with the commercial construction industry’s current use of a default slump value of 80 mm. A structured research study could investigate this issue in more depth however; this was not within the scope of this project.

Conclusion

Concreting involves many high risk manual tasks with a range of risk factors that are predominantly impacted on by design issues. Due to the number of variables, this assessment was unable to obtain an accurate quantitative measurement of body stress related specifically to slump values. However, based on the literature and anecdotal evidence, it would appear that higher slump values require less muscular effort. To effectively target a reduction in musculoskeletal injury risk associated with concreting tasks, it is essential that all the manual task risk factors are identified and targeted during the construction project’s planning and design stages.

The construction industry recognises that there are MSD risks associated with concreting tasks. Their approach to WHSQ for assistance is one way that the industry has attempted to deal with the problem. This report may assist the industry in recognising that although forceful exertions is an identified risk factor during concreting activities, unless the design issues impacting on working postures is also addressed, the risk of MSDs will not be significantly reduced.

Recommendations

It is recommended that:
1. An industry working party be established to develop solutions for key design issues related to concreting. The working party should:
   (a) Consist of the wide range of stakeholders involved in concreting including designers, engineers, manufacturers and suppliers, unions and industry representatives and WHSQ.
   (b) Consider slump values in conjunction with the other risk factors identified when exploring concreting related solutions.
   (c) Share the solutions developed with all industry stakeholders.
   (d) Monitor outcomes of the initiative of the Department of Main Roads.
   (e) Discuss with the designers and developers of commercial constructions:
i) the issues relating to slump and other construction related design issues; and
ii) their obligations under the *Workplace Health and Safety Act 1995* - (Obligations of manufacturers and designers – Attachment 4).

2. Industry considers promoting an increase in the commercial default slump value from 80 mm to a default slump value of 100 mm for commercial flat work.

3. The construction industry be provided with information and solutions which may be applied in the current commercial environment through the WHSQ Manual Tasks Solutions in Construction Project.
References


Mitelecher, M. Re-Evaluating the slump test. Volume 14; Issue 10; Pages 53-56. 1992


Appendix
Appendix 1.1

1.11 Task description
The concrete pour was on a commercial construction site on the fourth floor. Workers access the area via stairs.

The site assessed was having a pour of 1168 squares (315 cubes) of concrete, with the pour expected to take all day. There were 13 men in the team on this day. The team consisted of a supervisor, leading hand, concrete pump operator and 10 workers performing a range of concreting tasks. The workers were on site at 6:00 am and the pour commenced at 6:30 am. The five finishers completed the job at 5:20 pm. This was reported as a typical pour day.

Workers were observed performing a range of concreting tasks. After the pour, the main tasks associated with concreting included:
- compacting using a vibrating needle
- levelling concrete by raking and screeding
- finishing the surface initially by raking and screeding and finally by screeding, bull floating and edging.

Workers used a range of hand tools including:
- mechanical vibrating needle
- long handled rake
- 8 foot screeding tool
- 4 foot screeding tool
- bull float
- hand trowel.

Mechanical aids included the use of a helicopter screeding machine.

1.12 Risk assessment
Risk assessment included the following activities and tools:
- observation of work tasks
- worker consultation
- task analysis
- Manual Tasks Risk Assessment tool (ManTRA)
- force gauge
- stop watch
- tape measure
- digital video camera
- digital camera.
1.13 Task analysis
Concrete is a mixture of paste and aggregate (sand and rock). The paste consists of cement and water. The concrete mixture and the ratios are critical to the workability, integrity and quality of the end product. The slump of concrete is a rough measure of the amount of water in the concrete mix.

There are a number of tasks associated with concreting activities. Three tasks were observed for inclusion in this report. These tasks are raking, screeding and edging. The tasks of raking and screeding aim to level the concrete and the edging is done to achieve a smooth finish on the concrete. Specifically:

1. Raking
   Raking is a part of the levelling process. The task of raking involves using a long handled implement to rake the concrete and smooth it out. The workers are spreading out the concrete and pushing it in to place using the rake while the worker stands in 15–20 cm wet concrete.

2. Screeding
   Screeding levels and compacts thin concrete slabs and the top layers of thicker slabs. This task involves pulling a screeding tool over the concrete a zigzag pattern in order to even out and fill in the surface while the worker stands in 15–20 cm wet concrete.

3. Edging.
   Edging is one of the finishing tasks and gives a smooth and stronger edge. This task is done with the use of a hand tool (trowel) and is done one handed.

1.14 Workers’ report
The six workers performing the concreting tasks were approached and asked if the slump value made a difference to the effort required to do their job. All six confirmed that a slump value of 80 mm is much harder to work with, requiring increased physical effort. The low back was identified as being the area of most significant discomfort with the knees and shoulders also being affected.

The workers reported that when edging with the hand tool the effort is required in the wrist and forearm and that the task is performed one handed. They also reported that the finishing tasks may be more strenuous, as the concrete is much drier and harder to work relative to the initial pour. Three of the workers also suggested that this day was a relatively easy day and that it was unlikely that the slump value was the prescribed value of 80 mm. This was later confirmed by the slump report, which reflected values 90 mm and 95 mm over the course of the day.
### Appendix 1.2

**Task Analysis – Risk Assessment**

**Task:** Raking  
**Assessor:** Deidre Rutherford  
**Date:** 17/12/08.

| Elements | Working posture | Forceful exertions | Repetition and duration | Vibration |  |
|----------|----------------|-------------------|------------------------|-----------|-
| 1. Raking | Asymmetric posture with moderate and full bending and moderate twisting and lateral movements of the spine; forward reaching of shoulders; sustained periods of neck extension; sustained grip and moderately awkward wrist positions. | Moderate force required through shoulders and back and more force at wrists and forearms. | The cycle time is less than 10 seconds. It is not performed continuously for one hour. It is performed frequently for most of the day for durations of 8-10 hours with irregular, brief breaks for fluids, food and toilet breaks. Longer breaks may occur during interruptions to the pour. This time then needs to be made up with a faster work rate. The size of the pour was 1168 squares. This impacts on the duration of the pour. | Nil |  |

### Step 1

#### Task

**Direct stressors**  
(A direct stressor must exist for any risk of injury related to manual tasks to exist.)

### Step 2

#### Direct stressors

The worker is required to rake the concrete at ground level which requires forward bending, twisting and reaching whilst standing in freshly poured concrete up to 20 mm thick which is on steel mesh. This results in poor foot stance. There are a number of service pipes protruding through the base, obstructing the raking action.

#### Contributing and modifying risk factors

(Cause the direct stressors and should be controlled.)

<table>
<thead>
<tr>
<th>Work area design</th>
<th>Tools</th>
<th>Loads</th>
<th>Load handling</th>
<th>Organisationa l factors</th>
<th>Individual factors</th>
</tr>
</thead>
<tbody>
<tr>
<td>The work area is required to rake the concrete at ground level which requires forward bending, twisting and reaching whilst standing in freshly poured concrete up to 20 mm thick which is on steel mesh. This results in poor foot stance. There are a number of service pipes protruding through the base, obstructing the raking action.</td>
<td>The rake handle requires a forceful gripping action with one hand guiding the direction of the pull.</td>
<td>The concrete was identified as having a slump range between 90 mm and 95 mm during this pour. This indicates that the concrete was wetter than on this day. The concrete drying rate on this day was moderate as the temp was 29 degrees with a mild breeze. This allows for a 3-4 hour set time.</td>
<td>The worker levels the concrete using the rake with fast, jerky motions and must work quickly behind the person screening. The size of the pour was 1168 squares. This impacts on the duration of the pour.</td>
<td>The pace of work is dictated by the volume of the pour and setting time of the concrete on the day. These environmental variables cannot be controlled. There is minimal task variation. Breaks are irregular and reliant on variations and interruptions to the pour. Forceful exertions and awkward and static postures are exacerbated during high pour volume periods and environment extremes.</td>
<td></td>
</tr>
</tbody>
</table>
### Step 1
**Task:** Screeding

- **Direct stressors**
  - **(A direct stressor must exist for any risk of injury related to manual tasks to exist.)**

<table>
<thead>
<tr>
<th>Elements</th>
<th>Working posture</th>
<th>Forceful exertions</th>
<th>Repetition and duration</th>
<th>Vibration</th>
</tr>
</thead>
<tbody>
<tr>
<td>2. Screeding Leveling and smoothing the concrete using a predominant pulling action with some pushing, zigzagging and chopping motions.</td>
<td>Full bending of the spine; deep squat position with forward and sideways reaching of shoulders; sustained periods of neck extension; sustained grip and moderately awkward wrist positions.</td>
<td>Significant force required through back and shoulders; moderate force through wrists and forearms; moderate force through legs and buttocks.</td>
<td>The cycle time is less than 10 seconds. It is not performed continuously for one hour. It is performed frequently for most of the day for durations of 8-10 hours with irregular, brief breaks for fluids, food and toilet breaks. Longer breaks may occur during interruptions to the pour. This time needs to be made up with a faster work rate.</td>
<td>Nil</td>
</tr>
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</table>

### Step 2

<table>
<thead>
<tr>
<th>Elements</th>
<th>Working posture</th>
<th>Forceful exertions</th>
<th>Repetition and duration</th>
<th>Vibration</th>
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<tbody>
<tr>
<td>2. Screeding Leveling and smoothing the concrete using a predominant pulling action with some pushing, zigzagging and chopping motions.</td>
<td>Full bending of the spine; deep squat position with forward and sideways reaching of shoulders; sustained periods of neck extension; sustained grip and moderately awkward wrist positions.</td>
<td>Significant force required through back and shoulders; moderate force through wrists and forearms; moderate force through legs and buttocks.</td>
<td>The cycle time is less than 10 seconds. It is not performed continuously for one hour. It is performed frequently for most of the day for durations of 8-10 hours with irregular, brief breaks for fluids, food and toilet breaks. Longer breaks may occur during interruptions to the pour. This time needs to be made up with a faster work rate.</td>
<td>Nil</td>
</tr>
</tbody>
</table>

### Step 3
**Contributing and modifying risk factors**

- **(Cause the direct stressors and should be controlled.)**

<table>
<thead>
<tr>
<th>Elements</th>
<th>Work area design</th>
<th>Tools</th>
<th>Loads</th>
<th>Load handling</th>
<th>Organisationa l factors</th>
<th>Individual factors</th>
</tr>
</thead>
<tbody>
<tr>
<td>2. Screeding Leveling and smoothing the concrete using a predominant pulling action with some pushing, zigzagging and chopping motions.</td>
<td>The worker is required to screed the concrete at ground level which requires forward bending, deep squatting and reaching whilst standing in freshly poured concrete up to 20 mm thick which is on steel mesh. This results in poor foot stance. There are a number of service pipes protruding through the base, obstructing the worker and making the screeding task more difficult.</td>
<td>There are two screeding implements; 4’ and 8’ with the 8’ tool requiring more force to use. The handle requires a forceful bilateral gripping action.</td>
<td>The concrete was identified as having a slump range between 90 mm and 95 mm during this pour. This indicates that the concrete was wetter and easier to work with on this day. The concrete drying rate on this day was moderate as the temp was 29 degrees with a mild breeze. This allows for a 3-4 hour set time.</td>
<td>The worker levels and smooths the concrete using the screed with fast, jerky motions and must work quickly in front of the person raking. The size of the pour was 1168 squares and this impacts on the duration of the pour.</td>
<td>The pace of work is dictated by the volume of the pour and setting time of the concrete on the day. The environmental variables cannot be controlled. There is minimal task variation. Breaks are irregular and occur as trucks empty and are reliant on variations and interruptions to the pour. Forceful exertions and awkward and static postures are exacerbated during high volume pour periods.</td>
<td></td>
</tr>
</tbody>
</table>
**Task: Edging (finishing screeding)  Assessor: Deidre Rutherford  Date: 17/12/08.**

<table>
<thead>
<tr>
<th>Elements</th>
<th>Task</th>
<th>Direct stressors</th>
<th>Contributing and modifying risk factors</th>
</tr>
</thead>
<tbody>
<tr>
<td>3. Edging (finishing screeding). This task involves smoothing and compacting the edges with a hand trowel. This is one of the final stage tasks and is done to further compact the surface of the concrete around the edges (for strength) and to give the concrete the smooth finish required.</td>
<td><strong>Step 1</strong></td>
<td><strong>Step 2</strong></td>
<td><strong>Step 3</strong></td>
</tr>
<tr>
<td><strong>Step 1</strong></td>
<td><strong>Step 2</strong></td>
<td><strong>Step 3</strong></td>
<td><strong>Contributing and modifying risk factors</strong></td>
</tr>
<tr>
<td><strong>Task</strong></td>
<td><strong>Direct stressors</strong></td>
<td><strong>(A direct stressor must exist for any risk of injury related to manual tasks to exist.)</strong></td>
<td><strong>(Cause the direct stressors and should be controlled.)</strong></td>
</tr>
<tr>
<td><strong>Elements</strong></td>
<td><strong>Working posture</strong></td>
<td><strong>Forceful exertions</strong></td>
<td><strong>Repetition and duration</strong></td>
</tr>
<tr>
<td></td>
<td>Asymmetric posture with full bending of the spine; semi squat with wide apart foot placement; hips in abducted and moderately flexed position with full forward and sideways reaching of shoulders; sustained periods of neck extension; sustained grip and moderately awkward wrist positions. Feet in a range of awkward postures.</td>
<td>Significant force required through wrist and forearm; moderate force through the back and shoulders; moderate force through legs and buttocks during the motion of moving the trowel over the concrete.</td>
<td>The cycle time is less than 10 seconds. It is not performed continuously for one hour. It is performed frequently for most of the day for durations of 6-8 hours with irregular, brief breaks for fluids, food and toilet breaks. Longer breaks may occur during interruptions to the pour. This time then needs to be made up with a faster work rate. The size of the pour was 1168 squares and this impacts on the duration of the pour.</td>
</tr>
</tbody>
</table>
Appendix 2

ManTRA scores

ManTRA scores for tasks of raking, screeding and edging assessed 17 December 2008.

Exertion scores
Workers reported that the muscular effort required during these tasks was greater when the concrete has a lower slump value.
Raking had exertion scores of 5 for the back, neck/shoulder and wrist/hand.
Screeding had exertion scores of 5 for the neck/shoulder and wrist/hand.
Edging had exertion scores of 5 for the back, neck/shoulder and wrist/hand.

The sum of exertion and awkwardness scores
Raking had the sum of exertion and awkwardness scores of 8 for the back, neck/shoulder and wrist/hand.
Screeding had the sum of exertion and awkwardness scores of 8 or greater for all 4 body parts i.e. the lower limbs, back, neck/shoulder and wrist/hand.
Edging had the sum of exertion and awkwardness scores of 8 for the back, neck/shoulder and wrist/hand.

Cumulative risk scores
Raking had a cumulative risk score of 17 the back, neck/shoulder and wrist/hand.
Screeding had a cumulative risk score of 16 or greater for all 4 body parts i.e. the lower limbs, back, neck/shoulder and wrist/hand.
Edging had a cumulative risk score of 17 or greater for the back, neck/shoulder and wrist/hand.
### Manual Tasks Risk Assessment tool (ManTRA) V 2.0 Scoring Matrix

**Task: Raking**  
**Date: 17.12.08.**

<table>
<thead>
<tr>
<th>Body Region</th>
<th>Total time</th>
<th>Duration</th>
<th>Cycle time</th>
<th>Repetition Risk</th>
<th>Force</th>
<th>Speed</th>
<th>Exertion Risk</th>
<th>Awkwardness</th>
<th>Vibration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lower Limbs</td>
<td>5</td>
<td>1</td>
<td>5</td>
<td>3</td>
<td>2</td>
<td>2</td>
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<td></td>
<td></td>
<td></td>
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<td></td>
<td>1</td>
<td>17</td>
</tr>
<tr>
<td>Neck/Shoulder</td>
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<td>5</td>
<td>3</td>
<td>4</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td>1</td>
<td>17</td>
</tr>
<tr>
<td>Arm/Wrist/Hand</td>
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<td>1</td>
<td>5</td>
<td>3</td>
<td>4</td>
<td>5</td>
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<td>3</td>
<td>(8)</td>
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Cumulative risk is the sum of unshaded cells.

Action may be indicated if, for any reason, the exertion risk factor is 5, the sum of exertion and awkwardness is 8 or greater, or the cumulative risk is 15 or greater.
Manual Tasks Risk Assessment tool (ManTRA) V 2.0 Scoring Matrix

Task: Screeeding  
Date: 17.12.08.

<table>
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<tr>
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<th>Cycle time</th>
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<th>Force</th>
<th>Speed</th>
<th>Exertion Risk</th>
<th>Awkwardness</th>
<th>Vibration</th>
<th>Cumulative risk</th>
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<tbody>
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<td>4</td>
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<td>3</td>
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<td>4</td>
<td>5</td>
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</tr>
<tr>
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<tr>
<td>Arm/Wrist/Hand</td>
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</table>

Cumulative risk is the sum of unshaded cells.

Action may be indicated if, for any reason, the exertion risk factor is 5, the sum of exertion and awkwardness is 8 or greater, or the cumulative risk is 15 or greater.
## Manual Tasks Risk Assessment tool (ManTRA) V 2.0 Scoring Matrix

**Task:** Edging  
**Date:** 17.12.08.

<table>
<thead>
<tr>
<th>Body Region</th>
<th>Total time</th>
<th>Duration</th>
<th>Cycle time</th>
<th>Repetition Risk</th>
<th>Force</th>
<th>Speed</th>
<th>Exertion Risk</th>
<th>Awkwardness</th>
<th>Vibration</th>
<th>Cumulative risk</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lower Limbs</td>
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</tr>
<tr>
<td>Neck/Shoulder</td>
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<td>4</td>
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<td>19</td>
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<tr>
<td>Arm/Wrist/Hand</td>
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</tbody>
</table>

Cumulative risk is the sum of unshaded cells.

Action may be indicated if, for any reason, the exertion risk factor is 5, the sum of exertion and awkwardness is 8 or greater, or the cumulative risk is 15 or greater.
### Codes

#### Total time

<table>
<thead>
<tr>
<th></th>
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<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0-2 hours/day</td>
<td>2-4 hours/day</td>
<td>4-6 hours/day</td>
<td>6-8 hours/day</td>
<td>&gt; 8 hours/day</td>
</tr>
</tbody>
</table>

#### Duration of continuous performance

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>&lt; 10 minutes</td>
<td>10 min - 30 min</td>
<td>30 min - 1 hr</td>
<td>1 hr - 2 hr</td>
<td>&gt; 2 hr</td>
</tr>
</tbody>
</table>

#### Cycle time

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>&gt; 5 minutes</td>
<td>1 – 5 minute</td>
<td>30 s - 1 min</td>
<td>10 s - 30 s</td>
<td>&lt; 10 s</td>
</tr>
</tbody>
</table>

#### Force

<table>
<thead>
<tr>
<th></th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Minimal force</td>
<td>Moderate force</td>
<td></td>
<td>Maximal force</td>
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</table>

#### Speed

<table>
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<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Slow movements</td>
<td>Moderately paced</td>
<td>Little or no movement – static posture</td>
<td>Fast and smooth movements</td>
<td>Fast, jerky movements</td>
</tr>
</tbody>
</table>

#### Awkwardness - Vibration (whole body or peripheral)

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>None</td>
<td>Minimal</td>
<td>Moderate</td>
<td>Large amplitude</td>
<td>Severe amplitude</td>
</tr>
</tbody>
</table>
## Scoring keys for repetition

<table>
<thead>
<tr>
<th>Cycle Time</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
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</tbody>
</table>

## Scoring key for exertion

<table>
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<tr>
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<td>4</td>
<td>5</td>
<td>5</td>
<td>5</td>
</tr>
</tbody>
</table>

Action may be indicated if, for any reason, the exertion risk factor is 5, the sum of exertion and awkwardness is 8 or greater, or the cumulative risk is 15 or greater.