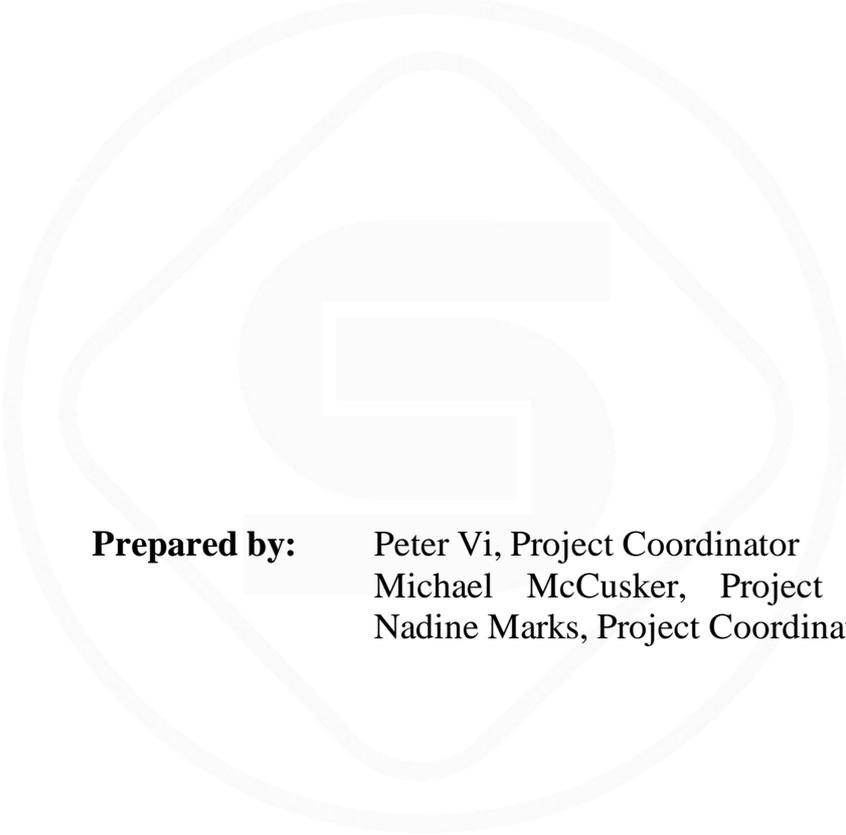


EVALUATION OF MASONRY TROWEL SIZES ON RISK OF HAND INJURIES



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1.0 INTRODUCTION

Lost-time injury (LTI) analyses from the Workplace Safety and Insurance Board (WSIB) database (1994 to 1998) reveal that bricklayers suffer 1.7 times more musculoskeletal injuries to the arms and hands than do other construction trades persons. The total cost of LTI (sum of direct compensation cost and medical aid) suffered by bricklayers is also high. The average cost of each LTI to the arms and hands of bricklayers was found to be over \$14,700, as compared to an overall construction average of \$9,400.

A literature review conducted by Schneider & Susi (1994) found that ergonomic risk factors related to bricklayers are awkward posture, heavy weight, and hand tools. Among the variety of hand tools used by bricklayers, the masonry trowel is the most common. Most masonry trowels have a similar triangular blade shape. The trowel size can range from 10" to 13" long. According to one trowel manufacturing company, the top four most popular trowel sizes are 11", 12", 11.5", and 13" (Marshalltown Trowel Company, www.marshalltown.com, May 2000).

The purpose of this project was to evaluate the relationship between trowel length and biomechanical stresses on the wrist joint. An evaluation of the relationship between trowel size and mortar spreading time was also conducted.

2.0 METHOD

2.1 Participants

Five mason apprentices and one mason-journeyman participated in this experiment. The participants' average height and weight were 1.78 m and 82.7 kg, respectively.

2.2 Experimental Task

Three trowel sizes, 10", 11", and 12", were used in this experiment. For each trowel size, participants were asked to perform a mortar spreading task without actually laying blocks or bricks. Mortar spreading tasks were chosen because they involve lifting and spreading large quantities of mortar, action which can place large biomechanical stresses on the distal upper extremity.

Previous time and motion studies conducted by CSAO found that spreading mortar to current brick course involves 15% of bricklaying tasks (Vi & Marks, 1999). Mortar spreading tasks involve three major actions: 1) scoop mortar from the workbench using a trowel, 2) transfer the mortar to the current course, and 3) spread mortar across the top surface of the blocks or bricks until there is no mortar on the trowel. Table 1 contains a summary of the length and height of the blocks and bricks used in this experiment.

Table 1: Lifting ranges for each course height.

Material	Course Height (m)	Course Length (m)
Block	1.2	3.2
Brick	0.59	3.18

2.3 Dependent Variables

Three dependent variables were measured in this study: peak moment at the wrist joint, duration of experimental task, and cumulative moment at the wrist joint. Separate statistical analyses were performed for the block and brick conditions.

Link-segment models were used to calculate the moment at the wrist joint. Peak moment at the wrist joint was calculated at the instant when the participants scooped the mortar with the trowel. Cumulative moment was calculated by multiplying the peak moment with the duration of the experimental task. We identified peak moment and cumulative moment as dependent variables because previous studies have consistently found these variables to be highly correlated with the risk of musculoskeletal disorders (Arras et al, 1991; Marras et al, 1993; Norman et al., 1998).

2.4 Experimental Procedure

On each experimental trial, participants were asked to perform a simulated mortar spreading task using a 10", 11", or 12" trowel. After each experimental trial, the participants were allowed to have a 10-minute rest period before starting another experimental trial.

While the participants were performing the experimental task, a videotape of the participants' working postures was recorded. After videotaping all participants, the videotapes were used to quantify the working posture. The combined weight of the trowel and mortar, and the working postures were used for the biomechanical analyses. All biomechanical analyses were assessed at the beginning of the lifting tasks (i.e. scooping mortar from workbench).

The weight difference of the mortar board before and after the experimental task was measured in this experiment. The number of full-trowels was also quantified. The weight difference of the mortarboard and the number of full-trowels were used to calculate the average weight of each full-trowel's mortar material used by the bricklayers.

3.0 RESULTS AND DISCUSSION

3.1 Bricks

Figure 1 contains summaries of time required to spread mortar across a brick course of 3.18 m. In this experiment, trowel size was not a significant [$F(2,18)=0.589$, $p=0.567$] factor affecting mortar spreading time. This result would indicate that regardless of the trowel size used to spread mortar across the brick, the time required to perform the task will be approximately equal to each other.

The results of the peak and cumulative moment at the wrist joint are shown on Figure 2 and 3. Statistical analyses using one-way ANOVA indicates that both dependent variables are significantly ($p<0.05$) affected by trowel size. A post-hoc test using Tukey's method indicated that peak moment at the wrist joint is significantly ($p<0.05$) lower when the 10" trowel is used to spread mortar across the brick. There were also significant peak moment differences between 11" and 12" trowels (see Figure 2).

For the cumulative moment, as measured by multiplying peak moment with trial duration, post-hoc test indicated that values for the 10" trowel are significantly ($p=0.017$) lower than for the 12" trowel. Tukey's test found no significant ($p>0.05$) differences between the 10" and 11" trowels or between the 11" and 12" trowels (see Figure 3).

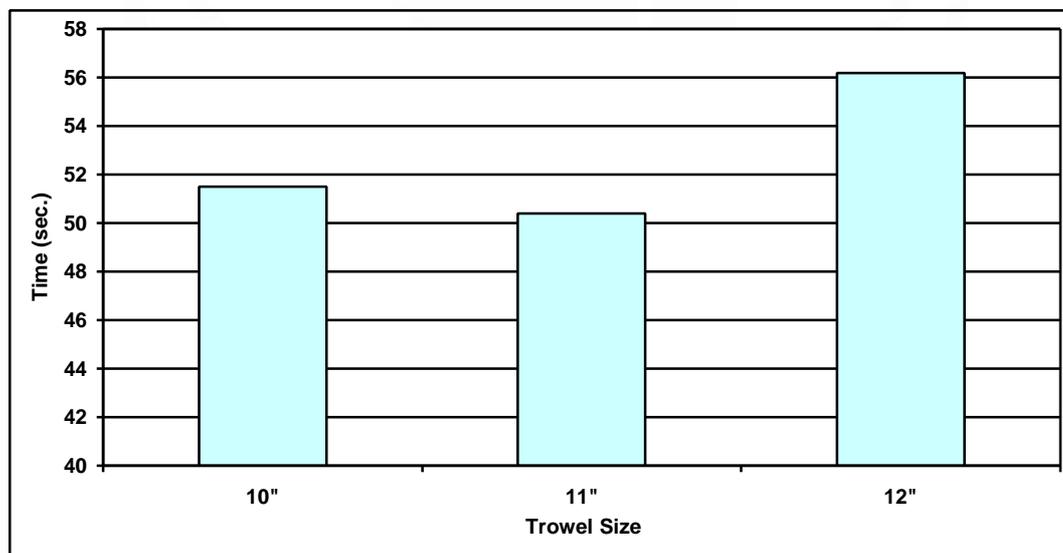


Figure 1: Mean time required to spread mortar across a brick length of 3.18 m. Time differences between each trowel size are not significant [$F(2,18)=0.589$, $p=0.567$].

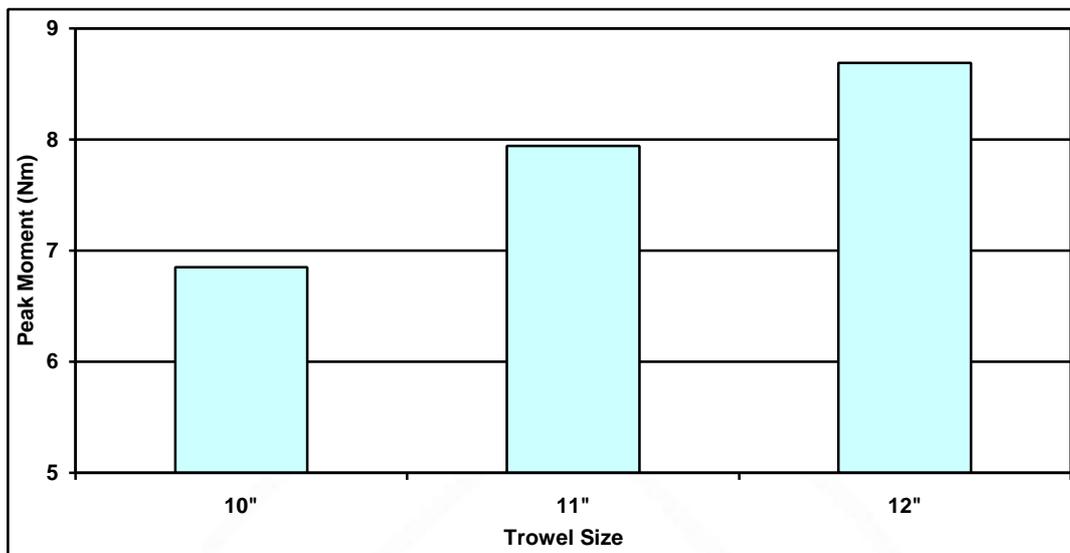


Figure 2: Calculated peak moment at the wrist joint. Trowel size is a significant [$F(2,18)=412$, $p=0.000$] factor affecting peak moment.

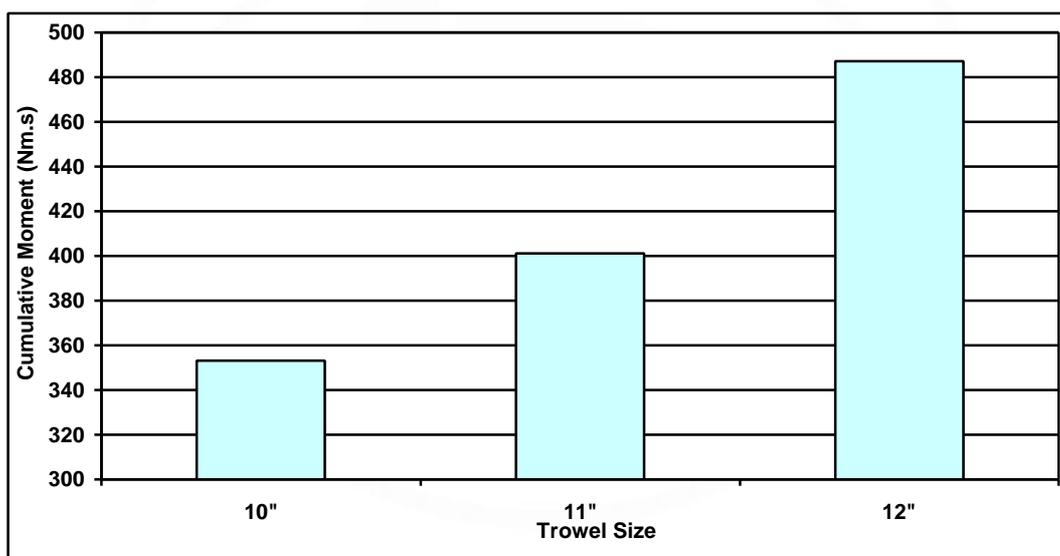


Figure 3: Calculated cumulative moment at the wrist joint. Trowel size is a significant [$F(2,18)=5.077$, $p=0.021$] factor affecting cumulative moment.

3.2 Blocks

Figure 4 contains summaries of time required to spread mortar across a block course of 3.2 m. In this experiment, trowel size was a significant [$F(2,18)=4.928$, $p=0.023$] factor affecting work duration. A post-hoc test showed significant ($p=0.02$) differences in the spreading mortar time between the 10" and 12" trowels. There were no significant ($p>0.05$) differences between the 11" versus the 12" trowel, and the 10" versus the 11" trowel.

The values for the peak and cumulative moment at the wrist joint are shown in Figure 5 and 6. Statistical analyses using one-way ANOVA indicates that peak moment is significantly ($p < 0.05$) affected by trowel size. A post-hoc test using Tukey's method indicated that peak moment at the wrist joint is significantly ($p < 0.05$) lower when the 10" trowel is used to spread mortar across the block. There was also a significant peak moment difference between the 11" versus the 12" trowel (see Figure 5).

For the cumulative moment, measured by multiplying peak moment with mortar spreading time, trowel size was a statistically significant [$F(2,18)=5.081$, $p=0.029$] factor affecting cumulative moment. A post-hoc test indicated that the values for the 10" trowel are significantly ($p < 0.05$) lower than the 12" trowel. No significant ($p > 0.05$) differences between the 10" versus the 11" trowel, or between the 11" versus the 12" trowel (see Figure 6) was found.

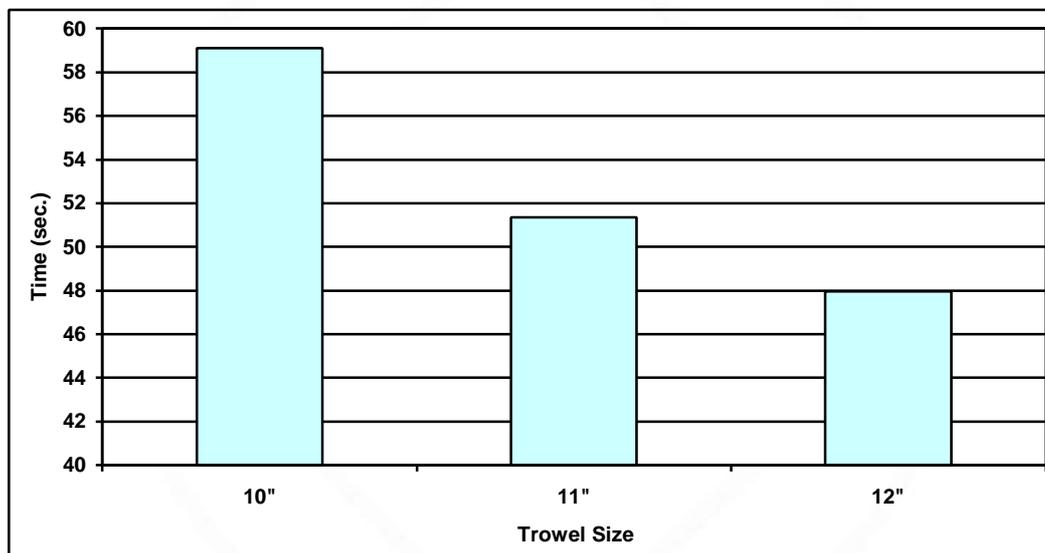


Figure 4: Mean time required to spread mortar across a block length of 3.2 m. Time differences between each trowel size are significant [$F(2,18)=4.928$, $p=0.023$].

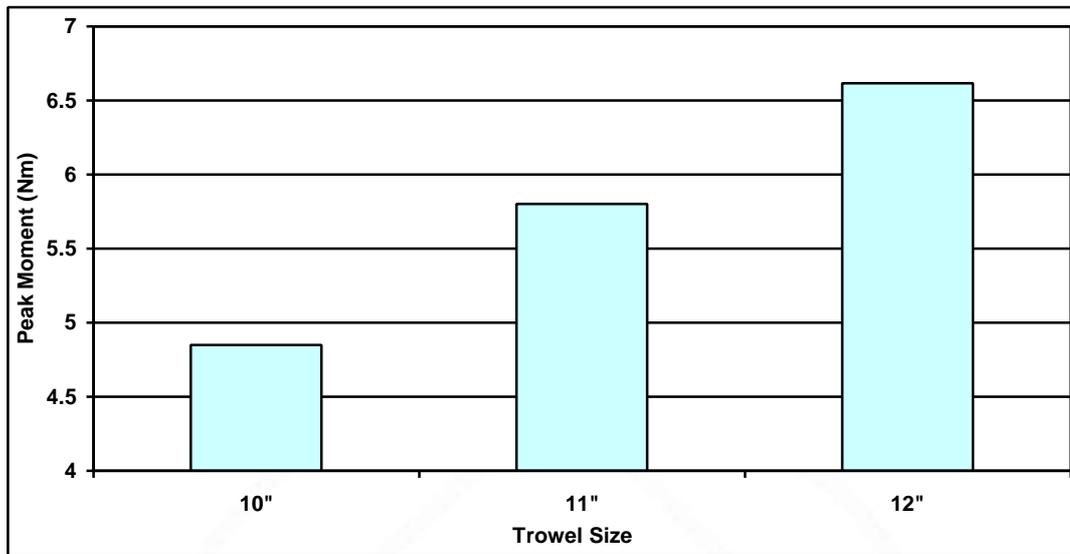


Figure 5: Calculated peak moment at the wrist joint. Trowel size is a significant $[F(2,18)=672, p=0.000]$ factor affecting peak moment.

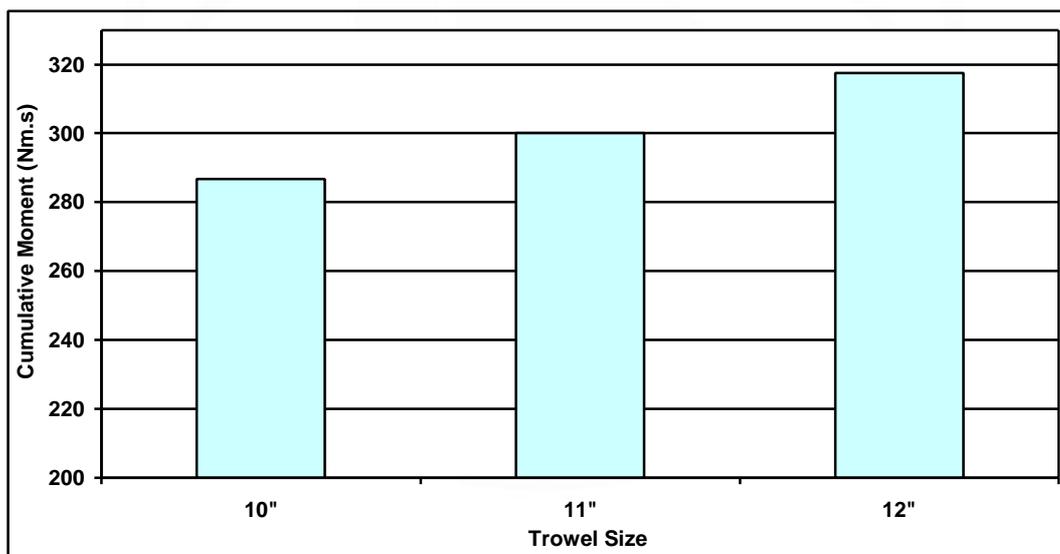


Figure 6: Calculated cumulative moment at the wrist joint. Trowel size is a significant $[F(2,18)=5.081, p=0.029]$ factor affecting cumulative moment.

4.0 CONCLUSION

The results of this experiment showed that it is best to work with a 10” or an 11” trowel for spreading mortar onto brick. This conclusion was based on the fact that wrist peak moment and cumulative moment were lowest for the 10” and 11” trowels. Furthermore, the mortar spreading time was also found to be faster for the 10” and 11” trowels.

This experiment also found that the 11” trowel was the best trowel size for use in spreading mortar onto masonry block. This conclusion was based on the fact that the 11” trowel performed just as fast as the 12” trowel in terms of mortar spreading time. Furthermore, the 11” trowel did not significantly increase biomechanical stresses on the wrist. The 10” trowel was not found to be the best size to spread mortar on block – the bricklayers took significantly more time when spreading mortar with the 10” trowel than with the 12” trowel.