A Field Study of Rebar Tying Machine as a Tool to Reduce Risk of Musculoskeletal Injuries

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Introduction

In Ontario, rodworkers have a higher lost-time injury (LTI) rate due to non-traumatic musculoskeletal injury than the construction average. Dababneh and Waters (2000) reviewed the literature on the ergonomic issue of rebar tying, and concluded that properly designed powered tying tools may be the best ergonomic solution. Extended tool-body design or extended arm attachments can be used to eliminate the need for stooping when working on a horizontal platform (see Figure 1). Although there are many potential benefits in using the rebar tying machines, their effectiveness in a field setting has never been verified. The objective of this study was to conduct an intervention study in the field setting to verify the potential reduction in risk of musculoskeletal disorders when using a rebar tying machine with arm extension attachment as an alternative work method.

Figure 1: Rebar tying using a rebar tying machine (left) and manual tying using pliers (right).

Methodology

A before-and-after design approach was used in this study to evaluate the effectiveness of the rebar tying machine with an extension arm attachment. Only ground level rebar production was used to evaluate the intervention. Before implementing the intervention, all participants were asked to fill out a usability questionnaire regarding manual tying with pliers. Rebar tying time and trunk work postures while performing manual tying was also quantified. After the initial observation, each participant was trained and given the rebar tying machine for use in normal ground level rebar production. Each participant was allowed to use the rebar tying machine for three months. After the intervention period, each participant was asked to fill out a usability questionnaire regarding the use of the rebar tying machine. The questionnaire given after intervention was similar to the manual tying usability questionnaire. Rebar tying time and trunk work postures while performing rebar production with the tying machine was also quantified. The repeated measurement of all dependent variables (i.e., before and after) allowed comparison of the differences between the two work methods.

Results

1. Using the traditional manual method the participants finished with an average rebar tying cycle time of 8.9 seconds. Using the rebar tying machine, the participants finished with an average rebar tying cycle time of 4.2 seconds - a decrease of 52% in comparison to the traditional method.
2. During manual tying with pliers, the highest and longest duration of trunk postures was skewed heavily in the neutral posture (<20°) and very extreme awkward trunk postures (>60°). During machine tying, however, the distribution of the magnitude, frequency, and duration of the trunk posture was found to be concentrated between the trunk angles of greater than -10° and less than 50°.
3. The amplitude of the median and peak trunk posture level was found significantly ($p<0.05$) higher when participants tied rebar with pliers as compared to the tying machine.
4. The percentage of work time with the trunk in severe forward flexion (greater than 45°) was also evaluated. A mean value of 50.4% and 14.9% of the total work time in forward severe trunk flexion was found for manual and machine tying, respectively.
5. The self-report questionnaires identify several user preferences among the tying methods. Generally, working with the rebar tying machine was the preferred work method in several categories on the questionnaire for ground level rebar tying.

Recommendations

Based on the findings and experiences gained from this field study, the following issues should be considered when introducing and using the rebar tying machine:

1. Choose a rebar tying machine that allows tying steel rebar at a comfortable back posture. An adjustable extension arm helps to ensure that rodworkers differing in height can tie rebar in a neutral trunk posture.
2. The rebar tying machine should not be limited to rodwork. The machine can be used to tie electrical conduit and radiant heat tubes and decrease the risk of musculoskeletal injuries to electricians and heating tube installers. Furthermore, field experience has shown that the rebar tying machine can significantly decrease the time to tie rebar, which in turn can improve productivity. The increase in productivity however, can be more dramatic if used by electrician or radiant heat installer since manual tying with pliers is very slow and awkward when performed by a non-rodworkers trade.
3. Select a rebar tying machine that can tie rebar at a variety of rebar sizes.
4. For slab-on-grade rebar, tying rebar with the rebar tying machine will require the use of a lightweight steel hook to lift rebar off the ground.
5. Many of the rebar tying machines on the market require warm-up during cold weather. Therefore, proper tying tension of the rebar machine should be adjusted during cold days.
6. On very hot summer days, allow the machine to cool down in a shady area during regular breaks and lunch.
7. Working with the rebar tying machine is very productive for a crew of 4-5 workers per site. One worker can use the machine to tie, while two handle and place rods under the direction of the fourth.
8. When purchasing a rebar tying machine, select a vendor that will provide on-going support and can provide regular maintenance.
9. Use the rebar tying machine to assist workers who have an injury of the low-back or hand to return-to-work.