

## **The Design and Evaluation of a Universal Rig for Supporting Large Hammer Drills to Reduce Injury Risk**

David Rempel and Alan Barr

*Department of Bioengineering, University of California, Berkeley, CA, USA*

### **1. Introduction**

Drilling holes into concrete with heavy hammer or rock drills is one of the most physically demanding tasks performed in commercial construction by labourers, electricians, plumbers and carpenters. The drills can weigh 5 to 25 kg and the task typically involves drilling 1 to 2 cm diameter holes 10 to 40 cm deep into concrete. Some jobs require drilling 1,000 to 40,000 such holes for structural upgrades and large anchor attachment. The work poses risks for musculoskeletal disorders of the hands, arms, shoulders, and back due to the applied forces, awkward postures and handle vibration. The aim of this study was to use a participatory process to develop a rig to support pneumatic rock drills or large electric hammer drills in order to reduce the risks for musculoskeletal disorders and regional fatigue while maintaining productivity and usability.

### **2. Methods**

Six prototype drill rigs were developed with feedback from commercial contractors and construction workers. A final design, that received good feedback from workers, was then evaluated at 6 commercial construction sites. The rig included a saddle for supporting the drill(s); a carriage that advancing the drill with a linear gear and crank handle; a vertical column for changing the height of the carriage; a carriage attachment to the column that allowed carriage rotation over a 360 degree range; and a wheeled base. Labourers and electricians (N=29) performed their usual dowel and rod drilling for 4 hours with the usual method and also with the new rig and completed questionnaires on usability and fatigue after each method. A subset of the workers was videotaped in order to measure drilling productivity. In a laboratory setting, the drill handle and the rig crank handle vibration were measured during concrete drilling and the handle forces were estimated.

### **3. Results**

Usability ratings for the rig were significantly better than the usual method on stability, control, drilling, accuracy, and vibration. Across four body regions (e.g., neck, shoulders, hands and arms, lower back), subjective fatigue was significantly less when using the universal rig compared to the usual manual method. Drilling time was reduced by approximately 50% with the rig. The mean handle vibration during drilling was higher with the usual method than with the rig (9.04 ( $\pm 0.81$ ) vs. 3.26 ( $\pm 0.03$ ) m/s<sup>2</sup>; p=0.007). The estimated hand force for the usual method was higher than the rig (211 ( $\pm 26$ ) vs. 19 ( $\pm 2$ ) N).

### **4. Discussion**

A participatory feedback process involving construction workers led to the development of a rig for supporting heavy hammer and rock drills with good usability. The final design significantly reduced hand vibration, hand forces, and regional body fatigue and also improved productivity. Commercial construction contractors, labourers and electricians who use large hammer drills for drilling many holes should consider using such a rig to prevent musculoskeletal disorders and fatigue.

### **Acknowledgements**

This research was supported under the Center for Construction Research and Training (CPWR) agreement with the National Institute of Occupational Safety and Health (U54-OH009762).