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Construction

Indoor Wet Concrete Cutting and Coring Exposure Evaluation

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High exposures to crystalline silica can result when concrete is cut dry. It is commonly believed that water spray provides adequate control to limit worker exposures to below the silica PEL. Observation of water spray-controlled versus uncontrolled crystalline silica clearly demonstrates a significant reduction in dust production. However, there are little data available on measured exposures when using water. Shields discussed exposures of 8, 28, 37, and 44 percent of the PEL for four air samples collected during wet sawing of concrete slabs.(1) In a 1997 presentation, Eversmeyer reported that an air sample collected during wet cutting on concrete was 1 percent of the PEL.(2) Lofgren reported two indoor concrete floor slab wet cutting exposures below the detection limit, as well as two indoor concrete wall wet cutting exposures at 230 and 250 percent of the PEL.(3) A NIOSH study found a mean exposure of 0.09 mg/m^3 for four wall saw/core drilling exposures.(4) These limited data suggest that water application often, although not always, maintains the silica content below the PEL.

Two concrete cutting and drilling companies were interested in characterizing workplace exposures to silica and respirable dust, in order to develop or enhance existing respiratory protection policies. These companies requested the assistance of either the University of Washington Field Research and Consultation Group (FRCG) or the Washington Department of Labor and Industries consultation service (L&I).

Site Selection

The study was conducted at 10 different construction sites, selected with assistance from the participating companies. Selection criteria included anticipation of worst-case scenarios, such as inside buildings or enclosed spaces with no dust-producing activities nearby. Cutting jobs vary widely in terms of size, and frequently a sawyer will be assigned to more than one job per day. For this study, the majority of the jobs selected lasted a full shift, so that a long cutting period could be sampled, in order to assure that the collected sample would exceed the detection limit of the method. The two hand sawing sampling sessions occurred on days when the operator also used another cutting tool. Hand sawing is typically done for short durations when space is inadequate for a larger walk-behind saw. Two outside slab sawing samples were collected to compare inside samples.

Tool Selection and Operation

The following four tools were selected for evaluation: walk-behind and handheld slab saws, core drill, and wall saw. All of the tools were designed to cut wet, primarily to limit wear on the expensive diamond cutting blade. The slab saws (Figure 1) are walk-behind models that the operator pushes or guides from behind while standing. Four different models were used in the five tests (see Table II). Operators tended to lean forward and to the side to watch precisely where the blade was cutting. Most saws have a bar that extends out in front to act as a guide, but operators favored the bent stance, reporting greater accuracy when they watched the blade as it moved forward. This bent and twisted position

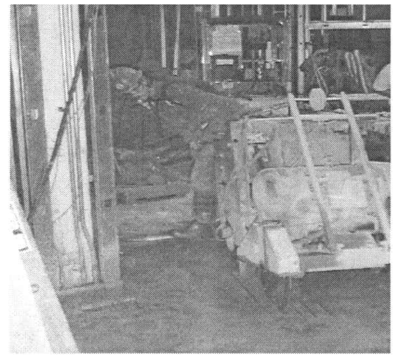

FIGURE 1
Slab saw.

while guiding this heavy tool forward also presents potential musculoskeletal risks. For walk-behind saws, blade size ranged from 14 to 24 inches, with 14- and 18-inch blades most commonly used. Rated saw RPMs were 2,000 and 2,200.

Operators were asked to set the water flow at the rate they had used that day. The selected rate was measured by disconnecting the feed hose and filling a one-gallon jug for 30 seconds. Operators reported an optimal flow rate that they believed controlled dust emissions without interfering with the visibility of the cutting line in front of the blade. They also reported that manufacturers had recommended that only enough water to control dust and cool the blade be applied. A telephone survey of several saw manufacturers revealed that many did not recommend specific rates, while some recommended anywhere from 3 to 10 gallons per minute. No manufacturers that recommended a specific rate had flow meters installed on their equipment.

Depending on water availability at the site, one of the following two water sources was used: a water truck filled

FIGURE 2
Handheld slab saw and helper.

off-site, or piped water from an on-site plumbing system.

Because the selected jobs were inside where water could cause damage and/or interfere with adjacent activities, a second worker assisted the saw operator by cleaning up the wet slurry, using a wet shop vacuum. The vacuuming kept the wet slurry controlled to within a few feet of the point of operation. Each operator of an evaluated tool had a helper to vacuum slurry.

For the handheld hydraulic saw, the operator stood above the tool and guided it along. The operator was closer to the point of operation for this tool than for the walk-behind saw because the tool itself was smaller (Figure 2). On the days of sampling, this saw was used with a 22-inch blade.

The core drill used for both wall and slab drilling was a Diamond Tech model using 2-, 4-, and 6-inch core bits. The core driller sat on a bucket positioned above the borehole for slab cuts, and stood on a stage in front of the drill for wall cuts. When wall coring, the drill was fixed in place with a jig attached to the wall (Figure 4).

The wall saw was mounted on a track guide attached to the wall with concrete bolts. The track guide had to be repositioned for vertical and horizontal cuts. The sawyer typically stood in back of the saw (Figure 3). Less experienced operators frequently watched the progress of the cutting blade, positioned so that their breathing zone was in the particle spray zone. More experienced operators relied on the track guides, and tended to stay out of the spray plume.

FIGURE 3
Wall saw.

Exposure Assessment

Field research and consultation group samples were collected with an SKC aluminum cyclone preselector, set at a pre- and post-calibrated flow rate of 2.5 Lpm, with a PVC filter. Washington Labor and Industries samples were collected with an MSA nylon cyclone calibrated at 1.7 Lpm, with a PVC filter. Respirable dust was analyzed gravimetrically using NIOSH method 600, and crystalline silica was analyzed by FTIR using NIOSH method 7602.

Each equipment operator was monitored for the full period of tool operation at the site, except in one case where the operator moved to a second job at a different site during the same shift. The reported 8-hour TWA concentrations were calculated assuming no other exposure. Full-shift samples were also obtained for the operator helper and area (within 10 feet of the operator) at four sites.

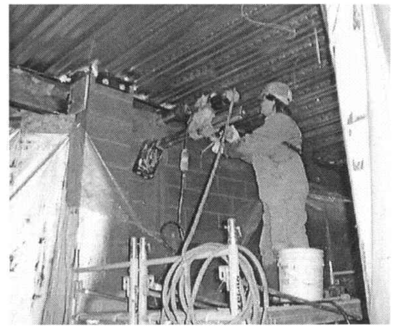

FIGURE 4
Core drilling on wall.

Information was collected on each tool (brand/model, blade size, and rated RPM), work characteristics (water flow rate, linear feet cut, depth of cut, and total minutes cutting), and site environment (cross draft, obstacles, dimensions, degree of enclosure) at six of the sites.

Findings

The operator's silica exposure for the four tools ranged from 0.05 to 0.71 mg/m^3 for the sample period measured (Table I). Interior slab sawing with handheld and walk-behind tools produced the highest exposures. In contrast, the mean exterior slab sawing exposures were only 12 percent of the interior exposures. Wall sawing produced one elevated exposure out of three. Concrete boring activities produced low concentrations of respirable quartz.

The 8-hour exposures for the 13 samples were compared to the Washington

TABLE I
Operator's resipirable quartz exposure during tool use

Tool	N	Mean conc. mg/m^3	Range mg/m^3	Mean min. sampled
Slab saw/walk-behind (inside)	4	0.34	0.13 – 0.71	297
Slab saw/walk-behind (outside)	2	0.04	0.05 – < LOD	240
Slab saw/handheld (inside)	2	0.25	0.24 – 0.26	130
Wall saw (inside)	3	0.13	0.06[1] – 0.22	294
Concrete boring (inside)	2	0.02	0.02	261

[1]Significant nonsawing time.

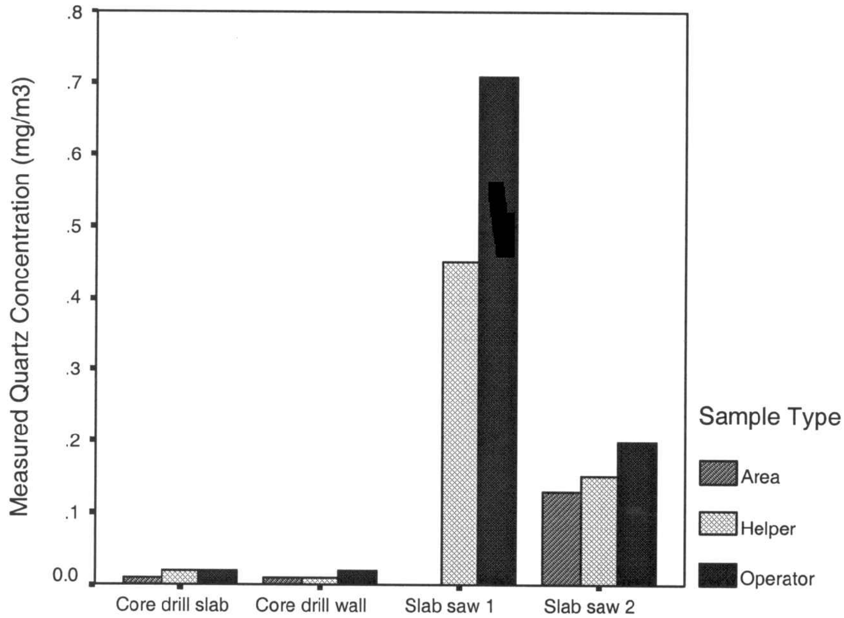

FIGURE 5
Operator, helper, and area concentrations.

Permissible Exposure Limit for crystalline quartz of 0.1 mg/m^3, and were found to be at or above the PEL in five cases: three interior slab saw samples (300%, 350%, 110%), a combined day of interior walk-behind and handheld saws (100%), and one of three cases for interior wall sawing (167%).

Operator, helper, and area concentrations are shown in Figure 5 for those cases in which helper and area sampling was conducted. Helper and area samples were similar in range, although somewhat lower than associated operator samples. These data indicate that other trades working in adjacent areas could be overexposed to quartz even when water is used for dust suppression. Since area and helper exposures are similar to the operator's exposure, the primary exposure may be due to a buildup of respirable aerosol within the enclosed space, rather than direct exposure to slurry spray. Judicious use of dilution ventilation with box fans and open doors and windows may reduce the exposure.

Because slab sawing was done on four separate days, further data analysis was performed to better characterize slab sawing. Three of the slab saw jobs were similar in that they used similar blade sizes and cut area (Table II). The slab sawing jobs included no further exposure on the day of sampling, and 8-hour TWAs were calculated based on that assumption. When the water flow rate was two gallons per minute, the exposure level was one-third of what it was when the water flow was 0.5 gallons per minute.

The slab sawing jobs all occurred indoors during remodeling projects. Tests 1 and 2 took place in large, open spaces, while Test 3 occurred in a retail shop storage room where storage racks created a more enclosed space. Although the three saw jobs were comparable in terms of tool used and material cut, the Test 3 space configuration was more enclosed, and one would expect it to result in higher exposures. Despite this, the concentration in Test 3 was relatively low, possibly due to the greater water flow used on this job. Perhaps the larger quantity of water being thrown off the blade produced larger aerosol particles that dropped out of the air more quickly, whereas with less water, the aerosol produced was more in the respirable range, creating a mist that remained airborne longer. Also, a fine aerosol may remain suspended longer in an indoor environment.

What Can Saw Manufacturers Do?

Saw manufacturers have a great opportunity to provide improved control technology. Following are a few suggestions for strategies to explore:

1. The amount of water delivered to the blade appears to affect silica exposure. Slab saw water flow rates observed in this study were less than any recommended by those manufacturers that made recommendations. Manufacturers should be encouraged to determine a recommended water flow rate (or range), using a standardized test method, install flow meters on equipment, and sign equipment with the recommended flow rate.
2. A better steering/guiding mechanism for the walk-behind saw would allow the operator to remain upright and out of the aerosol

TABLE II
Slab saw operator exposure

Test	Measured conc. (mg/m^3)	Sampling time (min)	8-hour TWA (mg/m^3)	Cut area (ft^2)	Water flow (gal/min)	Blade size (in.)	Brand
1—Inside slab saw	0.71	235	0.35	93	0.5	14	Meco
2—Inside slab saw	0.33	437	0.30	83	0.5	14–24	Core cut CC6500
3—Inside slab saw	0.20	275	0.11	100	2.0	14–18	Meco

plume emitted from the saw blade. This would also reduce the need to see the cutting line, which can be obscured when more water is applied.

3. Collecting slurry at the point of emission would be the most efficient mechanism to control aerosol silica slurry exposure. One manufacturer who offers an optional vacuum attachment to collect slurry was identified. This attachment should be evaluated to determine its effectiveness for controlling aerosol in the respirable size range. The test could also include an assessment of the vacuum exhaust air as it is emitted into the room.

Implications for the Wet Saw Cutting Industry

- Water appears to be effective for reducing concrete core drilling emissions. When the core bit is sunk into the concrete, dust particle velocity is slowed and mixed with water before exiting the borehole, emitting slurry with little velocity to produce an airborne aerosol.
- Wall sawing and slab sawing with water spray have potential for overexposures to silica when working in an enclosed environment.
- Area and helper monitoring data suggest a need to inform the site superintendent that there is also potential for overexposure to silica for adjacent trades when wet sawing inside.
- When cutting concrete inside, using water for dust reduction, it is recommended that saw operators and others in the area wear respiratory protection. Disposable respirators are commonly used in this industry, although half-facemasks with disposable cartridges are advisable, because it is difficult to achieve an acceptable fit with disposable respirators.

Limitations

The very limited sample size in this study can only suggest potential for overexposures. Situations were selected that are likely worst cases in terms of enclosure and amount of cutting done per shift. Many jobs do not involve such extensive periods of cutting, with workers often working at two or three job sites per day. Time spent commuting between sites and setup/cleanup time for each job provide periods of minimal or no exposure. Additional work to characterize wet cutting outside of an enclosed area would afford more confidence that wet cutting provides adequate control in these situations.

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