All Hands Safety Meeting

May 10, 2017
Agenda

Welcome
Marina Roelofs, University of Michigan, AEC

U-M Construction Safety Update
Mike Marenghi, Project Director and Matt Kettman, Construction Safety Specialist

Occupational Health Standard, Part 690 – Silica in Construction
Eric Allen, Construction Safety & Health Division Manager, MIOSHA

Emergent Technologies & Studies in Worker Safety and Employee Performance
Dr. SangHyun Lee, Associate Professor, University of Michigan/Civil & Environmental Engineering
Annual OSHA Recordable Incidents Rate

As of 04/19/2017

*OSHA Annual Recordable Incident Rate as reported by the U.S. Bureau of Labor Statistics
Changes to the Safety Guidelines

- New Project Safety Scope Checklist
- Post-assembly inspections
  - Must be performed whenever a crane is assembled or altered onsite
- Change to near miss reporting
- Temporary Elevator Policy
  - No more separation of doors!
  - Simplified
    - Car is to left with doors open and a barricade placed across the opening
Project Safety Scope Checklist

- New Form that should be submitted with all safety plans
- Assist EHS in prompt and accurate review
- Located on the EHS website under “Contractor Safety”
- Please start using immediately!
Monthly Safety Report

- Please use the current version.
- Revised 12/22/16.

### Monthly Safety Report

<table>
<thead>
<tr>
<th>INCIDENT TYPES</th>
<th>Number of Cases</th>
<th>U-M Project Goal</th>
<th>Rates</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Current Month</td>
<td>Year to Date</td>
<td>Project to Date</td>
</tr>
<tr>
<td>OSHA Recordable Incidents</td>
<td>0</td>
<td>3.5</td>
<td></td>
</tr>
<tr>
<td>DART Incidents</td>
<td>0</td>
<td>2.0</td>
<td></td>
</tr>
<tr>
<td>Lost Work Incidents</td>
<td>0</td>
<td>1.3</td>
<td></td>
</tr>
<tr>
<td>Non-recordable, near misses, etc.</td>
<td>0</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**OSHA RECORDABLE INCIDENTS:**

- Please classify incident type below and also complete page 2 with details:

- Fall (e.g., floors, platforms, roofs)
- Struck by/against (e.g., falling objects, vehicles)
- Caught in/between (e.g., cave-ins, unguarded machinery, equipment)
- Electrical (e.g., overhead power lines, power tools/cords, outlets, wiring)
- Overexertion
- Inhalation
- Heat
- Other (other items not covered above)

**EMPLOYMENT INFORMATION**

- (includes contract workers)
- Average Daily Number of Employees (FTE’s)
- Total Hours Worked by Employees
Crane Lifts Over Occupied Buildings

- Registered structural engineer shall review
- Must determine capability of building to withstand dropped load
- Coordinate with UM project manager
Respirable Crystalline Silica
MIOSHA Part 690

University of Michigan
May 10, 2017

Presented by Eric Allen
Adopts Federal OSHA Standard

• Published on March 25, 2016.
• Addresses employee exposures to respirable crystalline silica.
• Impacts both Construction and General Industry activities (maritime is protected by federal OSHA).
• Reasons for the new standard:
  – Current PELs do not adequately protect construction and general industry employees.
  – Extensive epidemiologic evidence that lung cancer and silicosis occur at exposure levels below 100 µg/m³.
Exposure and Health Risks

Exposure to respirable crystalline silica has been linked to:

– Silicosis,
– Lung cancer,
– Chronic obstructive pulmonary disease, and
– Kidney disease.
Respirable Crystalline Silica Standards

• Two standards in Michigan:
  – MIOSHA Part 590 for general industry (maritime is addressed by federal OSHA).
  – MIOSHA Part 690 for construction.

• Adopts the federal OSHA requirements by reference.
Scope (a)

Construction Standard (MIOSHA Part 690)

• **Applies to all occupational exposures to respirable crystalline silica in construction work,**

• **Except where employee exposure will remain below 25 micrograms per cubic meter of air (25 µg/m³) as an 8-hour time weighted average (TWA) under any foreseeable conditions.**

• Foreseeable exposures must remain below the action level.
Objective Data

• Information, such as air monitoring data from industry-wide surveys or calculations based on the composition of a substance, demonstrating employee exposure to respirable crystalline silica associated with a particular product or material or a specific process, task, or activity.

• The data must reflect workplace conditions closely resembling or with a higher exposure potential than the processes, types of material, control methods, work practices, and environmental conditions in the employer’s current operations.
Objective data must include...

- The crystalline silica material in question.
- The source of the objective data.
- The testing protocol and results of the testing.
- Description of the process, task, or activity on which the objective data were based.
- Other data relevant to the process, task, activity, material, or exposures on which the objective data is based.
Specified Exposure Control Methods (c)

Construction Standard (MIOSHA Part 690)

• **Option 1**: If an employee is engaged in a task is identified in Table 1, fully and properly implement the engineering controls, work practices, and respiratory protection specified by Table 1; **UNLESS**

• **OPTION 2**: Assess and limit employee exposure to respirable crystalline silica in accordance with paragraph (d) of this section.
Specified Exposure Control Methods
MIOSHA Part 690, Table 1 Equipment/Tasks

1. Stationary masonry saws
2. Handheld power saws
3. Handheld power saws for cutting fiber-cement board
4. Walk-behind saws
5. Drivable saws
6. Rig-mounted core saws or drills
7. Handheld and stand-mounted drills
8. Dowel drilling for concrete
9. Vehicle-mounted drilling rigs for rock and concrete
10. Jackhammers and handheld powered chipping tools
11. Handheld grinders for mortar removal (i.e., tuckpointing)
12. Handheld grinders for uses other than mortar removal
13. Walk-behind milling machines and floor grinders
14. Small drivable milling machines
15. Large drivable milling machines
16. Crushing machines
17. Heavy equipment and utility vehicles used to abrade or fracture silica-containing materials
18. Heavy equipment and utility vehicles for tasks such as grading and excavating
### Example of Table 1 Entry

Handheld Power Saws (any blade diameter)

<table>
<thead>
<tr>
<th>Equipment / Task</th>
<th>Engineering and Work Practice Control Methods</th>
<th>Required Respiratory Protection and Minimum APF</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Handheld power saws (any blade diameter)</strong></td>
<td>Use saw equipped with integrated water delivery system that continuously feeds water to the blade.</td>
<td>≤ 4 hr/shift</td>
</tr>
<tr>
<td></td>
<td>Operate and maintain tool in accordance with manufacturers’ instruction to minimize dust.</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>- When used outdoors</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- When used indoors or in an enclosed area</td>
<td>APF 10</td>
</tr>
</tbody>
</table>
For tasks performed indoors or in enclosed areas...

Provide a means of exhaust as needed to minimize the accumulation of visible airborne dust.
For tasks performed using wet methods...

Apply water at flow rates sufficient to minimize release of visible dust.
For measures implemented that include an enclosed cab or booth ...

Ensure that the enclosed cab or booth:

A. Is maintained as free as practicable from settled dust;

B. Has door seals and closing mechanisms that work properly;

C. Has gaskets and seals that are in good condition and working properly;

D. Is under positive pressure maintained through continuous delivery of fresh air;

E. Has intake air that is filtered through a filter that is 95% efficient in the 0.3-10.0 µm range (e.g., MERV-16 or better); and

F. Has heating and cooling capabilities.
When implementing Table 1 control measures...
(continued)

• Where an employee performs more than one task on Table 1 during the course of a shift, and the total duration of all tasks combined is more than four hours, the required respiratory protection for each task is the respiratory protection specified for more than four hours per shift.

• If the total duration of all tasks on Table 1 combined is less than four hours, the required respiratory protection for each task is the respiratory protection specified for less than four hours per shift.
Employees Engaged in Table 1 Tasks

• Employees are “engaged in the task” when operating the listed equipment, assisting with the task, or have some responsibility for the completion of the task.

• Employees are not “engaged in the task” if they are only in the vicinity of a task.
Silica Exposure Limits

- **PEL**: 50 µg/m³, 8-hr TWA
- **AL**: 25 µg/m³, 8-hr TWA

PEL: permissible exposure limit
AL: action level
<table>
<thead>
<tr>
<th>Frequency of Monitoring</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Initial results &lt; AL:</strong></td>
</tr>
<tr>
<td><strong>Most recent result &gt; AL</strong></td>
</tr>
<tr>
<td><strong>Most recent result &gt; PEL</strong></td>
</tr>
<tr>
<td><strong>When two consecutive non-initial results, taken 7 or more days apart, but less than 6 months, are &lt; AL</strong></td>
</tr>
</tbody>
</table>

If/when conditions change...
Reassessment of Exposures

• Reassess exposures whenever a change in the production, process, control equipment, personnel, or work practices may reasonably be expected to result in new or additional exposures at or above the action level, OR

• When the employer has any reason to believe that new or additional exposures at or above the action level have occurred.
Methods of Sample Analysis

Use of Appendix A

• Employers must ensure that samples are analyzed by a laboratory that follows the procedures in Appendix A.

• Appendix A specifies methods of sample analysis:
  – Allows for use of OSHA, NIOSH, or MSHA methods.
  – Analysis must be conducted by accredited laboratories that follow specified quality control procedures.
Methods of Compliance
Engineering and Work Practices Controls

- Employers shall use engineering and work practice controls to limit exposures to or below the PEL unless they are demonstrated to be not feasible.
- Use such controls even if they do not reduce exposures to or below the PEL.
- Respirators permitted where PEL cannot be achieved with engineering and work practice controls
Written Exposure Control Plan

The plan must describe:

– Tasks involving exposure to respirable crystalline silica.
– Engineering controls, work practices, and respiratory protection for each task.
– Housekeeping measures used to limit exposure.
– Procedures used to restrict access to work areas, when necessary (minimize exposed employees).

• Review the plan annually; update as necessary.
• Make the plan readily available.
Medical Surveillance

• Employers must offer medical examinations to **workers required to wear a respirator under Part 690 for 30 or more days a year.**

• Employers must **offer examinations every three years** to workers who continue to be exposed above the trigger.

• Exam includes medical and work history, physical exam, chest X-ray, and pulmonary function test (TB test on initial exam only).
Medical Opinion

• Worker receives report with detailed medical findings.
• Employer receives an opinion that only describes limitations on respirator use, and if the worker gives written consent, recommendations on:
  – Limitations on exposure to respirable crystalline silica, and/or
  – Examination by a specialist.
Compliance Dates

Employers must comply with all requirements (except methods of sample analysis) by June 23, 2017.

Compliance with methods of sample analysis required by June 23, 2018.

Methods of sample analysis, section (d)(2)(v):
The employer shall ensure that all samples taken to satisfy the monitoring requirements of paragraph (d)(2) of this section are evaluated by a laboratory that analyzes air samples for respirable crystalline silica in accordance with the procedures in Appendix A to this section.
Appendix A

• Specifies procedures for analyzing air samples for respirable crystalline silica and quality control procedures employers must ensure laboratories use when performing an analysis.

• The employer must ensure the laboratory:
  – Evaluates all samples using one of six analytical methods;
  – Is accredited with respect to crystalline silica analyses;
  – Uses the most current traceable standards for instrument calibration or instrument calibration verification;
  – Implements an internal quality control (QC) program;
  – Characterizes the sample material; **AND**
  – Analyzes quantitatively for crystalline silica and performs specified instrument calibration checks.
The End!

Any Questions?
Emergent Technologies for Construction Safety and Health

SangHyun Lee, PhD
Associate Professor & John Tishman Faculty Scholar
Department of Civil & Environmental Engineering
University of Michigan
UM Dynamic Project Management Group

- [http://dpm.engin.umich.edu](http://dpm.engin.umich.edu)

- 1 Post doctoral fellow, 5 PhD students, 2 MSc student, 5 undergraduate students

- Construction safety and health
  - Sensing technologies, human behavior, social influence
Work-related Musculoskeletal Disorder

- High risks of WMSDs during construction tasks
- Account for 33.6% of non-fatal injuries in construction
- Could be more severe due to underreporting (30-40%)

Source: NIOSH Construction Safety & Health Initiatives
This is What Automotive Industry Does
Computer Vision for Ergonomic Posture Analysis

- NIOSH Lifting Equations, OWAS, RULA, REBA, etc.

- Posture Classification
- Frequency
- Duration
- Severity (body angles)
Smartphone-based Ergonomic Risk Assessment
Mobile System: Ergo-Ray
3D Skeleton with Dual-Lens Phone

Lifting Block

Spreading Mortar

Removing Mortar

Walking
Field Tool for Biomechanical Analysis
Biomechanical Analysis for Masons

- 21 Subjects, 45 Concrete Blocks (12*6)

<table>
<thead>
<tr>
<th>Number of participants</th>
<th>Experience (years)</th>
<th>Height (SD)</th>
<th>Weight (SD)</th>
<th>Skill</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>0</td>
<td>176.6 (8.41)</td>
<td>83.8 (7.6)</td>
<td>Novice</td>
</tr>
<tr>
<td>4</td>
<td>1</td>
<td>174.7 (8.73)</td>
<td>80.75 (15)</td>
<td>Apprentice</td>
</tr>
<tr>
<td>7</td>
<td>3</td>
<td>179.7 (4.7)</td>
<td>93.4 (4.75)</td>
<td>Apprentice</td>
</tr>
<tr>
<td>5</td>
<td>&gt;5</td>
<td>176.8 (8.84)</td>
<td>85.6 (10.5)</td>
<td>Journeymen</td>
</tr>
<tr>
<td>---</td>
<td>Average</td>
<td>177.3 (7.17)</td>
<td>86.85 (9.98)</td>
<td>---</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Duration</th>
<th>34min</th>
<th>47min</th>
</tr>
</thead>
<tbody>
<tr>
<td>Distance per block (m)</td>
<td>Head</td>
<td>Dominant Hand</td>
</tr>
<tr>
<td></td>
<td>21.75</td>
<td>45.88</td>
</tr>
</tbody>
</table>
Biomechanical Analysis for Masons

- 21 Subjects, 45 Concrete Blocks (12*6)

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<tr>
<td>—</td>
<td>Average</td>
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<td>86.85 (9.98)</td>
<td></td>
</tr>
</tbody>
</table>
Wristband for Workers’ Safety & Health

Dynamic Project Management Group

Motion Data (IMU Signals)

Automated Action Recognition (Work Sampling)

Physical Demands

Heart Rate Variability

Other Physiological Signs

- Galvanic Skin Response
- Skin Temperature

Diverse Health Risk Indices

- Heat Stress and Strain
- Dehydration Rate
Action Recognition: Masonry Work

Spreading Mortar

Laying Brock

Adjusting

Removing Mortar

Dynamic Project Management Group
%HR Reserve (%HRR) for Physical Demand Analysis

\[
%HRR = \frac{HR_{Working} - HR_{Resting}}{HR_{Maximum} - HR_{Resting}} \times 100\%
\]

where

- \( HR_{Working} \) = average working heart rate [bpm];
- \( HR_{Resting} \) = resting heart rate [bpm];
- \( HR_{Maximum} \) = the maximum heart rate estimated by the equation of age: \( 208 - 0.7 \times \text{age} \) [bpm] (Tanaka et al. 2001)
- Aging Workforce
- Different Working Conditions

**Physical Demand Comparison**

- Workers with different ages
  - #1: Young Worker
  - #2: Old Worker
- Workers in different locations
  - #1: Inside
  - #2: Outside (Sunny)
Heatmap w/ BIM

- Location, Actions, Physical Demands, Attention, etc.
Field Stress Measurement

- Electroencephalogram (EEG)
Signal Processing Framework

Extracting 3,840 Data Points

Band Pass Filter

ICA Analysis

Artefacts Corrected EEG
Stress in Hazardous Work Conditions

- Frontal EEG Asymmetry (FEA)

  - Ground Work
  - Working at height in confined space
  - Working at height
  - Russell’s Affective Space Model in Understanding Emotions (Russell 1980)
Social Influence on Workers’ Safety Behavior

- 80-90% of accidents are caused by unsafe behavior
- Safety culture/climate and safety norm
  - Workers’ safety behaviors are under the influence of the group level informal controls (i.e., safety norm, safety climate) (Zohar 1980; Neal et al. 2000; Mohamed 2002; Choudhry et al. 2007; Nahrgang et al. 2011).

Social norms can account for varied and situational behaviors
- More cost effective and durable than regulating by formal rules
Social Identity Theory

- Self-image derived from the social categories to which he/she perceives himself/herself as belonging (Tajfel and Turner 1979).

Mix of social norms and social identities makes the effect of social norms more complex.
What is the level of workers’ social identification with each group in their jobsite?

<table>
<thead>
<tr>
<th>Pair</th>
<th>Mean Difference</th>
<th>SD</th>
<th>T</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crew – Company</td>
<td>.45</td>
<td>1.00</td>
<td>4.04**</td>
</tr>
<tr>
<td>Crew – Project</td>
<td>.71</td>
<td>.96</td>
<td>6.70**</td>
</tr>
<tr>
<td>Crew – Trade</td>
<td>-.35</td>
<td>.81</td>
<td>-3.92**</td>
</tr>
<tr>
<td>Crew – Union</td>
<td>.02</td>
<td>1.28</td>
<td>.17</td>
</tr>
<tr>
<td>Company – Project</td>
<td>.27</td>
<td>1.04</td>
<td>2.33</td>
</tr>
<tr>
<td>Company – Trade</td>
<td>-.80</td>
<td>1.22</td>
<td>-5.89**</td>
</tr>
<tr>
<td>Company – Union</td>
<td>-.42</td>
<td>1.51</td>
<td>-2.52</td>
</tr>
<tr>
<td>Project – Trade</td>
<td>-1.06</td>
<td>1.04</td>
<td>-9.25**</td>
</tr>
<tr>
<td>Project – Union</td>
<td>-.69</td>
<td>1.45</td>
<td>-4.32**</td>
</tr>
<tr>
<td>Trade – Union</td>
<td>.37</td>
<td>1.02</td>
<td>3.33*</td>
</tr>
</tbody>
</table>

Note: N=82, *p < .05, ** p < .01
Moderator: Project Identity

Project identity positively moderates relationship between management norm and safety behavior

Project identity negatively moderates relationship between workgroup norm and safety behavior

Prediction of workgroup norm (M) = \( \beta_{10} + \beta_{11}X + \epsilon_1 \)

<table>
<thead>
<tr>
<th>Variable</th>
<th>b</th>
<th>( \beta )</th>
<th>S.E</th>
<th>R^2</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Management Norm (X) - ( \beta_{11} )</td>
<td>.770**</td>
<td>.689**</td>
<td>.048</td>
<td>.475</td>
<td>255.44</td>
</tr>
</tbody>
</table>

Prediction of safety behavior (Y) = \( \beta_{20} + \beta_{21}X + \beta_{22}M + \beta_{23}V + \beta_{24}Q + \beta_{25}A + \beta_{26}C + \beta_{27}XV + \beta_{28}MQ + \beta_{29}XQ + \beta_{30}MQ + \beta_{31}U + \beta_{32}K + \epsilon_2 \)

<table>
<thead>
<tr>
<th>Variable</th>
<th>b</th>
<th>( \beta )</th>
<th>S.E</th>
<th>R^2</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Management Norm (X) - ( \beta_{21} )</td>
<td>.117</td>
<td>.123</td>
<td>.070</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Workgroup Norm (M) - ( \beta_{22} )</td>
<td>.200**</td>
<td>.236**</td>
<td>.057</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Project Identity (V) - ( \beta_{23} )</td>
<td>.054</td>
<td>.050</td>
<td>.069</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Collective Self (Q) - ( \beta_{24} )</td>
<td>.257**</td>
<td>.220**</td>
<td>.072</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Attitude (A) - ( \beta_{25} )</td>
<td>.157**</td>
<td>.143**</td>
<td>.055</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Experience (C) - ( \beta_{26} )</td>
<td>-.011</td>
<td>-.076</td>
<td>.007</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Management Norm x Project Identity (XV) - ( \beta_{27} )</td>
<td>.133*</td>
<td>.202*</td>
<td>.069</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Workgroup Norm x Project Identity (MV) - ( \beta_{28} )</td>
<td>-.239**</td>
<td>-.350**</td>
<td>.064</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Management Norm x Collective Self (XQ) - ( \beta_{29} )</td>
<td>-.143*</td>
<td>-.214*</td>
<td>.067</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Workgroup Norm x Collective Self (MQ) - ( \beta_{30} )</td>
<td>.082</td>
<td>.107</td>
<td>.066</td>
<td></td>
<td></td>
</tr>
<tr>
<td>U.S. (U) - ( \beta_{31} )</td>
<td>-.015</td>
<td>-.006</td>
<td>.168</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Korea (K) - ( \beta_{32} )</td>
<td>.068</td>
<td>.028</td>
<td>.138</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: N = 284, *p < .05, **p < .01
Can We Improve Project Identity?

- **Research Objective**
  - To identify effective management interventions to promote workers’ social identification with project

- **Field Experiment Design**

  ![Diagram of experiment design]

  - Baseline Questionnaire
  - T1 Questionnaire
  - T2 Questionnaire
  - T3 Questionnaire

  **Ordinary management**
  - 1 Month
  - Information Sessions
  - Unique PPE
  - Uniforms

  **Short-term impact**
  - Intervention
  - 1 Month
  - Photo-ID card

  **Long-term impact**
  - 1 Month
  - Timeline Photo
Ongoing Work

- How to improve project identity and its impact on worker behavior

- Wearable technology (e.g., wristband) + Social influence (e.g., peer pressure)

- Other techs