No Worker Left in the Dust:
A case study on the highly-contrasted and variable levels of silica safety

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Abstract

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With the new silica standards set forth by OSHA in 2016, environmental health and safety officials are trying to crack down on the development of silicosis in the construction workforce. However, the construction industry is quite large and contains a lot of diversity between project types (single-family residential, commercial, public works, heavy civil, etc.) and the people that work on them (unionization, migrancy, trade differences, education levels, etc). Because the topic of health and safety is already so disproportionate across these different types of people and projects, it would be suffice to say that the effectiveness of the new Silica Standards might only be reaching certain types of projects.

The main objective of this thesis is to show the highly variable and contrasting levels of silica safety programs across different types of construction projects in the United States, to determine why some projects are so much safer than others, and to attempt to lay a groundwork for how construction companies with unsafe practices can meet the standards and regulations for silica safety as set out by Federal OSHA. The thesis contains a review of the programs of successfully silica-safe projects, as well as projects where standards are not met across two different U.S. cities.

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Chapter 1: Introduction

Respiratory health and occupational disease in the construction industry has been one of a class struggle ever since the concept emerged in Bernardino Ramizzini's treatise in 1700. The treatise was a full breakthrough in determining dust as a cause for respiratory illness, and was published as a documentation of craftsmen's diseases. He spoke of dusty workplaces as being "haunted by devils" and "close to the classical representation of an inferno or hell." (Rosenthal, 2017).

Roughly 200 years later, in the early 1900s, Dr. Alice Hamilton spearheaded the first formalized study and documentation of the effects of a certain type of dust found in mineral quartz - respirable crystalline silica dust - that was damaging the lungs of granite workers. These findings led to the first efforts for regulating and developing safe working conditions for those exposed to the risk of a harmful disease known as silicosis (Silica Safe, 2020).

In 2016, for the first time since the adoption of the Occupation Health and Safety Act in 1971, the US government issued an increase in regulation across all industries that produce respirable crystalline silica dust, i.e. the 2016 Silica Standards:

> "On March 25, 2016, OSHA published a final rule regulating occupational exposure to respirable crystalline silica (81 FR 16286). The final rule established a new permissible exposure limit (PEL) for respirable crystalline silica of 50 micrograms per cubic meter of air (50 mg/m3) as an 8-hour time-weighted average in all industries covered by the rule. The rule also included other provisions, such as requirements for exposure assessment, methods for controlling exposure, respiratory protection, medical surveillance, hazard communication, and recordkeeping. OSHA issued two separate standards— one for construction (29 CFR 1926.1153) and one for general industry and maritime (29 CFR 1910.1053)." (Department of Labor, 2019).

It has taken over 318 years from the first discovery of the dangers of respirable crystalline silica dust, to the enforcement of a standard across the entire nation. And yet, countless construction projects have little to no understanding of the dangers of silica dust, the proper techniques to prevent harmful exposures, or the regulations and the rights that protect workers from those harmful exposures. The creation and enforcement of these new standards do wonders for some workers in organized settings. However, there is a wide gap between these projects and the rest of the industry. Small projects, non-union projects, projects in areas where workers don't exercise as many occupational rights, can barely see any protections or understanding of the dangers of this deadly disease. With every increased regulation there is a gap that widens, and a disparity that increases in workplace health and safety. Whether you have zero exposure, or are on track to develop acute silicosis, it all depends on what project you find yourself working on, and certain demographic groups discussed in the literature review can be seen on either side of this disparity.

The importance comes from the idea of health equity. If the success of these newly implemented standards are much more present on large-scale, multi-billion dollar construction projects in cities like Los Angeles, but not on the residential project with undocumented workers located not three miles away, can this disparity be resolved by comparing the differences? Why do some workers have access to a silica safe work environment when others do not? What types of workers are more vulnerable to these unsafe work environments? If these questions can be understood, it would help solve the presented hypotheses:

What role does unionization play in helping companies follow the new standards?
What are the crucial factors that have helped some projects follow silica-safe protocol?
What types of projects are more susceptible to unsafe and dusty work environments?

Hopefully these questions can open a greater dialogue and provide an industry snapshot on the levels of silica safety and worker education today.

Chapter 2. Literature Review

The literature review is intended to be used as a tool to reflect upon and understand the history of silicosis, the wide range of demographics and standards in an industry as large as construction, and the systems for worker health and safety that are currently in place federally across the U.S. It is also intended to be used as a tool to analyze and discuss previous successes in the fight for worker health and safety protections, not all specifically pertaining to silica exposures. The intention is that successes within other aspects of construction worker health and safety may be applied to reducing silica exposures as well.

2.1 Silica Dust and Silicosis

What is respirable crystalline silica dust? Silica is a compound that occurs in the mineral quartz, and can be found in most types of rock, primarily sandstone. It therefore occurs in construction-related, stone-based materials like asphalt, brick, cement, concrete, drywall, grout, mortar, stone, sand, and tile. Respirable crystalline silica dust is created by activities such as abrasive blasting with sand; sawing brick or concrete; sanding or drilling into concrete walls; grinding mortar; manufacturing brick, concrete blocks, stone countertops, or ceramic products; and cutting or crushing stone result in worker exposures to respirable crystalline silica dust (OSHA, 2020).

Figure 1: *Heavy Silica Exposure (Benton, 2017).*

How is respirable crystalline silica dust harmful? Breathing in silica dust can lead to an incurable and deadly fibrosis disease known as silicosis, as well as lung cancer, asthma, pneumonia, tuberculosis, etc (CPWR, 2017). Because the silica dust particles are so fine and sharp, the dust gets into workers lungs and cuts up the respiratory system continuously, and the lungs begin to harden due to scar tissue build up. Eventually, a patient with silicosis will lose the ability to take in oxygen, because of the build-up of scar tissue. There is currently no cure for the disease, though lung transplants are possible. NORA states that however deadly of a disease it is, silicosis is highly preventable (CDC, 2013).

Figure 2: *Silicosis Lungs (Basque Museum of the History of Medicine and Science, 2007).*

Who is at risk of silica exposures and developing silicosis? All of the listed above are performed heavily across all aspects of construction and mining projects. Millions of workers in the US are exposed to silica dust through a variety of construction-related occupations. The CDC estimates that from 2005 to 2014, approximately 20,549 American workers died from pneumoconioses. Of that number, 1,167 of those died from silicosis. In a breakdown study of silica dust content in the construction industry, the CDC found that over 1,073 samples, 33.9 percent were over the permissible exposure limit set by OSHA (CDC, 2019). This means that approximately more than one third of registered and monitored construction projects are not meeting the standard of silica dust control.

Typical latency periods for developing silicosis are anywhere from 10 to 20 years, so workers that have been in the industry for a long time, working directly with silica-producing activities have a greater risk at developing silicosis. However acute silicosis is another form of the disease that can become onset within a few years if the worker is exposed to particularly heavy doses of respirable crystalline silica dust (Bleasdale, 2016).

2.2 Engineering Controls and PPE

How are respirable crystalline silica dust levels reduced and monitored on jobsites? The leading regulatory standard, and what is believed to be the best form of monitoring and control going forward, is the use of the new 2016 OSHA Standards on Respirable Crystalline Silica (§1926.1153). The standards are broken into 9 enforceable subparts c-k, and are listed here:

1926.1153(c): Specified exposure control methods. This section is where Table 1 is laid out. This table should specifically be the holy grail for future work done with silica containing materials. Table 1 lays out exactly what engineering and administrative controls are necessary for each task, and when a respirator is needed and which level of respirator to use.

Not surprisingly, the use of respiratory protection devices is not the major area of focus when protecting workers' lungs from crystalline silica dust. In fact, the table below shows that many silica-producing activities don't require a respirator at all if the proper controls are put into place. Engineering controls typically involve the use of water in cutting and ventilation in enclosed spaces. Administrative controls typically revolve around shortening the exposure time for a particular activity (trying to rotate workers from specific silica producing tasks).

Table 1: *OSHA's Table 1 from the 2016 Silica Standards (OSHA, 2016).*

Equipment/Task	**Engineering and Work Practice Control Methods**	**Required Respiratory Protection and Minimum Assigned Protection Factor (APF)**	
		≤ 4 hours /shift	**> 4 hours /shift**
(i) Stationary masonry saws	Integrated water delivery system	None	None
(ii) Handheld power saws (any blade diameter)	Integrated water delivery system	APF 10 (None when used outdoors)	APF 10
(vi) Rig-mounted core saws or drills	Integrated water delivery system	None	None
(vii) Handheld and stand-mounted drills (including impact and rotary hammer drills)	Shroud or cowling with dust collection system	None	None
(x) Jackhammers and handheld powered chipping tools	Integrated water delivery system OR Shroud or cowling with dust collection system	APF 10 (None when used outdoors)	APF 10

(xi) Handheld grinders for mortar removal (i.e., tuckpointing)	Shroud with dust collection system	APF 10	APF 25
(xii) Handheld grinders for uses other than mortar removal (OUTDOORS)	Integrated water delivery system OR Shroud or cowling with dust collection system	None	None
(xii) Handheld grinders for uses other than mortar removal (INDOORS)	Shroud or cowling with dust collection system	None	APF 10

If these engineering controls and personal protective equipment standards are put into place per the activity, then no formal measurements would have to be performed. The observed tasks in the field during the case studies in this thesis will use this table to compare whether appropriate cautions were taken.

1926.1153(d): Alternative exposure control methods. According to the standards, if an employer can test and prove that a task is not exposing the worker to dust levels above the 8-hour TWA exposure limit, the worker would not have to follow Table 1 protocol. If an activity or task is not incorporated into 1926.1153(c): Table 1, that task should be monitored with a dust measuring instrument, and employ proper engineering controls to ensure the exposure does not exceed limits.

1926.1153(e): Respiratory protection. As shown in Table 1 above, the activities only require the worker to be wearing APF 10 masks (besides tuckpointing which requires APF 25). This can be deceiving, because while these medical-style dust masks are seen so commonly on jobsites, they do not provide a sufficient level of protection if they are not paired with the proper integrated water-delivery or dust-collection systems. Workers must apply the proper engineering controls first, and then follow the required respirator protection afterwards.

Figure 3 below shows examples of the two commonly used masks. APF 10 masks are half-masks, meaning they only cover half of the face. These require fit tests, where a competent person ensures that the mask is sealed correctly to the face. APF 25 full-face masks don't require this fit test, as they are full-face masks. However, proper tests are required to ensure the mask and filter are functioning correctly.

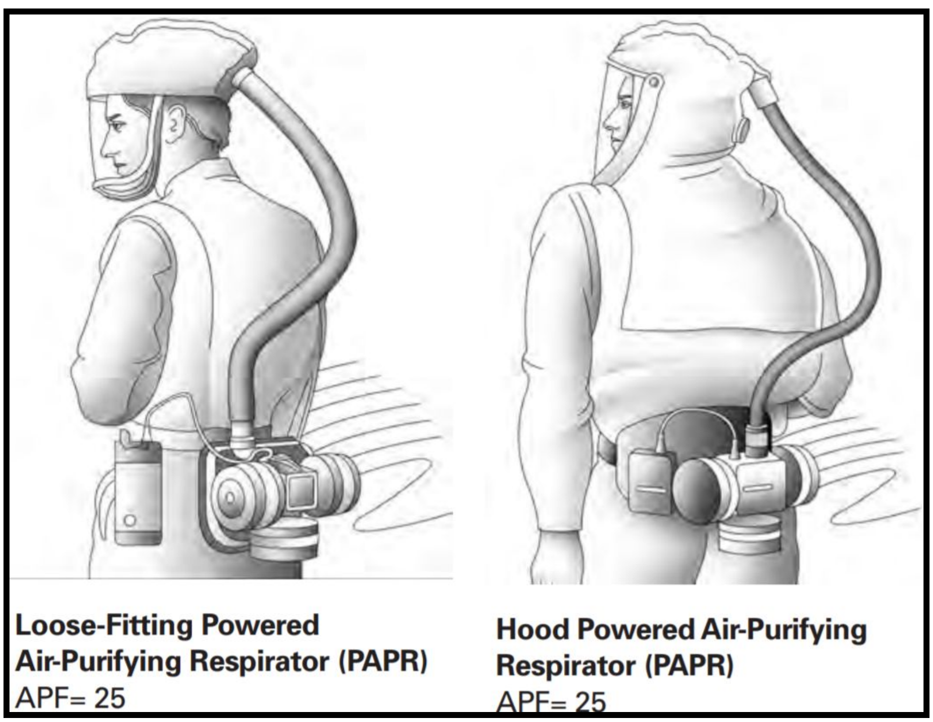

Figure 3: *APF 10 and APF 25 Masks (OSHA, 2009).*

1926.1153(f): Housekeeping. This is the simplest rule to follow. Dry sweeping should not be allowed when silica dust is to be swept (a dry or wet sweeping compound is to be used, or proper water misting/HEPA vacuuming technique). Compressed air should also not be used to clean silica dust.

1926.1153(g): Written exposure control plan. All construction contracting companies must have a written exposure control plan present on the site of the work being performed at all times, and the plan must comply with the 2016 OSHA Silica Standards and Regulations.

1926.1153(h): Medical surveillance. The contracting employer should be responsible for the medical monitoring of its employees that are subject to working with silica dust. Testing should occur prior to hire, and every three years following. Testing should include (NIOSH,2014):

- "A medical and occupational history to collect data on crystalline silica exposure and signs and symptoms of respiratory disease
- A chest X-ray classified according to the 1980 International Labour Office (ILO) International Classification of Radiographs of Pneumoconioses [ILO 1981]
- Pulmonary function testing (spirometry)
- An annual evaluation for tuberculosis [ATS/CDC 1986]."

1926.1153(i): Communication of respirable crystalline silica hazards to employees. Construction contracting companies are required to communicate the hazards of working with silica to their employees. This must be taken in two forms, jobsite warning signs and worker training.

Warning signs should be posted to mark the boundaries of work areas contaminated with crystalline silica. These signs should warn workers about the hazard and specify any protective equipment required (for example, respirators) (NIOSH, 2014).

Workers should receive safety training and education that includes the following (NIOSH, 2014):

- Information about the potential health effects of exposure to respirable crystalline silica
- Material safety data sheets for silica, masonry products, alternative abrasives, and other hazardous materials [29 CFR 1926.59]
- Instruction about the purpose and set-up of regulated areas marking the boundaries of work areas containing crystalline silica
- Information about safe handling, labeling, and storage of toxic materials
- Discussion about the importance of substitution, engineering controls, work practices, and personal hygiene in reducing crystalline silica exposure
- Instruction about the use and care of appropriate protective equipment (including protective clothing and respiratory protection).

1926.1153(j): Recordkeeping. This standard states that any form of knowledge, event, or happening that deals with silica dust on the jobsite must be recorded and kept for 30 years. This includes medical exams, air quality monitoring, and other objective data.

1926.1153(k): Dates. This section merely states that the standards came into effect on June 23, 2016, all obligations in the standards should have been enforced by June 23, 2017, and all recordkeeping and data collection obligations should have commenced by June 23, 2018.

There are several activities observed later on in this thesis that are not listed as an activity in Table 1, including mixing and pouring concrete and mortar, applying Shotcrete/gunite, and operating a Tunnel Boring Machine. Other tasks that are not laid out by Table 1 but should still be taken as dangerous. Hand concrete and mortar mixing often exceeds exposure limits when it is mixed onsite by one or two workers, as opposed to being mixed in a facility and transported to the jobsite by truck (Echt, 2017).

OSHA makes this clear in a standard interpretation from 2019, stating that "breaking open bags of mortar and dumping them into mechanical mixers for an extended period during a work shift could foreseeably result in employee exposures that reach or exceed the AL." (OSHA,2019). However, there is still no interpretation presented by OSHA that states the proper means for breaking open bags of mortar.

Spraying concrete presents another means for high exposures that is not discussed in Table 1. The spraying operator at the end of a Shotcrete hose in the United Kingdom is required to wear a battery operated respirator rated at APF 40 or higher (BOHS, 2020). The idea is that some tasks result in so much respirable silica dust, it is only acceptable to have an air monitoring device to decide the proper controls needed, rather than a table laying out specifics.

Highly specific forms of machinery and equipment that are only seen rarely are not presented for interpretation in Table 1, like the Tunnel Boring Machine (TBM). In a study conducted in Norway, operators of the TBM in the tunneling project had the highest exposure levels of crystalline silica (Bakke et al., 2001). Suggestions from OSHA on how to comply with standards while operating a TBM are nowhere to be found, other than to measure the air quality and apply the appropriate controls and respirator.

2.3 Silica-Safe Practice Enforcement

Who enforces these regulations? Ultimately, it is up to the employer and the general contractor to make sure that their employees are aware, protected, and safe at work.[1] It is the duty of the management to ensure a safe and clean work environment for its employees and projects. When that system fails, who comes in to enforce silica regulations?

State health and safety agencies (CalOSHA in California, MNOSHA in Minnesota, DOSH in Washington) have enforcement branches that are sent out to inspect jobsites periodically. High-hazard industries (tunnelling among them), have mandated inspections, whereas lower hazard industries (like construction) only get inspected upon complaint and accident investigation (CalOSHA, 2018).

Federal OSHA also employs an enforcement branch for inspecting jobsites, but like state health and safety agencies, their resources continue to be stretched thin, which doesn't allow for nearly enough coverage of random construction jobsite inspections. Table 2 is depicted below, and shows the gradual decline in safety and health compliance staffing from 1975 to 2017. The number of staff dropped from 1,102 employees to 896. Meanwhile, the number of construction workers in the U.S. more than doubled from 1975 to 2017, going from approximately 3,501,000 workers to approximately 7,093,000 workers (FRED, 2020).

[1] It is important to note moving forward that the General Contractor with the largest stake in the project is the one ultimately responsible for the health and safety of every worker on that project. While the employees may be employed by any subcontractor on the job, their safety is first and foremost in the hands of the general contractor (Washington State Supreme Court, 2019).

Table 2: *Federal OSHA Safety and Health Compliance Staffing, 1975 - 2017 (AFL-CIO, 2018).*

What role does Union representation play in enforcing health and safety standards on jobsites? Workers in the United States have been faced with adversity and exploitation in many forms, especially in the construction industry. Unionization and organization of workers has helped workers rise out of that adversity and exploitation. Unionized workers are more likely to exercise their rights under OSHA, and many previous studies have shown that health and safety inspections are much more frequent on union sites than their non-union counterparts (Weil, 1992). Some studies, however, point to the idea that labor unions, while effective in promoting worker wellbeing, are not up to speed in workplace safety and health, and thus don't represent the worker in that regard as well they could (Hagedorn et al., 2016).

When companies fail to enforce standards, can silica-educated workers be the driver of health and safety enforcement? Worker education is one of the bases for implementing the proper exposure-limiting engineering, administrative, and PPE controls. As stated above, the CDC requires that workers go through a training program to help protect themselves to high exposure levels, and posters explaining the dangers of silica dust should be posted on jobsite. Is this training sufficient in empowering workers to stand up for their health and safety rights? Does the training create enough empathy for the worker to follow silica-safe practices, and encourage others to do the same?

Studies have shown positive correlations between worker education, empowerment, and confidence in the ability to create a healthier working environment by approaching management with concerns (Wallerstein et al., 1992). Some companies have also reported great success in empowering workers with even greater access to training, and appointing special roles for working-craft safety management (Kiewet, 2019).

Chapter 3: Methodology

The study is broken down between two major U.S. cities, Los Angeles and Minneapolis. These two locations were selected for a number of reasons. One of those reasons was accessibility to construction sites and the people working there, but mainly they were chosen because they were both cities with strong union forces in the city centers, and they represented very different parts of the country. California and Minnesota are among the most heavily unionized states and have historically strong backgrounds for worker protections. 15.2% of all employees in California are unionized and 14.3% of all Minnesotan workers are unionized, both well above the U.S average of 10.1% (BLS, 2020). The reason it was important to use two heavily unionized cities was so that the level of Union leveredge could be somewhat equalized between the two.

A case study of one large, fully unionized project was done in both cities. The large, unionized project in Los Angeles was a tunneling project for a future subway, and the large, unionized project in Minneapolis was a 27-story historic renovation in the city center. While these are two very different projects, they were chosen because they both present the potential for heavier silica exposures than newly built vertical construction. Both projects involve a lot of demolition and removal of silica-containing materials, as well as a lot of newly poured concrete. It would be better to think of the demolition phase of the historic renovation project as a vertical tunneling project.

The other three case studies were taken from small, non-unionized projects. These consisted of a multi-family home construction in Los Angeles, a single-family home construction in Lake Elmo, Minnesota (a suburb of Minneapolis), and one rock-climbing gym project in Minneapolis. The residential projects were selected because of the vast differences they presented in their nature compared to the large projects, and the rock climbing gyms were studied because they were small, non-union projects with lots of silica-producing activities.

3.1 Personal Interview Methods

In total, 26 people across these five construction sites were interviewed. Of the 26, 11 were at a management level and either did not perform any of the physical labor, or sometimes participated in physical labor. The managers were classified as having primarily oversight and supervisory job duties, and eight of the nine were stationed with offices on the jobsite. Titles held by the managers included Project Engineer, Project Manager, Superintendent, and Foreman. The other 15 interviewees were all hands-on workers that routinely performed silica-producing activities. Most of the interviews happened while the interviewees were active on the site being discussed, besides the two examples of non-union projects in Minnesota, which were retrospective interviews.

Another subsequent interview was taken from a tunneling project in Seattle, Washington, without further field observation. This was done to compare to the case study of the Los Angeles tunneling project, and brings the total number of interviewees to 27. This interview was retrospective, and not taken during the time that the interviewee was currently working on the job. Again, field observations were not taken for the Seattle tunneling project.

Table 3: *Interviewees by Project Type*

	Union Project	Non-Union Project	**Total**
California	3	6	**9**
Minnesota	9	8	**17**
Washington	1	0	**1**
Total	**13**	**14**	**27**

Table 4: *Interviewees by State and Occupation Type*

	Managers	Laborers	**Total**
California	3	6	**9**
Minnesota	8	9	**17**
Washington	0	1	**1**
Total	**11**	**16**	**27**

The questions were selected to answer six domains about the interviewee. These domains will be compared in the analysis and used to answer study questions in the conclusion.

- ❖ Knowledge
- ❖ Education (Training)
- ❖ Concern for Health
- ❖ Trust in Management
- ❖ Management Approachability

Most of the questions were very broad and open ended, and they were meant to encourage the interviewees to elaborate on their understanding of the topics. These questions were selected to create open dialogue on silica and silicosis between the interviewer and interviewee. The interviews mostly changed from "question and answer" to the interviewee giving their narrative on dust exposures in the workplace, while still answering all of the questions in the prompt. Some interviewees were asked more questions than the ones listed below.

The 11 managers were asked the following set of questions:

1. How long have you been working on this project?

2. How long have you been working in [the construction] industry?

3. Do you ever wear a respirator when walking [around] the job[site]?

4. What masks (PPE) are provided to you?

5. Have you received formal training in silica safe practices?

6. What do you know about silica dust?

7. What do you know about silicosis?

8. Do you feel or have you ever felt like you are breathing in dangerous amounts of dust on this project?

9. Do you believe your company protects workers from breathing harmful amounts of silica dust?

10. Do you feel that your workers can come to you about concerns regarding harmful amounts of dust?

The 16 laborers were asked the following set of questions:

1. How long have you been working on this project?

2. How long have you been working in your trade?

3. Do any of your work activities involve [silica producing activities]?

4. What masks (PPE) are provided to you?

5. Have you received formal training in silica safe practices?

6. What do you know about silica dust?

7. What do you know about silicosis?

8. Do you feel or have you ever felt like you are breathing in dangerous amounts of dust on this project?
9. Do you trust your company management to protect you from breathing in harmful amounts of dust (without you knowing)?
10. Do you feel like you can approach your management about concerns regarding harmful amounts of dust?

All interview answers were recorded into a Table 12 in Appendix A. Answers were recorded into "yes/no" (1/0) when applicable, or graded on scales of 0-3 when applicable. The scoring systems are shown in Tables 5 and 6 below.

Table 5: *Silica Knowledge Scoring Table*

Rating	Description
0	● No prior knowledge of the terms "silica" or "silicosis." ● No understanding that there is any danger involved in breathing silica dust.
1	● No prior knowledge of the terms "silica" or "silicosis." ● Slight understanding that respirating rock dust is harmful to the lungs. ● No knowledge of proper engineering controls and/or PPE.
2	● Prior knowledge of the terms "silica" or "silicosis." ● An understanding of why breathing silica dust is harmful to the lungs. ● Some knowledge of the proper engineering controls and PPE required.
3	● Prior knowledge of the terms "silica" or "silicosis." ● An understanding of why breathing silica dust is harmful to the lungs ● A strong understanding of the 2016 OSHA Silica Standards.

Table 6: *Level of Respirator Provided Scoring Table*

Rating	Description
0	No respirator provided by management
1	One single-use APF 10 mask provided by management
2	Unlimited single-use APF 10 masks provided by management
3	Reusable APF 10 mask (or greater if task requires) w/ fit test provided by management

3.2 Field Observation Methods

Field observations consisted of observing how silica-producing tasks were handled compared with 1925.1153(c) Table 1, the level of visible dust in the air on any given day, and whether or not the jobsite followed the rest of the standards in CFR 1925.1153(d-j). These field observations occurred over a number of days, weeks, and sometimes months. In a study conducted by the University of Washington Department of Environmental and Occupational Health and Safety, researchers determined exposure levels by activity (Flanagan et al., 2003). This study determined the top eight most common silica-producing activities on construction sites. Special attention was taken to the execution of these tasks. Those activities are[2]:

1. Cleanup
2. Demolition Using Hand Tools
3. Concrete Cutting with Handheld or Table-Mounted Saws
4. Concrete Mortar Mixing
5. Tuck-Point Grinding
6. Surface Grinding
7. Sacking and Patching Concrete
8. Concrete Floor Preparation with a Sandpaper Disk

This methodology was chosen for simplicity, as it's easy to compare an observed task to the proper controls of Table 1. It was also chosen because of pure feasibility, and the fact that field observations could be taken over such long periods of time. A list of all observed broken sections from the OSHA Silica Standards will be given, as well as ones that were observed to be followed correctly.

The field observations did not consist of any formal dust measuring instruments. Silica dust and exposure levels are difficult to measure on a typical basis due to the fluctuation in jobsite

[2] Other activities producing dangerous amounts of respirable silica dust were seen and discussed further in the study.

activities throughout the day (Flanagan et al., 2003). It wouldn't have been as feasible to take measurements for quantification, and that also wasn't the goal of this study.

All people being interviewed have elected to remain anonymous, and all projects being reviewed have requested to remain anonymous, besides both of the case studies taking place in Los Angeles, who gave up some liberties to discuss their project name.

3.3 Study Limitations

Hopefully the content in this thesis can be used as a launching point for further field research on the topic of silica exposures. There were many domains that the author wanted to test further, but the research constraints did not allow those. Hopefully future studies can be conducted without the limitations in this one.

Limited geographic locations of construction sites. A further study that covers more unique demographic locations may give a stronger understanding of silica protections across the United States. For example, the construction industries in both Los Angeles and Minneapolis are heavily unionized. Time and connections permitting, it would have been helpful to survey construction sites in states such as Louisiana or South Carolina, where the percentage of workers in unions are respectively 5.3% and 2.2% (BLS, 2020). These places undoubtedly have differing demographics, and might see less regulation when working with silica-containing materials.

Project type incompatibility. Another limitation was the type of work being performed on both large, union jobs during field observations. The project in Minneapolis was a commercial building, a historic renovation. The project in Los Angeles was a tunneling project. While both projects contain lots of potential for very heavy silica exposures compared to new vertical construction projects, it would have been great to review a tunneling project in Minneapolis and a historic renovation project in Los Angeles. It would have also been great to have had access to observe the operations of the Seattle tunneling project as well.

Interviewee sample size. The sample size of people being interviewed was much too small to attempt any formal data calculation from answers. The figures shown in the Analysis and Appendix A should be taken lightly, and should not be meant to prove any causation. Getting people to interview was difficult due to the amount of workload that subjects already face in high demanding construction occupations. A more quantitative study could be done in the future with a greater sample size with a greater representation of the construction industry population.

Extreme cases of jobsites are not entirely representative of the bigger picture. It would be fair to say that the Los Angeles project is on the extreme side of an unorganized project, and not representative of other non-union jobsites operating under CalOSHA's safety standards. It also had an extreme amount of concrete being poured for a residential project, as well as a unique method of form-building.

Wide disparities in observation time periods could create bias in case studies. Some of the job sites gave access for field observations over an eight month period, while others were limited to less than a week of observations. Given the chance to observe those jobsites for a longer period of time, there may have been more instances of observed compliance failure.

Lack of silica-dust measuring instruments. In a further quantitative study, a greater look at the failure to comply could couple quantitative samples taken with measuring instruments with the qualitative samples from field observations and personal interviews.

Chapter 4. Case Studies

This study is based on five separate case studies of five construction projects, with a subsequent interview taken from a separate project. These case studies are organized by their location (except for the Seattle project, which was placed directly after the Los Angeles tunneling project for comparison). Each case study will include an overview, followed by a description of the field observations and a description of the general contractor silica control plan, and then ending with a summarization of the personal interviews from the project.

4.1 Los Angeles, California

4.1.1 *Subway Tunneling, Union Project [LA - U]*

4.1.1.1 Overview

Oftentimes when occupational health professionals discuss the history of silicosis in the workplace, it revolves around the coal mining and resource extraction industry. Mining operations are inherently enclosed spaces and involve the crushing and removal of stone and packed gravel, and modern times call for precast or cast-in-place structural concrete shoring systems and walkways. Left unchecked, mining jobsites can be (and have been) deadly with heavy concentrations of silica dust. Though the end-goal is different, the potential for silica exposures in subway construction projects are the same as for coal extraction. The subway tunnel is still a mining project, and thus presents a lot of opportunity to expose workers to heavy amounts of silica dust.

Today, in an effort to solve large cities' transportation problems, mining and tunnel construction projects are abundant across the United States. This is especially true in Los Angeles, a city known worldwide for its traffic congestion. Los Angeles currently has two tunneling operations running, with two seperate Tunnel Boring Machines (TBM's). One project is located on the East side of downtown LA in Little Tokyo, while the other project is located in Beverly Hills. The jobsite observed for this case study was the one located in Beverly Hills, a planned extension to the already running map shown below.

Figure 4: *Los Angeles Extension Map (Metro, 2020).*

As a multi-billion dollar public works project located in the center of the second largest city in the U.S., the Westside extension is heavily unionized and heavily scrutinized by the city. Any subcontractor operating without union certification was not allowed to bid work on the project. Union officials would visit the jobsite monthly to check union identification cards. Representatives from CalOSHA would visit the project up to 7 times a week for safety and health inspections. This was mostly related to testing for methane levels in the mine air, but when health and safety authorities were onsite they would also inspect silica-producing activities, fall hazards, electrocution safety, etc.

4.1.1.2 Silica Control Plan

The safety management team alone on this project was greater than the entire management staff on any of the other projects in this study. The silica control plan developed by the general contractor was extensive, and laid out in two separate documents. One was in a project-wide safety document that was put together by the joint venture between three contractors. The other was specific to the Westside project's silica safety needs.

The job-wide program gave a simplified version of OSHA Table 1 to follow. The idea is that this would make it easier for workers to follow the proper engineering controls when performing silica producing activities. The Westside-specific program reiterated much of the job-wide program, with a few exceptions. It included the specific medical examination required for all employees working on the project that are involved in silica-producing activities for more than 30 total workdays. It also laid out mandatory documentation and recording procedures for air quality in the mine, as well as specific instructions to stock and supply everyone working in the mine with a reusable APF 10 respirator with a filter on request. Most importantly, it contained information on a mandatory employee silica safety training video. This was to be watched by all employees that would potentially be at risk to dangerous exposures, and was one aspect of the silica control plan that differed from all others in this study.

4.1.1.3 Field Observations

These tunneling projects are huge and highly complex, and almost every aspect of construction occurs, from pile driving to trim installation. At any point in time there could be up to 300 trade workers in the mine. For the sake of feasibility, the observations taken were limited to the workers operating the TBM, those applying Shotcrete, and those pouring cast-in-place concrete.

Tunnel Boring Machine Operation

As the tunnel boring machine moves forward, it grinds and cuts through soil with the cutterhead, pulling the displaced soil through the excavation chamber and onto a conveyor belt. The Los Angeles project had an installed water-misting delivery system inside of the excavation chamber, wetting any soil and rock that came through the conveyor belt. This created zero visible dust past the bulkhead and in the shield. Any silica dust inside these places was negligible, or didn’t matter because no worker would move past the gripper shoe during TBM operation. The only reason any worker would move past these points and closer to the cutterhead was when there were mechanical problems with the machine, and the engineer and/or mechanic needed to access it. Workers that were operating inside the TBM did not wear respirators of any kind, and no dust was apparent in the work space.

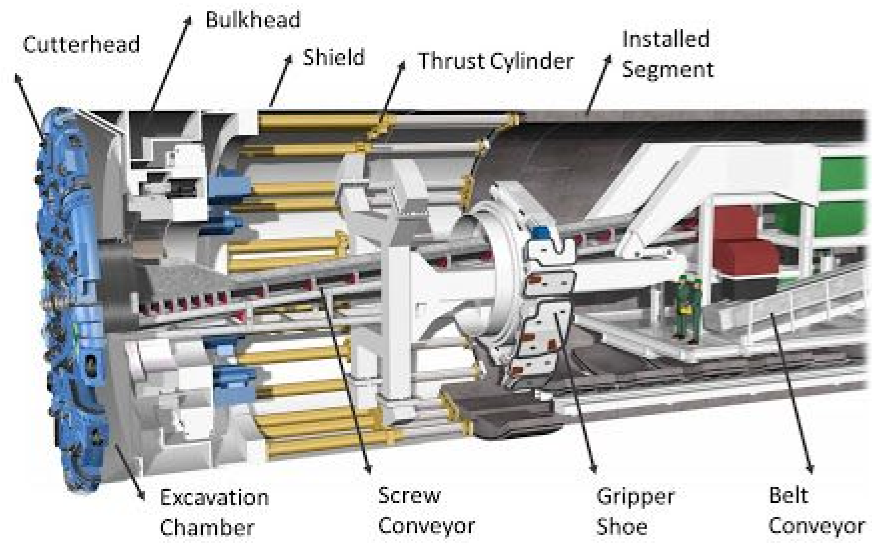

Figure 5: *Tunnel Boring Machine Diagram (RailSystem, 2015).*

Shotcrete Installation / Cast-In-Place

There were two types of concrete applications throughout the field observations, shotcrete and cast-in-place through a hose and a truck. During the application of cast-in-place, all workers anywhere near the gunite process were required to be wearing full-face APF 25 respirators, with an attached filtration system. The administrative controls were used in this situation by restricting anyone from going near the site of the Shotcrete work if they were not essential to the task. During the pouring of cast-in-place concrete, all workers within a small radius from the site of the pour had to be wearing a fit-tested, reusable APF 10 respirator with a filter. Again, administrative controls called for only workers absolutely essential to the task to be present for the pour.

Concrete Cutting / Chipping

When pouring concrete, it was much more efficient to pour the forms all the way through, and then come back through with core-drilling for pipes rather than form the pipes into concrete. This allowed more flexibility and greater room for error throughout the process. The electricians on the project performed core-drills, and laborers chipped and jackhammered at excess concrete.

Anybody that was core drilling was required to use a water integrated delivery system, and wear a reusable APF 10 respirator with a filter. This is going beyond the requirement of just using the engineering control. Throughout the observations, any electrician that was performing the core drilling, or anywhere near the act of the core drilling, was wearing a reusable respirator.

The laborers that were chipping and jackhammering were required to do so with an attached shroud collector as an engineering control. They were also required to wear the reusable APF 10 dust mask. During field observations, everybody that was performing or nearby during any concrete chipping, wore a reusable APF 10 mask with a filter.

During field observations, all OSHA silica standards were followed correctly:
1926.1153(c) Table 1, 1926.1153(d) Alternative recordings, 1926.1153(e) Respirators, 1926.1153(f) Housekeeping, 1926.1153(g) Written exposure control plan, 1926.1153(h) Medical surveillance, 1926.1153(i) Communication, and 1926.1153(j) Recordkeeping.

4.1.1.4 Personal Interviews [L1, M1, M2]

In total, three people were interviewed on the Los Angeles tunneling project. One was a low-level manager, a project engineer. One was the safety manager from the general contractor, overseeing all aspects of safety and employee health on the Westside project. The third was an electrician employed by the electrical subcontractor on the job, working closely with the tunnel boring machine.

The project engineer had been working on the Los Angeles tunneling system since he graduated with a civil engineering degree three years prior. He had been stationed on the Downtown project for the first two years, and had now spent a year on the Westside extension. His duties differed from day to day, but he spent roughly three quarters of his time physically in the mine, and the other one quarter at his desk in the job site trailer. His job was mainly to work with the carpentry subcontractor on quality control issues, where he worked daily with almost every carpenter present.

When asked if he ever wore a respirator when walking around the jobsite, he said that he never had and never felt that he needed to. He felt that he had never entered a situation or environment inside the mine where there was a dangerous amount of dust in the air. He was provided as many standard APF 10 single-use masks as he wanted (boxes of them were located in several different places around the mine). Also, he stated that on request, anyone on the project at any time could request a reusable APF 10 half-mask, and they would receive a fit test and proper training on use and treatment of the mask.

He received training on silica dust and silicosis through his OSHA 30 training, and he stated that all of his managerial co workers received the same type of training on the disease. He explained that he knew the dangers of silica dust, where it came from and how it was produced, and that he was aware OSHA had come out with some strict standards regarding the illness. He wasn't aware though, of what those standards were, or of the Table 1 that showed the proper PPE, engineering, and administrative controls for each task. Though he stated that he didn't know of Table 1, he was sure that each of the labor subcontractors had a sufficient number of competent persons on the job, because silica exposures were taken very seriously. He believed that if any worker on any part of the project had an issue with the amount of dust on the job, or had a complaint about the lack of access to a respirator, it would be taken care of promptly.

The Safety Manager on the project had a lot to worry about on a day to day basis. He oversaw every aspect of worker health and safety on the purple line extension. The main area he had to spend most of his time on was ensuring that the methane detectors in the mine were working, because every day the crews would hit methane pockets that would shut the jobsite down and bring one or two CalOSHA representatives out to clear the job and allow them to continue work. This, he said, was adversely another driving factor in why this tunnel was so free of dust in the air. He stated, "when you have government health and safety officials on a jobsite this big every day, you have to run a very tight ship."

The safety manager had been working for almost two decades in construction health and safety, specializing in tunneling, and had been on this specific tunnel for three years now. He stated that he never wore a respirator when walking in the mine for the purposes of silica exposure, but that everyone entering the mind was required to bring a respirator and oxygen tank with them, in case of high methane exposure levels. He stated that he never had to wear a respirator because every crew that worked with silica or performed activities that produced silica dust followed the essential engineering controls as laid out in Table 1, and he was never close enough to crews that were performing tasks that also required respirators. He stated that in his two decades of work, this had by far the [least respirable silica dust] out of any project he had been involved in, and that the industry had changed significantly in the last five years to make this happen.

He stated, as the project engineer had stated, that everyone on the jobsite was entitled to a reusable APF 10 half-mask at the request of the general contractor. He stated that even some workers were required to wear heavier respirators than required. For instance, workers spraying shotcrete were required to wear full-faced APF 25 masks (a mask rating that is only called for during tuckpoint under OSHA Table 1). Anybody that requested a reusable APF 10 half-mask could get one right then and there, and would have a fit test immediately provided for them, as well as training on proper use and maintenance.

The electrician had been working in the tunnel for just 13 months, out of the four years he had been in the trades. His job didn't involve much in the way of producing silica, as he was mostly there to perform maintenance on the tunnel boring machine, but when he wasn't stationed in the TBM he would be out core drilling and roto hammering concrete for whatever his foreman told him to. He said that he had access to as many dust masks as he wanted, but he and most of the coworkers that he knew on the project had requested reusable APF 10 masks, and he wore that whenever he was core drilling or roto hammering.

He said that he hadn't received much in the way of "formal" silica safe training, but he had to watch a short video on the dangers of silica exposures before he started working on the project. He said he didn't retain much of the science behind why it's bad for you, but that the images of unhealthy lungs scared him into wearing a respirator whenever he worked with silica. He stated that now that he knew silica dust was as dangerous as it is, he didn't always trust his foreman regarding safe levels of dust as much as he used to. He never asked his foreman about the right methods to take when performing silica-producing tasks, he just always made sure there was a “water getting the dust down” or a “vacuum on the tool” and that he always wore his reusable mask. Although he said he didn’t always trust his management with providing the right [engineering controls] for the specific task, he did trust them to get any equipment he needed to make his job safer. “If I wanted a new mask, or a new tool with the water or vacuum equipment, I could get it within the hour probably.”

4.1.2 *Comparative Interview: Seattle Tunneling, Union Project [SEA - U] [L7]*

To contrast against the highly effective and enforced silica plan of the Los Angeles tunneling project, a subsequent interview was conducted with a union electrician from a tunneling project in Seattle, Washington. The electrician interviewee will be referred to as "S" from here on out for anonymity and simplicity's sake. The interview was retrospective, and the S was reflecting on her time on the project between the years of 2016 and 2018. At the time, she was going through her third and fourth years of an electrician apprenticeship program. As a graduate student studying occupational health and safety in construction now, she now reflects back on her time on the project with dismay, thinking about the harmful levels of dust she was exposed to.

On a daily basis in the tunnel, she would be involved in any number of silica-producing activities including saw-cutting, core-drilling, and roto-hammering/concrete chipping. For the first two-thirds of the time she was on the project, no engineering controls were used whatsoever, except for two industrial fans placed at the either end of the 1.5 mile long tunnel. For the last ⅓ of her time on the project, her employer gave her a shop-vac to use as a "shroud collection system" while roto-hammering concrete. For her last six months, a set of water-misters were placed sporadically around the job to cut down on the amount of stagnant dust in the air. This is not equivalent to an integrated water delivery system needed to complete the saw-cutting and core-drilling she was performing weekly. When asked whether masks were provided for her from her employer, S stated that "dust masks were provided sporadically, and would have to be reused for weeks at a time."

S had never received any formal training through her union, employer, or any other source at the time of her work on the project. She had never heard the terms "silica dust" or "silicosis", and didn't think that breathing in concrete dust was harmful. She stated that (at the time) she believed that if she was ever breathing in harmful amounts of dust her employer would put a stop to it, so she didn't "pay much mind" to the levels of dust in the tunnel. She trusted her company to tell her if she was being exposed to harmful situations. On the other hand, S felt that she or anybody else on the crew had no problem speaking up to their foreman or other supervisors when they felt there was a threat to their safety or health on the job. S stated that whenever a safety problem was brought up (frigid temperatures and metal pipe work, ice on scaffolding, lock-out-tag-out procedures, etc.), the issue was always resolved by the end of the day. However, because S and her peers (and mostly likely her foreman as well) didn't understand the dangers of silica dust, the issue was never brought up. Over the two years she worked there, she guessed that health and safety officials visited the project approximately six times, but never inspected any of the work she was doing, as she was told to stop working as soon as the officials walked on site. Also during her two years, her union representatives only came to the site twice, and each time was just to check workers for union cards.

S believes that she is still suffering from the effects of the dust to this day, two years after she stopped working in the tunnel. She started suffering from respiratory-related symptoms about six months into her time in the tunnel. Her reported symptoms and time frame are not really indicative of silicosis development, but could be other complications caused by breathing in excessive amounts of dust. She states that several of her coworkers developed similar symptoms in a similar timeframe

4.1.3 *Los Angeles Single-Family Construction, Non-Union Project [LA - NonU]*

4.1.3.1 Overview

The Waterloo House is a single-family construction project being built in one of the fastest up-and-coming and trendiest neighborhoods in Los Angeles. The architecture, materials, and constructability methods are incredibly unique, utilizing 2x6 concrete formwork techniques to build pour-in-place concrete walls for the first two floors and the basement of the house. When complete, the house should be an architectural marvel, with it’s own stormwater collection system and tanker (made entirely of concrete) and efficiently designed landscape to allow for a completely self-sustaining urban farm in the heart of one of the largest cities in the U.S.

Figure 6: *Concrete Walls in Los Angeles*

The labor being used and the organization of the workforce represents the antithesis of the unionized tunneling project located not 3 miles away. The job is headed by the “Master Builder”, the owner and designer of the home with a long career as a builder. He employs a crew of four full-time workers, all skilled in carpentry and masonry. The project is about as under-the-table as it gets, and everyone on the crew is paid bi-weekly in cash. Any benefits such as health care are completely out the window, and no one on the crew reports any earnings or pays any federal or state income tax. All workers on the crew provided their own tools and PPE.

Depending on the type of work to be done on any given day, a crew of three to seven day laborers might be picked up from the Home Depot parking lot in Hollywood. Typically, none of these day laborers spoke any English, and were all undocumented immigrants from El Salvador, Guatemala, and Mexico.

4.1.3.2 Silica Control Plan

Needless to say, a house made mostly of concrete presents lots of challenges when it comes to silica exposures. Observed silica-producing activities consisted of:

1. Cleanup
2. Demolition Using Hand Tools
3. Concrete Mortar Mixing
4. Surface Grinding
5. Other

On this jobsite, the dangers of silica were never spoken about and all aspects of safety were in the hands of the worker, including acquiring their own PPE and respirators (outside of the dust mask provided by the employer).

4.1.3.3 Field Observations

Cleanup

Cleanup occurred on the jobsite every day by at least one laborer who would keep tidy while the rest of the crew worked. This involved stacking lumber forms covered in concrete dust from previous floors, cleaning up dried concrete slurry from previous pours, as well as sweeping the dust that collected on the concrete slabs. Dry-sweeping was an everyday occurrence, and the employer did not provide any sweeping compound as required by OSHA 29 CFR 1926.115(f).

Probably the most awful aspect of the job was the basement made entirely of concrete walls, floor, and ceiling. This basement was accessed through a hatch where a ruggedly built ladder brought people up and down. There were six large window openings on the North and South walls, which led to window wells and outside air. There were no ventilation or dust collection techniques being used in the enclosed space, except for a 2' x 2' house fan. At one point, a day-laborer was sent to the basement to clean up excess dried concrete slurry from the finished slab. He worked with a hammer and masonry chisel for seven work days in this enclosed space with an APF 10 dust mask supplied to him by the owner of the project.

2' x 6' forms were recycled after each pour for the next one. The removal process is described below in the demolition section, but the formboards needed an extensive amount of cleaning to remove the dried concrete from them in order to leave the grain of the board visible for the next pour. The cleaning consisted of scraping the used boards with a thick metal brush to remove all of the dried concrete that stuck to the boards. This activity created a considerable amount of visible silica dust, and none of the employees wore respirators greater than APF 10 dust masks.

Demolition Using Hand Tools

After every vertical concrete pour, the crew would strip the 2x6's being used for the forms, clean them, and use them for the next set of forms. This removal process was not unique to this job, as formboards are typically reused to decrease waste. The boards would be tapped off gently with a hammer (in order to not disturb the finished wall product) or pried off gently with a crowbar.

When the form boards would break loose of the pressure from the expanded concrete, they would fall to the ground at the same time. The faces of these form boards still contained a large amount of dried concrete, which would blow up in a dust cloud when the board dropped. None of the workers would wear a respirator during this activity (except one who wore a reusable APF 10 mask).

Figure 7: *Reused Concrete Form Boards, Scraped*

Concrete Mortar Mixing

During pours, concrete would be delivered by a truck, and would come premixed. One worker would stand by the truck to ensure that enough concrete was flowing from the truck to the mobile pump which supplied the stream of wet concrete to the house, and finally to the formwork. When the concrete stopped flowing from the truck to the pump, the worker would move it down with a shovel, or smack the ramp with a shovel to get the sludge to move down.

Though the concrete was wet, some dust was present, likely from the mixing process, and from mortar that wasn't sufficiently mixed in. When the worker smacked the ramp with his shovel, a cloud of dust would form. The worker would not wear any respirator during this activity.

Surface Grinding

One worker recalls being tasked to grind and level the top of several poured-in-place concrete beams to allow for wood base plates to sit atop them. The task involved grinding over 200 feet of 8-inch concrete beams to a completely level surface, and took about two full working days. The tool he used had no water-spray or shroud-collection hookup. The worker quickly realized at the start of the first day that it would take more than a medical mask to shield himself from the amount of dust created by the grinding, and the worker had a little understanding that breathing concrete dust was harmful in some way to him. He showed up to work the next day with a 3M, Medium Professional Multi-Purpose Respirator that he found at the Home Depot. The worker was unaware of the level of safety it provided, just that it seemed more sufficient for the task than an APF 10 dust mask. When he showed up for work the next day, his coworkers derogatorily referred to him as wearing a "[expletive] mask".

Other Silica-Producing Activities

An impact rotary hammer drill was used to drill deep holes that were small in diameter to insert necessary vertical rebar into the already-poured concrete. OSHA Table 1 requires that this tool uses an integrated water delivery system or dust collection system. This task was routinely performed on this project, and the worker performing it had no water suppression or dust collection system, and wore no respirator.

During field observations, none of the eight OSHA silica standards were followed correctly: 1926.1153(c) Table 1, 1926.1153(d) Alternative Recordings, 1926.1153(e) Respirators. 1926.1153(f) Housekeeping, 1926.1153(g) Written Exposure Plan, 1926.1153(h) Medical Surveillance, 1926.1153(i) Communication, and 1926.1153(j) Recordkeeping.

4.1.3.5 Personal Interviews [M1, L2, L3, L4, L5, L6]

At the Waterloo House Project, six people were interviewed. Of the six, all of them performed activities that put them at risk to silica exposures above the permissible exposure limit. The sole manager on the project was interviewed, and it's important to note that he was a working manager, more of a foreman with bags on that worked with the rest of the crew, and was thus exposed to the same silica-producing activities as the rest of the crew. For the sake of this study, he was interviewed as a manager because he was the sole employer of the crew. For the sake of anonymity, he will be referred to as "M."

M had been working in the construction industry for approximately 20 years. He was primarily a framing carpenter throughout that time, but spent a few years working as a concrete formwork carpenter in a non-union setting. He had been given a large sum of money from his family to build a house in Los Angeles, and has been working on that project as a worker and employer for two years.

M has never received any training in silica dust suppression, or silicosis awareness. While he stated that he knew that breathing in concrete dust was generally unhealthy for you, he believed that it wouldn't do any permanent damage to your lungs. M was more concerned about concrete that was still wet coming into contact with his skin and damaging it permanently. Most of the time, M would not wear a respirator when on the jobsite, unless he was using a tablesaw to cut wood in an enclosed space, in which case he would use an APF 10 dust mask.

While M believed that the project was dusty, he said he never really thought about it and the fact never really concerned him. After work, he would often leave the jobsite covered in [silica] dust, or he would use an air compressor to blow the dust off of himself. At one point, M bought a number of medical masks to give to his workers if he or they were concerned about the amount of dust they were breathing in. He believed these masks were adequate, and that if the workers wanted greater respiratory protection they would have to go buy masks for themselves. If the workers were concerned about the amount of dust they were breathing in at work, they should figure out how to limit the amount of dust they created during their activity.

The other five interviewees were all full-time employees of M, and worked solely on the Waterloo Project. Their interviews are summarized and described below.

Most of the crew had been working on the project for approximately one year or less. The crew's experience working in the construction industry ranged from less than one year to 15 years. All of the workers were involved in silica-producing activities at some point on the job. No one on the crew had received any formal training in silica-safe practices, and no one on the crew had ever heard the terms "silica dust" or "silicosis", though everyone seemed to agree that breathing in concrete dust caused long-term harm to the respiratory system.

The entire crew believed they were exposed to dangerous levels of [silica] dust on the job. When probed if they were concerned, three stated that they were not concerned about their respiratory health, one stated that they were somewhat concerned about their respiratory health, and one stated that they were very concerned about their respiratory health in regards to dust in the workplace.

Everyone on the crew was provided one APF 10 dust mask at the start of the project, and was expected to reuse it multiple times instead of asking for a new one. When asked if they could go to their employer about concerns over harmful levels of dust on the job, no one on the crew trusted that their employer would respond in an empathetic way or increase protections for them from exposures. None of the crew believed that it was up to the employer to protect them from harmful levels of dust.

4.2 Minneapolis, Minnesota

4.2.1 *Downtown Historic Renovation, Union Project [MN - U]*

4.2.1.1 Overview

This project, fully unionized and with a contract of more than $50 million, took place in the center of Downtown Minneapolis. The city's labor force is heavily unionized, and any construction work being performed in the downtown core has to be performed by a union contractor, unless that specific task does not have a representative union. The General Contractor overseeing the construction was a large and well known, national company based in Minneapolis. The 27-story art-deco building was originally constructed in 1929, with several small tenant-improvement renovations being performed during its 90 year lifespan. The project being observed in this case study was the first full-building overhaul since its original construction, and was intended to convert the building from a commercial office space to a high-end hotel.

Every wall besides the exteriors and the elevator shafts were to be stripped. This involved a significant amount of demolition and concrete cutting, two activities with high potential for silica exposures. To make way for new pipes, new holes were core drilled through the existing concrete slabs on every floor. Large amounts of the existing concrete slabs were also cut from every floor to make way for a new staircase and a new elevator shaft. New slabs and concrete patching were also poured and finished. The exterior of the building, made of limestone and mortar, were to be refurbished. This involved a large amount of mortar tuckpointing, the only task in OSHA Table 1 that requires the use of an APF 25 respirator.

4.2.1.2 Silica Control Plan

The General Contractor's silica control plan consisted of two documents. One was a documented Silica Awareness Program. This document laid out the dangers of respirable crystalline silica dust and the appropriate plan for reducing employee exposures. It was intended to be read by each employee to increase their awareness of the dangers and their rights to prevention and medical care, though no employee interviewed had ever seen the document. The other was a checklist Exposure Control Plan intended to be completed by a foreman if their crew was participating in a silica-producing activity, and it was to be reviewed by the jobsite safety manager. The checklist went over the task being performed and the proper engineering administrative, and PPE controls required for the task at hand.

The General Contractor employed a safety manager who would come to the jobsite every Friday for a walk around. The safety officer never commented on the amount of dust, and was primarily concerned with the unmarked core drills, fall hazards, and improper ladder use. The demolition subcontractor was the only one who employed a safety manager that would come to the site roughly once a month to complete a checklist. Each subcontractor had to supply a Silica Safety Data Sheet before beginning work, handed off before their scope of work began. There was an Industrial Hygienist/Environmental Consultant staffed on the jobsite and was not allowed to leave at any point that construction activities were taking place. This was due to the amount of asbestos abatement being performed, but he was also present to monitor the air quality when asked by the General Contractor's superintendents.

4.2.1.3 Field Observations

The first observation that needs to be made about this project is that for the first eight months there was visible dust on every floor being worked on at any time. Again, the building was 90 years old, had a lot of settled dust, and the demolition process was extensive and very dust-producing. Figure 8 below shows what the average floor looked like on a day-to-day basis, even when no activity was happening.

Figure 8: *Visible Dust*

Cleanup

Cleanup was an essential part of every day for the general contractor. The Senior Superintendent on the project often stated how important cleanup was to the efficiency and safety of the workers on the project, and every subcontractor had a daily "broom-finish clause" in their contracts. Everyday, a crew of one worker from each subcontractor was assembled and sent to clean each floor of the building that was being worked on. For the most part, this cleanup crew all wore masks and used a sweeping compound to control the dust. The amount of dust this crew swept into the air was still extraordinary and clouded the rooms. If a worker was seen without a mask, they would be informed that it was in their best interest to do so by the superintendent that was running the cleanup crew. The use of the mask was still voluntary, not mandatory.

Another noticeable flagrancy of silica-safe policy was that, mo0re often than not, no one working in proximity to the cleanup crews wore the proper dust masks. The layout of floors was extremely tight in the building, and the cleanup crews would often be working right next to electricians, carpenters, etc. These other crews, although working in the same cloud of dust as the cleanup crews, almost never wore respirators. The idea seemed to be that workers were only encouraged to wear a proper respirator if they themselves were the ones creating the dust.

One worker was observed sweeping up a room following drywall installation. The room was similar to the one shown in Figure 9 below, with silica-containing drywall dust collected all over the floor.

Figure 9: *Drywall (Silica) Dust*

The worker was a general laborer, was employed directly by the general contractor, and was not using any of the dust-suppressing compounds supplied by his employer. He was also not using the medical mask supplied to him. When asked why he wasn't using any of the engineering controls or PPE required to complete the task, the worker replied that those items (the sweeping compound and masks) were in the basement, and he didn't want to take the elevator down to retrieve them. When asked if he understood the dangers of sweeping dust in an enclosed space without the proper specified protections, the worker replied that he "knew and didn't care."

Demolition Using Hand Tools

The demolition subcontractor had the largest crew of workers out of all of the contractors on site, by far. They were the first to mobilize onsite, working directly with the asbestos abatement contractor to identify hot areas. Soft demolition began on the top (27th) floor, and worked its way down the building. Abatement would follow behind, and then hard demolition would sweep through after abatement was finished.

The demolition process was the culprit for the amount of visible airborne dust on the project. Most of this dust was created from removing old drywall and plaster, saw cutting through the existing concrete slabs, and jackhammering/chipping concrete beams. These activities were compounded by the amount of dust that had been collecting in the building during its last 90 years of occupancy. The vibrations from jackhammering and related activities would shake the dust from these places of build-up.

The demolition contractor did not make many solid attempts at limiting the amount of dust they were creating. There was a mass worker complaint about the amount of dust in the building, and many workers took this up with the superintendents from the general contractor. The demolition subcontractor was scolded and told to do something about the amount of dust they were creating, or they would be booted from the job (it was their fourth safety violation in the first six months of the job). The solution was to start using a makeshift shroud collection when they were chipping out beams. One worker stood with the rotohammer above their head, while a coworker stood right next to him with a shop-vac to collect the dust. These two workers repeated this process every day, eight hours a day, for approximately three months until all of the beams were fully chipped out. Both wore single-use APF 10 masks throughout the process.

Concrete Cutting with Handheld or Table-Mounted Saws

During renovations of buildings with concrete floor slabs, oftentimes new layouts call for wiring, plumbing, and staircases to come up through holes that don’t exist. The holes then have to be cut. This involves core drilling for opening up small holes or sawcutting for larger openings. This building’s new plans called for both, and both were performed to satisfy OSHA’s standards, using water integrated delivery systems and APF 10 respirators. Figure 10 below shows the setup below the floor being core drilled, where a trolley was placed to collect the water that came through from the engineering controls. The image shows a slurry buildup on the side of the trolley.

Figure 10: *Water suppression used during core drilling.*

Figure 11 below shows the sawcutting process being used. Supports were set to hold the slab from below, and the floor was cut into square chunks and lifted up and out of the building. The Image shows slurry across the separate slab squares, from an adequate integrated water delivery system use.

Figure 11: *Remnants of water used while sawcutting*

These activities were not performed by the demolition subcontractor. The core drilling was performed by either the electrical subcontractor, plumbing subcontractor, or pipefitting subcontractor depending on what type of piping the hole was to be used for. The separate contractor was hired specifically for the sawcutting of the new staircase.

Tuck-Point Grinding

The exterior skin of the building was completely composed of stone, and many of the mortar joints were deteriorating. A lot of tuckpointing was performed during the renovation, the only task on OSHA's Table 1 that requires the use of an APF 25 rated respirator. On this project, anybody that was even working on the exterior of the building while tuckpointing was taking place, needed to wear a full face APF 25 respirator, as specified by the masonry subcontractor management staff, incase any cross draft was blowing silica towards any other workers. This is an example of where, instead of following the specified engineering controls, the general contractor used administrative controls, and didn't allow any other subcontractors to continue work on the exterior while tuckpointing was taking place.

Here is a list of standards that were not followed correctly by the project: 1926.1153(c) Table 1, 1926.1153(d) Alternative recordings, 1926.1153(e) Respirators, 1926.1153(i) Communication, and 1926.1153(j) Recordkeeping.

Here is a list of standards that were followed correctly by the project: 1926.1153(f) Housekeeping, 1926.1153(g) Written exposure control plan, and 1926.1153(h) Medical surveillance.

4.2.1.4 Personal Interviews [M4, M5, M6, M7, M8, L8, L9, L10, L11]

Nine people were interviewed from the jobsite in Minneapolis. Five of those had management positions and were working directly for the general contractor, stationed on site at an office in the building. The other four being interviewed were all trade workers from various subcontractors, two of which were electricians and the other two were laborers for the demolition subcontractor. Of the four workers, all of them performed silica-producing activities at least two days out of the week.

Of the managers, all except for one superintendent had been working on the job for the eight months that it had been going. Their range of years working in the construction industry went from 5 to 22. None of the five ever wore a respirator when walking the job. Only one had received formal training in silica safe practices, and that was through a college program when he was earning his degree away from the company he was working for now. Only the youngest three knew that breathing in concrete dust could lead to a disease known as silicosis. All five agreed that they were breathing in dangerous amounts of dust on the jobsite, and three believed that they were already suffering negative health effects from breathing in dust. None of the five managers believed their company was responsible for protecting their workers' lungs from silica dust, and none of them believed that they would do anything to change the situation if a worker came to them and complained.

One manager remarked that things had gotten much better since his time working as a laborer in the industry, and with the company. An assistant superintendent now, reflecting on his time as a demolition laborer 10 years prior for the same general contractor, he remarked that it would be "pulling teeth to get [dust] masks [for the crew]."

The two trades interviewed were electricians and demolitionists. Of the electricians, one was a journeyman and one was a foreman. The journeyman had been working in the field as an electrician for five years, and had been stationed on this specific project since its start, for about eight months. One of her specific activities was core drilling through the floors, or drilling holes through concrete slabs to make way for new conduit piping. Besides being physically present on the very dusty jobsite, this was the only activity that put her in a position to be exposed to high levels of silica dust. While core drilling, she always used an integrated water delivery system hooked up with a hose, and she also wore an APF 10-rated respirator which was provided by her company. She knew how to perform the task correctly, she said, because she had received formal training on the dangers of silica dust and how to correctly mitigate the dust for the specific task from her company. She understood that breathing in large amounts of silica dust from concrete could expose her to developing silicosis. She often felt that she was exposed to dangerous levels of dust on the project, mostly from the work being done by the demolition crews and the dust that had been settling in the building over the last 90 years. She believed that for the most part her company would protect her from dangerous levels of dust, but she would have to act or come to them with concern first. She believed she could go to her supervisor/foreman with concerns and they would get answered.

The electrical foreman rarely was involved hands-on in silica-producing activities, and had more to comment on the overall topic itself and the general dust found on the jobsite. He had been working as an electrician for 23 years and been stationed on this project since the beginning, for eight months. He stated that because he was in charge of every electrician on the job, any activity they were performing, he was also performing, so he made sure "they were gonna do it right." If he caught anyone not core-drilling with the right water-delivery system or not using enough dust-suppressant when sweeping, he would scold them and correct them. He was able to order as many dust masks as he wanted for his crew, and also made sure that everyone was supplied with a reusable APF 10 mask, though he himself never wore a respirator on the jobsite. He had received formal training on OSHA Table 1 two years prior so that he knew how to correct his crew and what engineering controls to perform. Despite his lack of respirator use, he consistently felt that he was breathing in dangerous amounts of silica dust. When pressed as to why he wouldn't wear his respirator, he shrugged the question off and said that he "wasn't breathing enough [dust] to kill him anyways."

The two laborers on the demolition crew were interviewed simultaneously. They both had been working on the project since it began eight months prior, and were about to be pulled off to a different project as soon as demolition wrapped it up in the coming month. The two were young, one had been working as a demolition laborer for five years and the other for just two. They both were provided as many dust masks as they wanted, rated APF 10, to use at their discretion, but they were never required to wear one if they didn't feel it necessary.

The laborer with two years of experience almost always wore his respirator when in the building. When asked why, he proclaimed, "it's just so damn dusty in here, there's no way this can be good for you." He had never received any formal training in silica safe practices, and was unaware of what silica or silicosis was. He felt that everyday he came to work he was breathing in dangerous levels of dust, but that he wasn't sure he could go to his foreman about it, or that if he did anything would come out of it. He stated that when he first started working in the industry, he trusted that if his foreman didn't say anything about the levels of dust then it would be a safe level. At this point in his career, he did not trust his supervisor or his foreman to know whether he was breathing in safe or harmful levels of dust.

The laborer that had been in the demolition industry for five years had even less to say about the topic. He was involved in silica-producing activities on a day-to-day basis through hard and soft demolition and cleanup practices. He had never received any formal training in silica safe practices or the topic of silicosis, and was unaware of what silica dust or silicosis was. He stated that he rarely wore his respirator, only when it got "really dusty" during activities like drywall demolition or sweeping. For the most part, he felt protected whenever he wore his mask as he felt this was adequate protection. He believed that if his company was putting him through it and his foreman was "standing in the same dust as [him]," then it probably wasn't that dangerous. He believed if he were to approach his management or supervisor about harmful levels of dust, they would just tell him to wear his dust mask if he was concerned.

4.2.2 *Home Renovation, Non-Union Project [MN - U1]*

4.2.2.1 Overview

Again, when it comes to single-family home construction, it's easy to forget that while these are much smaller projects than the historic renovation or tunnelling, the activities being done are the same. Workers in these settings have the same, if not greater, potential for going over the permissible exposure limit of respirable silica dust. This case study and set of field observations and interviews will look at one jobsite in particular, a home renovation on a multi-acre property on the outskirts of Minneapolis.

The work to be done included digging out a crawl space beneath the house and expanding it into a basement for a wine cellar, applying aesthetic masonry veneer to the exterior skin of the lower quarter of the building, demolishing a wooden deck and replacing it with a stone slab deck, and re-bricking the landscaping in the backyard surrounding the stone-slab deck. Every activity involved the creation of silica dust to some extent.

The job was being run by one person, the general contractor, who worked directly with the clients to understand what they wanted for the renovations. The general contractor also designed all the new components of the project. The working crew consisted of the general contractor and two employee carpenters, one skilled and one apprentice. None of the workers were unionized and both employees were paid under-the-table and neither employee reports any earnings or pays any federal or state income tax. The employees were provided tools by the general contractor except for a hammer, tape measure, speed square, and tool bags which were to be purchased by the employee for their own use. No form of PPE was given to the workers.

4.2.2.2 Silica Control Plan

The general contractor did not have any form of silica control plan for any aspect of the project being worked on. Silica-producing activities consisted of:

1. Heavy Machinery for Excavating
2. Concrete Cutting with Handheld or Table-Mounted Saws

3. Demolition Using Hand Tools
4. Soil Removal in an Enclosed Space
5. Concrete Mortar Mixing

4.2.2.3 Field Observations

The observations to be described below follows the general order of activities during the construction of the basement of the home, as every activity involved silica-producing components. The heavy machinery excavation, for removing soil and crushing rock to access the exterior of the basement wall, the cutting of the exterior wall with a demolition saw, the further demolishing of the wall using sledgehammers, the removal of soil in the crawlspace to create room for the basement, and the concrete mortar mixing for applying the masonry veneer finish on the new exterior wall.

Heavy Machinery for Excavating

OSHA's Table 1 lays out a simple requirement for anyone working within an enclosed cab and creating dust from excavation processes; as long as the cab is enclosed with proper seals and has the right air filtration rate, there shouldn't be any engineering controls necessary to prevent silica exposure. However, this requirement obviously changes the required controls when there are workers directly outside of the cab and working around the vehicle. During this process OSHA requires that the employer "Apply water and/or dust suppressants as necessary to minimize dust emissions." This could be as simple as having someone operate a hose with a misting nozzle to minimize the dust created from the machinery.

During this job, the general contractor was operating from within the enclosed cab, while his two employees worked with shovels and hands to clear any large rocks that the excavator couldn't grab. While the articulated loader was grabbing and removing sand and soil, the two carpenters were working within three feet of the basket, without any respirators or water-driven dust suppression system.

Concrete Cutting with Handheld or Table-Mounted Saws

Following the excavation process. A section of the cinderblock wall needed to be cut through to access the crawlspace. Figure 12 shows the process of cutting a similar wall to the one in the case study. First, the outline needs to be cut through with a demolition saw, and OSHA requires a hose attachment with a water delivery system to be used on the saw, unlike the one shown in Figure 12.

Figure 12: *Demolition saw being used to demolish a concrete/CMU wall (Televideeo, 2011).*

Demolishing a cinderblock wall was not an everyday occurence for the general contractors work, so he wouldn't need to use the saw more than once or twice a year. He decided to rent the saw from a local tool supply for a few hours, as opposed to spending thousands of dollars on a new tool. The rental tool came with an attachment for a hose, and the contractor was able to use the household hose to equip the saw, making a respirator nonessential for the task.

Demolition Using Hand Tools

After the outline was cut through, and the saw took a few more passes to break the negative space into smaller chunks, it was up to hand tools to clear the rest of the CMU out. This was done using sledge hammers, roto hammers, shovels, and hands. The old CMU were struck repeatedly until they broke into dust and pieces, and then were placed in the articulated loader basket to be carried away. During the process, no form of engineering controls were used, and no respirators were worn by either of the carpenters involved in the process.

Soil Removal in Enclosed Space

Removal of the soil bed within the crawl space to make way for a basement was an extremely dusty process taking place in an enclosed space with no ventilation. The only access to outside from the crawlspace was through the 4' by 6' hole, and a house fan was positioned in a top corner to move air out of the enclosed space.

The crawl space was not large enough to fit the articulated loader, and having a vehicle operating in the space presented too much risk of damaging structural components of the house. The two carpenters on the project had to shovel out all of the dirt from beneath the crawlspace, and would do so by carrying loads of soil out to the articulated loader basket. The air in the crawlspace was thick with visible dust, and neither of the carpenters wore respirators of any kind during the process. There was no form of shroud collection or water suppression system being used to minimize the dust.

Concrete Mortar Mixing

The new exterior to be finished outside of the basement only covered a small surface area. The masonry veneer then only required a small amount of mortar, enough to make mixing in a five-gallon bucket efficient. One of the carpenters was tasked at mixing the mortar by hand and then applying it with a trowel before the others began applying the veneer. The most amount of dust produced by this activity was through ripping open the bags and pouring the pre-mix into the mixing bucket. This created a plume of visible dust that would shoot straight into the worker's face. No respirator was worn at any time during the mixing process. The worker performing the task spent roughly six to eight hours a day on it.

During field observations, none of the eight OSHA silica standards were followed correctly: 1926.1153(c) Table 1, 1926.1153(d) Alternative recordings, 1926.1153(e) Respirators, 1926.1153(f) Housekeeping, 1926.1153(g) Written exposure control plan, 1926.1153(h) Medical surveillance, 1926.1153(i) Communication, and 1926.1153(j) Recordkeeping.

4.2.2.4 Personal Interviews [L12, L13, M9]

Three people were interviewed, and they were the only three physically working on the project. One was the general contractor, who acted as a working foreman, employing the crew and directing their work, but also swinging a hammer himself. The other two were direct employees of the general contractor and had varying levels of experience and skill in their trade. Only one of the interviews between these carpenters is discussed here to reduce redundancy, as they both had very similar responses to the questions being asked.

One of the carpenters was young and had only been working in the trades for a year. He never went to vocational school for carpentry and never came up through a union. He had worked on this project for approximately three months, over a summer. He stated that through various stages of the project, he was involved in silica-producing activities. These were in the form of concrete-mortar mixing, operating heavy machinery for digging gravel, and demolishing an existing concrete wall with a sledge hammer and demolition saw. He stated that his employer did not provide any dust masks for him or his coworker to use, and that they were expected to bring their own for their own use. He had never received any form of training on the topic of silica dust and silicosis, and at the time was unaware of what either of those terms meant.

Though he was unaware of what "silica dust" or "silicosis" was, he was still aware that there was some level of harm caused from breathing in a bagged mortar mix. At one point, he stated, his employer was instructing him to mix the mortar with a five gallon bucket and a drill attachment for mixing. His boss told him to not "breath in too deep" while he was doing it. He stated that he assumed from then on that there was some sort of toxic effect from inhaling mortar mix, but that he thought it was probably poisonous, rather than physically damaging to the lungs.

At the time, the carpenter did not believe he was being exposed to dangerous levels of silica dust, except for possibly when he was mixing mortar by drill. He knew the crawl space and basement he was working in was quite dusty, but didn't believe it would have any long-term effects on his health. He didn't know if he could trust his company to protect him from harmful levels of dust, because at the time the thought of dust being harmful never really crossed his mind. When asked if he could approach his employer about harmful levels of dust, he believed that his employer would probably just tell him to buy a mask "and stop complaining."

The general contractor had been working in various levels and aspects of the construction industry for three decades, and had worked on this specific project for a total of six months. He had a minor level of knowledge regarding the dangers of respirable crystalline silica dust, but didn't believe it was a major concern for small, home improvement projects. At one point during the timeframe of the project in this case study, the contractor had to attend mandatory environmental health training for all self-employed construction workers that wanted to maintain their contracting license in the state of Minnesota. Though this training took place directly following the release of the 2016 OSHA Silica Standards, he didn't recall any training or discussion surrounding silica dust or silicosis.

He was often involved in silica-producing activities during this case studies' project, including demolition of a concrete wall and excavation using heavy machinery. He stated that he "never really wore a mask," but he was "cautious with the dust so [he] never had to." He stated he never felt as if he was breathing in enough dust to cause negative long-term health effects, or that none of his employees were subjecting themselves to dangerous amounts of dust. If any of his employees were to approach him with concerns regarding dangerous levels of dust, he stated he would tell them to "go buy a mask or find another job."

4.2.3 *Rock Climbing Gym Construction, Non-Union Project [MN - U2]*

4.2.3.1 Overview

People seldom think about construction projects outside the usual concepts of single-family, commercial, infrastructure, etc. While rock climbing gyms are a very niche subset of the construction industry at large, people still have to construct them, and there is a lot of silica dust involved in the process.

One company based in Minnesota contracts work across the country for different gyms, universities, playgrounds, etc. The company uses a travelling crew of carpenters, ironworkers, and laborers to design and install the gyms on site. Seen in Figure 13 below, from a gym being constructed in Minneapolis, the climbing walls get their shape from a welded steel skeleton and a plywood shell. A special mix of concrete is applied over the lathed plywood for rock-like texture and aesthetics. Large amounts of bagged concrete gets used in the production of climbing gyms.

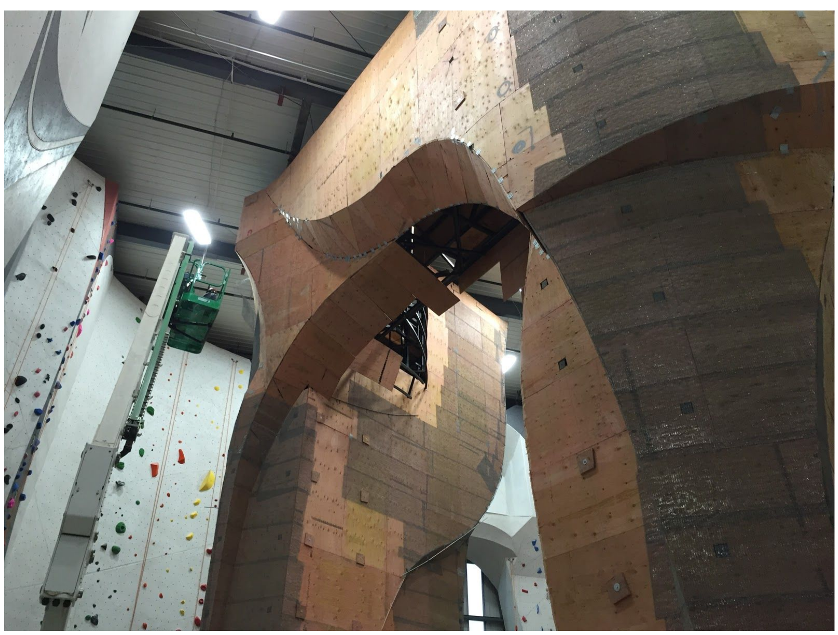

Figure 13: *The frame of a climbing wall, almost prepped for concrete cover*

The case study follows a set of projects being worked on by the company in Minneapolis and St. Paul, Minnesota. Because the projects were comparable, being worked on at the same time, and within such a close proximity to one another with the crews interchanging throughout the projects, the field observations and interviews will be mentioned as being part of the same project.

Crews on projects usually ranged from 3 to 25 depending on the size, complexity, and availability of non-union and temporary workers. Members of the crew were hired on legally, and the employer did remove money from their paychecks for taxation. All tools were provided to the crew, including PPE. Employees in the crew were given a supply of dust masks, gloves, safety glasses, hearing protection, and every employee was given a hard hat. None of the workers were unionized or received health care of any form from the employer, and sometimes the crew would bring on unskilled, temporary workers for menial labor tasks like cleanup.

4.2.3.2 Silica Control Plan

The company did not have any form of silica control plan for any project. Silica-producing activities consisted of:

1. Concrete Mixing
2. Surface Grinding
3. Cleanup

4.2.3.3 Field Observations

The silica-producing activities on this project were less straightforward. Concrete wasn't being used as a structural support or as a foundation or retaining wall, it was being used for aesthetic purposes. Nevertheless, these field observations take place in the order that the silica-producing activities were conducted in. The concrete was mixed in a trailer mixer in an outdoor space, after application it was often ground using various hand tools, and cleanup after a messy trowel application left lots of concrete slurry to clear with power tools and sweeping.

Concrete Mixing

There wasn't enough concrete being used to warrant a mixing truck being brought to the site, and with the specialty mix being used for applying by trowel, it made enough sense for the company to mix bagged concrete outside the jobsite building. One employee would be stationed outside, using a parked trailer mixer similar to the one shown below in Figure 14.

Figure 14: *Concrete Mixer, used on smaller jobs with custom mixes (Vega240, 2019)*

To mix the powder, the worker would drop the tightly packed bag on a sharp spike, and rotate it so that it would rip open further, and then drop the powder into the mixing drum. This created a large plume of dust that would rise into the air. Often, whoever chose to be the mixer would have their entire face and upper body covered in the pre-mixed dust. Depending on the surface area to be covered by concrete that particular day, the worker would be working at the mixer constantly for six to ten hours a day. Most of the workers that were mixing on any given day wore an APF 10 single-use mask, some wore no mask at all and just tried to hold their breath when ripping the bags open.

Surface Grinding

Surface grinding was used as a technique to smooth and create aesthetic edges in the concrete. Once the mix was applied to the lathe and then dried overnight, the crew would return the next day to fix any imperfections and to carve the granite-inspired crack lines as shown in Figure 15 below. This grinding was either done with a diamond-bladed skill saw or angle grinder. No form of integrated water delivery system was used, and no form of shroud collection system was equipped with the tools. None of the workers wore respirators when performing this task.

Figure 15: *Almost finished climbing wall, with visible slurry, cuts, and sweeping compound being used.*

Cleanup

As seen above in the last section's Figure 15, the trowel application of the mixed concrete was a messy process, and there were often many piles of dropped concrete dried to the floor slab. The crew would have to remove these dried piles using a chipping hammer or other power tool to break them from the floor slab. When this task was performed, no one wore a respirator, and there was no form of water suppression or shroud collection method being used.

The one standard that was followed correctly by the project was 1926.1153(f) Housekeeping. Whenever there was any dust on the ground that needed to be swept up, a sweeping compound was to be used. The company took this very seriously, and would not allow any dust to be swept up without the use of dry compound. If an employee was seen sweeping up floor dust without first applying dry compound, they would be reprimanded.

Here is a list of standards that were not followed correctly by the project: 1926.1153(c) Table 1, 1926.1153(d) Alternative recordings, 1926.1153(e) Respirators, 1926.1153(g) Written exposure control plan, 1926.1153(h) Medical surveillance, 1926.1153(i) Communication, and 1926.1153(j) Recordkeeping.

Here is a list of standards that were followed correctly by the project: 1926.1153(f) Housekeeping.

4.2.3.4 Personal Interviews [M10, M11, L14, L15, L16]

In total, five employees were interviewed. Three of these were laborers of various skills, the crew was a mix of ironworkers, carpenters, and those who were capable of both trades (these three laborer interviews were summed together for the sake of simplicity, as they all had similar answers to the questions presented to them. One was a working foreman, a manager who also swung a hammer. The fifth was a project manager, who didn't have an office on site but came to the job site roughly once a week to check on progress. These interviews were all retrospective, and took place approximately two years after the completion of the project.

At the time of project completion, two of the laborers had been working with the company for approximately eight years and had been working on this specific project for about 18 months. The third laborer had been working on the project and with the company for only six months. All of them were involved in work activities that produced silica dust every day. When asked whether they were provided masks, the answers ranged from "they're only provided for [those mixing concrete]," to "we don't ever need them," to "I think we have a stash [of dust masks] hidden somewhere on the jobsite."

None of them had received any formal training on silica dust and the dangers of silicosis, and none of them had ever heard the term "silica dust" or "silicosis." One laborer stated that the only safety training he had ever received from the company was a one-minute walk around the jobsite, where he was told which people he shouldn't physically work under because they were prone to dropping clamps and other tools. When asked if they ever felt as if they were breathing in dangerous amounts of dust on the project, all three responded that they felt at least once a week that they were breathing in dangerous amounts of dust. None of them responded that they trusted the company management to protect them from breathing harmful dust, or to tell them if the levels of dust were dangerous without having to ask. None of them responded that they believed they could approach their management about concerns regarding harmful amounts of dust. One laborer quoted, "[the management] would probably just show me where the [dust masks] were hidden [on site]."

The working foreman had been with the company for almost two decades, and had spent his career building and designing climbing gyms. He worked on the project from start to finish, for a total of 18 months. He had never received formal training in silica safe practices, but knew the term "silica dust" and that it caused a disease named silicosis. He said he wasn't very concerned with the amount of silica that he himself was breathing, and was more concerned about the amount of sawdust he had inhaled over the course of his career. He said that he believed silicosis was mainly an issue for miners, and not related to the construction industry as much. He stated that he believed the company did a fine job in making sure the respiratory health of its employees was taken care of, as there wasn't much risk to respiratory health involved in climbing gym construction. When asked if he believed his workers could come to him about concerns regarding harmful amounts of dust, he believed they could and that he would make sure their concerns were taken care of.

The project manager had been with the company for almost two decades, a few years less than the working foreman on the project. He had been overseeing this specific project from start to finish, for the total of 18 months. He had received formal training in silica safe practices through his OSHA 30-hour training program. He believed he had a firm grasp on OSHA's silica standards and the regulations he needed to follow to ensure his workers' lungs were protected. The project manager stated that he "whole-heartedly" believed that the company did everything it was supposed to in order to follow OSHA's silica regulations, and that he believed if any worker had any concerns regarding the amount of dust they were breathing in, they could come to him and he would "solve the problem" within the day.

Chapter 5. Analysis

5.1 Field Observations

Silica-creating activities can be highly variable in practice. It was important to be able to be on site, and observe the actual practices that were taking place. Being present at the jobsite gave a qualitative approach to figuring out why standards are not being followed, as opposed to just marking down which standards were and weren't followed. However, at the end of these field observation sections, a list was given all of the standards that either were or weren't followed by that particular jobsite. This was one of the main goals of the field observations, to witness first-hand exactly which parts of the silica standards are being followed. This list also allows the information to be somewhat quantified, in a way that's easier to analyze. The standards that were and were not followed by each jobsite are laid out clearly in Table 7 below. This makes it easy to visualize which jobsites were compliant and which jobsites weren't. This section will go through every standard used, and discuss the successes and failures that each job had with them.

Table 7: *Standards followed and not followed by each jobsite, as observed*

Blue (x) = correctly followed standard Red = failed to correctly follow standard	**LA - U**	**MN - U**	**LA - NonU**	**MN - NonU1**	**MN - NonU2**
1926.1153(c): Table 1	x				
1926.1153(d): Alternative recordings	x				
1926.1153(e): Respirators	x				
1926.1153(f): Housekeeping	x	x			x
1926.1153(g): Written exposure control plan	x	x			
1926.1153(h): Medical surveillance	x	x			
1926.1153(i): Communication	x				
1926.1153(j): Recordkeeping	x				

1926.1153(c): Table 1. This is the most important rule to follow, as it's essentially the basis for keeping a project dust free. Every project in this struggled with following Table 1, besides the Los Angeles tunneling project who had either employed the correct engineering, administrative, and PPE controls, or gone above and beyond.

It should be noted that even if a contractor used the proper engineering controls for one activity, they still failed the (1926.1153(c): Table 1) requirement if they didn't follow the right controls for another activity. For example, in the case of the historic renovation some subcontractors followed every engineering control and required PPE on Table 1. Others, like the demolition subcontractor, grossly mis-followed the regulations set forth in OSHA's Table 1. Therefore, the case study was marked as not following standard 1926.1153(c): Table 1. This is because even though the electrical subcontractor was following all regulations, there was still a very dangerous level of dust being created by the demolition subcontractor on the same floors, in the same vicinity.

This is ultimately the most important rule here, and it was the most difficult for the projects to follow. Mostly where the projects failed was not by utilizing the appropriate respirator, but by failing to utilize the appropriate engineering and administrative controls.

1926.1153(d): Alternative recordings. Again, the only jobsite that took alternative recordings was the Los Angeles tunneling project, though it's sort of a gray area as to whether they did pass it. The only area that was being monitored was inside the Tunnel Boring Machine, they didn't take any other recordings at any other activity that was observed.

1926.1153(e): Respirators. The successful distribution and use of respirators was only seen on the Los Angeles tunneling project. Though other jobs succeeded in distributing respirators, they failed at distributing fit tests and explaining proper use of the masks.

1926.1153(f): Housekeeping. Proper housekeeping was followed correctly for the most part. The use of dry sweeping compounds was common among all of the jobsites, and was especially common among jobsites with more experienced workers. Typically, younger workers who didn't know this compound existed were the ones who didn't use it. Where the two non-union projects failed to comply with proper housekeeping standards is when they used compressed air to clean surfaces and themselves.

1926.1153(g): Written exposure control plan. The two union projects (Los Angeles and Minneapolis) were the only two projects that had a written silica-safety plan onsite.

1926.1153(h): Medical surveillance. The two union projects were the only to follow the correct medical surveillance procedures, with medical examinations upon anyone's request. This was again a gray area for the Minneapolis union project, because there was a failure to communicate these tests to the workers/laborers on the site.

1926.1153(i): Communication. The Los Angeles tunneling project had both a silica-safety training video for all workers on site to watch, and it had posters demonstrating that working with silica dust was dangerous. None of the other jobsites had either of these training videos or posters.

1926.1153(j): Recordkeeping. The Los Angeles tunneling project was again the only project to successfully follow the recordkeeping standard.

5.2 Personal Interview Answers

5.2.1 Union Affiliation

Union workers were more likely to have had formal silica-safety training than non-union workers. This is shown in Figure 16 below. Union workers tended to have silica-safety training provided on the jobsite they were working on, while non-union workers that had the training typically received it as part of a larger environmental health training program required of employing contractors.

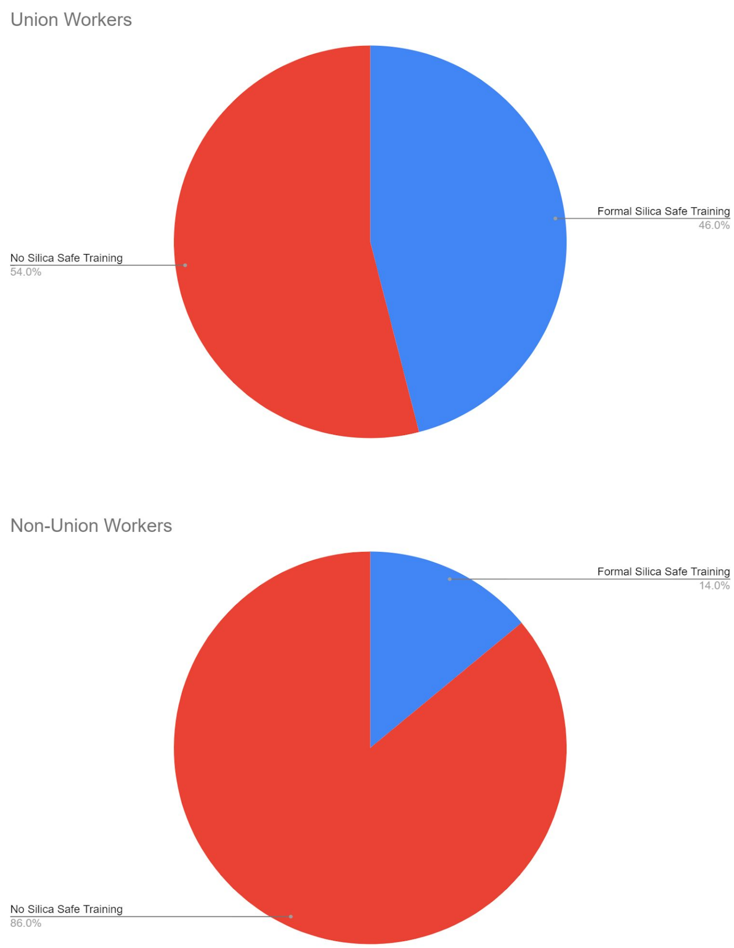

Figure 16: *Union Affiliation and Provided Silica-Safe Training*

Union laborers had a higher level of knowledge on the topic of silica and silicosis, and none of the non-union laborers knew the terms "silica" or "silicosis." This is shown below in Figure 17 as well. The pie chart representing non-union workers shows only knowledge ratings of 0 or 1, while the union-affiliated pie chart shows approximately 15% of workers with a knowledge rating of 2, and approximately 30% of workers with a knowledge rating of 3.

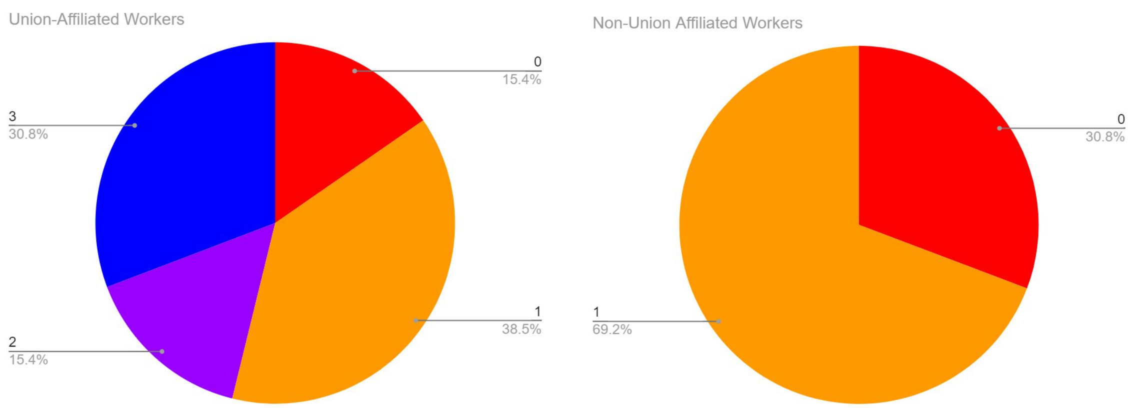

Figure 17: *Union Affiliation and Level of Knowledge*

Union workers and non-union workers felt the same levels of protection from, and trust in, their company management. Figure 18 below shows very similar levels in those that trusted their company management to protect them from harmful levels of dust between union and non-union contractors.

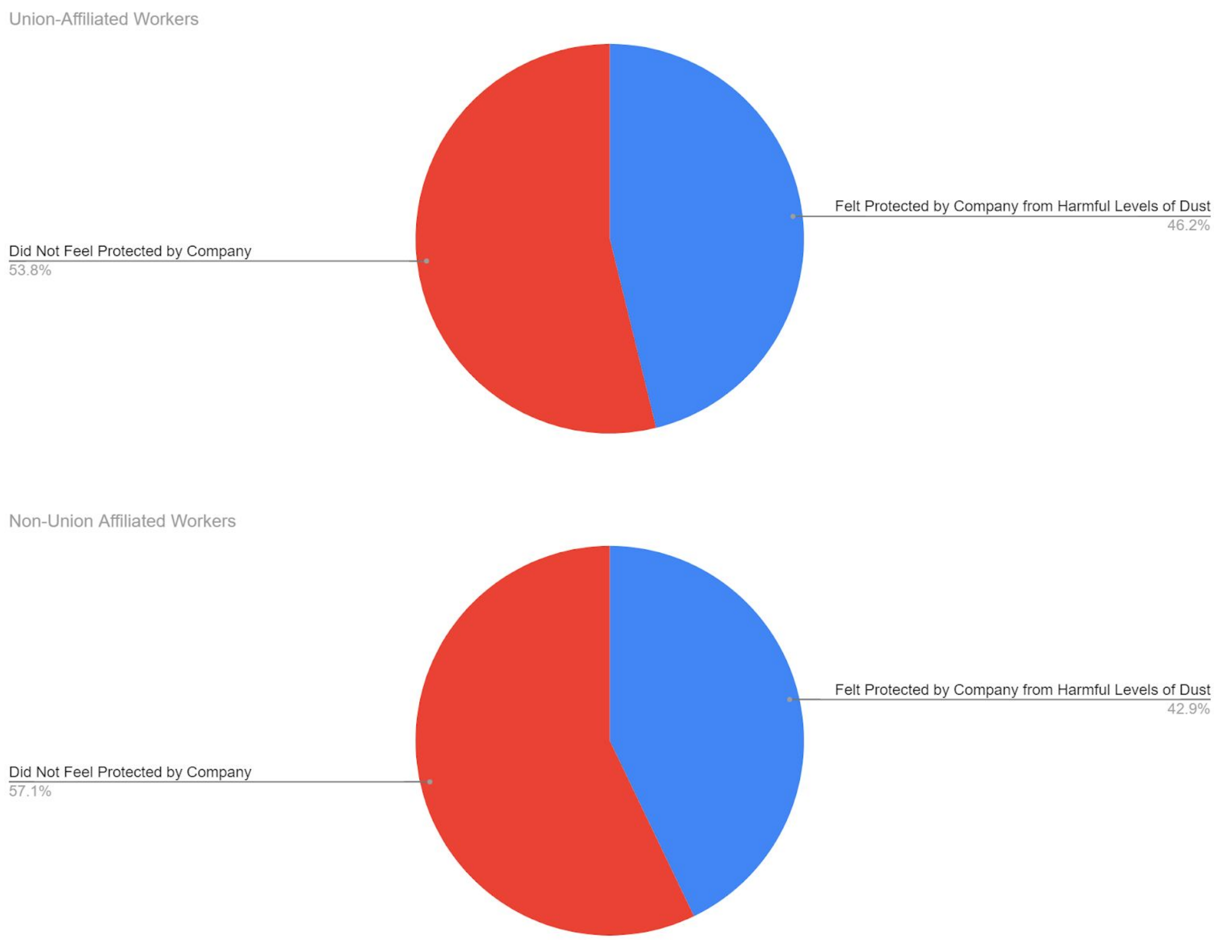

Figure 18: *Union Affiliation and Feelings of Company Protection*

Union contractor's field management staff were, on average, more approachable with concerns than non-union contractors. Figure 19 below shows a big difference in approachability between union and non-union contractors regarding dangerous dust levels. This is likely due to the fact that the non-union contractors had more leverage in terms of firing employees that didn't agree with the way the job was run, and worker fear of employer retaliation.

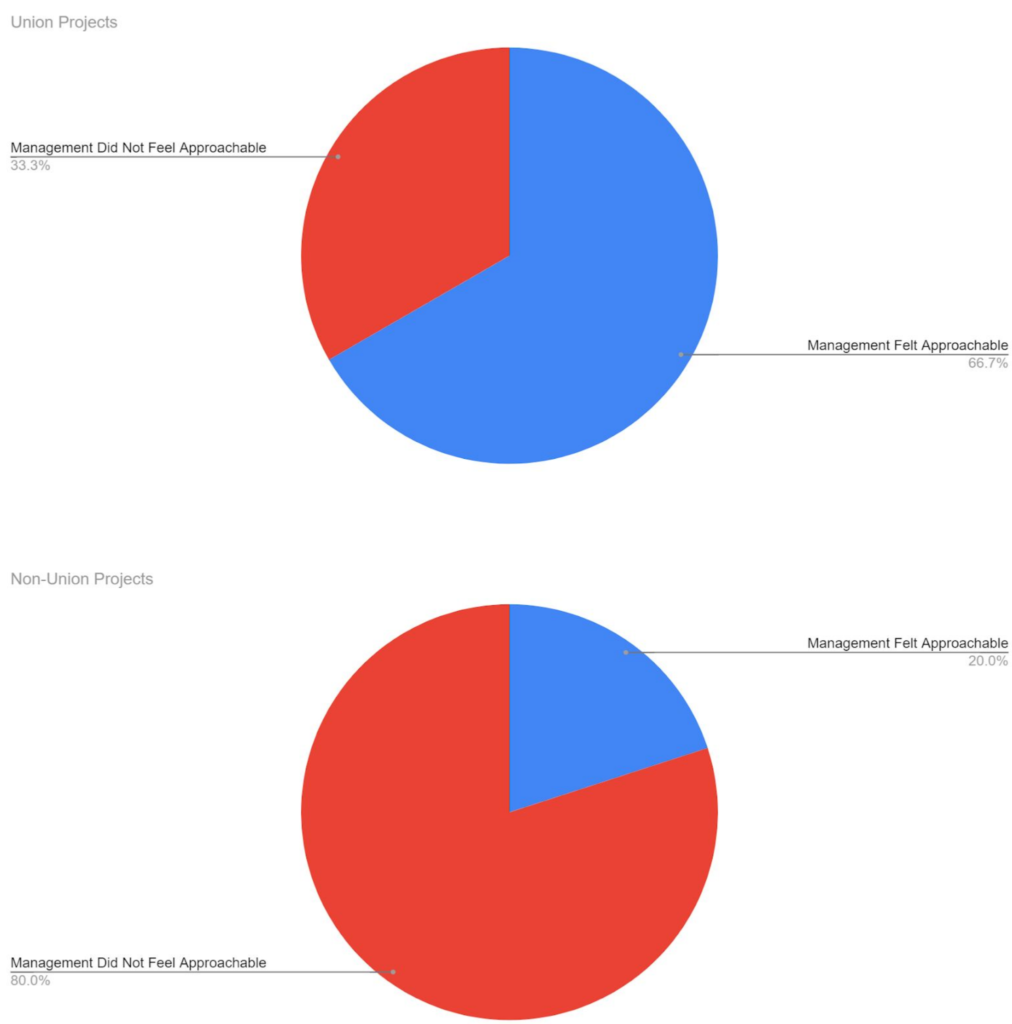

Figure 19: *Union Affiliation and Level of Management Approachability*

5.2.2 Silica-Safe Training

Workers that had formal silica-safe training were generally less likely to believe they were breathing in harmful levels of dust at work. This is shown below in Figure 20, and is likely due to the fact that workers who had silica-safe training were found on sites that didn't exhibit much visible ambient dust, or sites that already had a better handle on silica-safe practices.

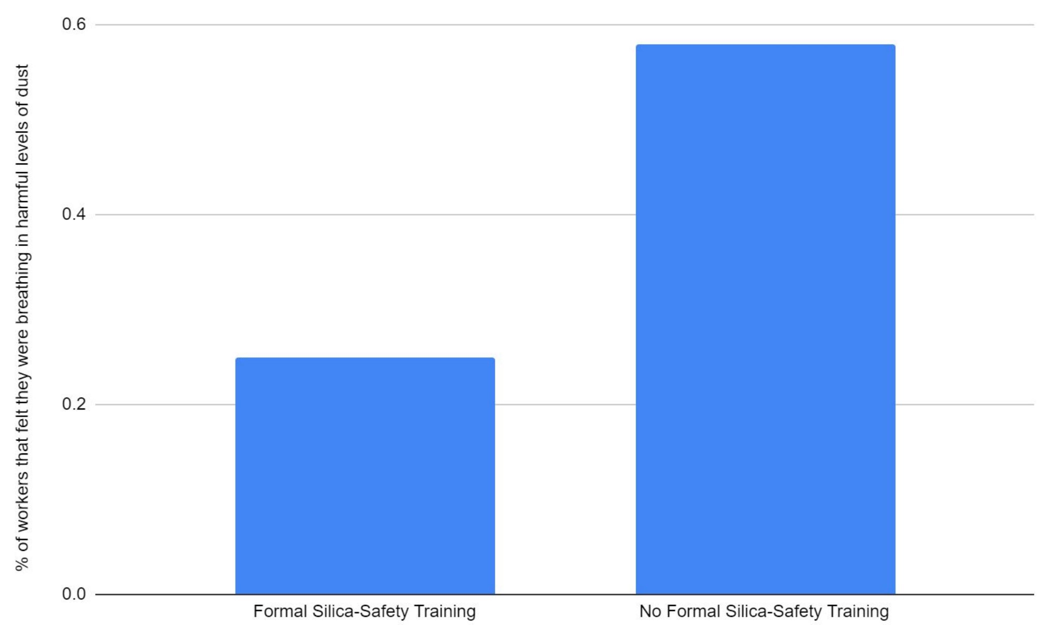

Figure 20: *Silica-Safe Training and Feelings of Unsafety*

Workers that had formal silica-safe training were generally more likely to trust their company management to protect them from breathing harmful levels of dust. This is shown below in Figure 21, and is likely due to the fact that company management staff providing silica-safe training to employees were more empathetic and approachable with concerns of harmful amounts of dust.

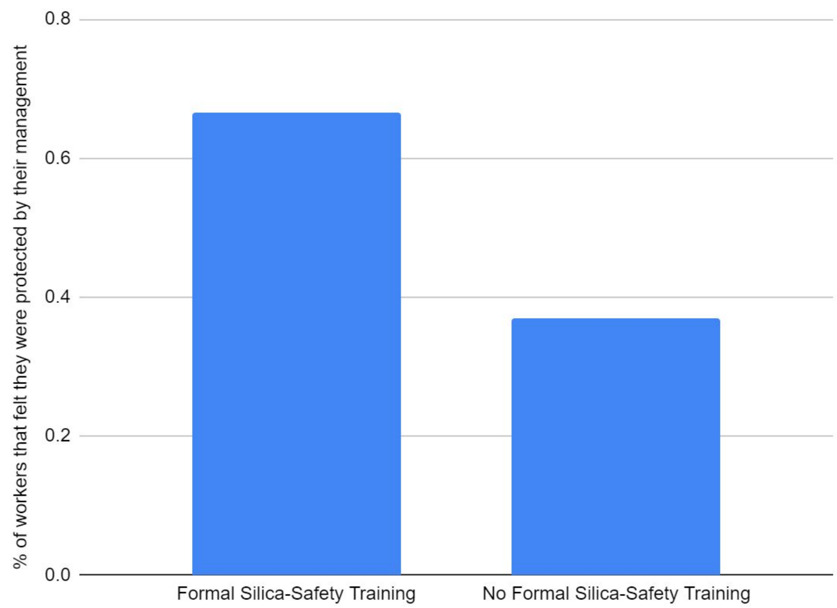

Figure 21: *Silica-Safe Training and Feelings of Company Protection*

5.2.3 Silica-Safe Knowledge

Workers that knew the terms "silica" and "silicosis" were more likely to wear their respirator at all. This is shown below in Figure 22. It could likely be the case that workers who knew the terms "silica" and "silicosis" had also gone through silica-safety training programs that taught them the proper use of respirator, and had their company management provide them with proper respirators.

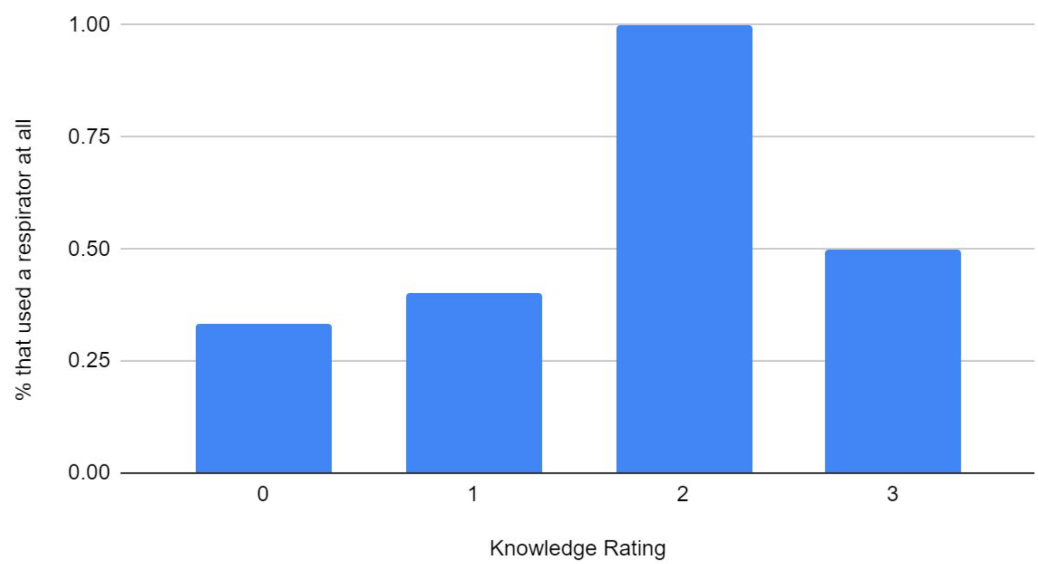

Figure 22: *Level of Knowledge and Respirator Use*

Workers that knew that breathing in concrete dust was dangerous, but that didn't know the terms "silica" and "silicosis" were more likely to feel that they were working in a dangerously dusty workplace than those who knew the terms. This is shown below in Figure 23, and again is likely attributed to the fact that workers who had gone through formal silica-safe training were working on jobsites that follow silica-safe procedures.

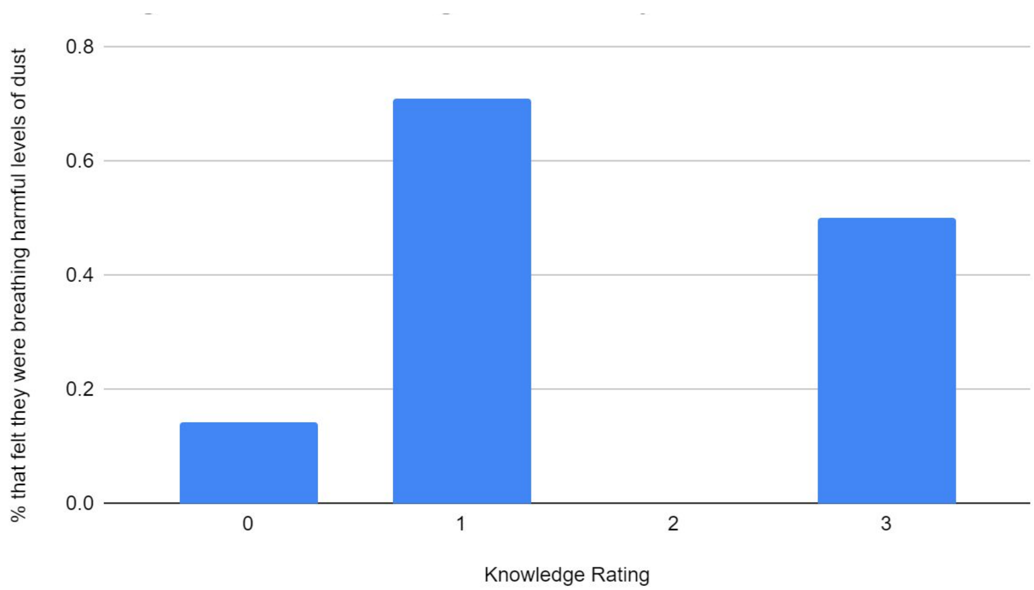

Figure 23: *Level of Knowledge and Feelings of Unsafety*

The greater level of knowledge that workers had on the 2016 Silica Standards, the greater the level of trust in their company management. This is shown below in Figure 24, and really makes sense as it was typically the companies training their own employees on silica-safe practices. The spike in workers that had zero knowledge of dust being harmful is self-explanatory as well, as they had no reason not to trust their company about harmful levels of dust.

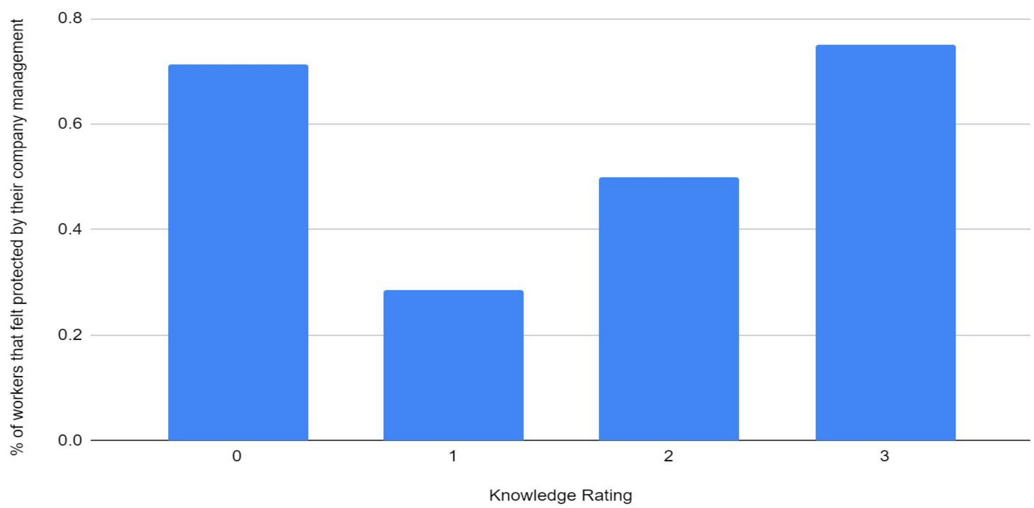

Figure 24: *Level of Knowledge and Feelings of Company Protection*

Chapter 6. Conclusion

The hope for this thesis was to create a snapshot of how silica exposures are handled across a wide array of construction projects in the United States, during a time of heightened awareness of the dangers of respirable crystalline silica dust. It was thought that union projects always followed regulation and safe working protocol. Through the observations and case studies, it was found that not all large, unionized projects are silica safe. Although it should be noted that unionization played a large part in making jobsites follow health regulations, that was not the end-all, be-all golden ticket to a healthy work environment. It was found through observations, interviews, and case studies that worker knowledge and regulatory agency enforcement were the two largest driving factors in making the construction site follow OSHA protocol for silica dust suppression. That being said, the snapshot of successes from some companies can benefit the failures of others. With that, a few key findings and recommendations should be considered.

Unionization isn't the solution to the problem, but it definitely helps. The two unionized projects studied in this thesis showed the most compliance by far than any of the non-union sites. However, that compliance still fell very short in the Minneapolis union project.

Unions representatives have the power to enter unionized work sites and make a difference, but the interviews gave a feel that union representatives are not up-to-date with all public health problems facing the construction industry. If more union representatives were aware of silica-safe procedures, the unions could be a greater driving force in worker respiratory protection.

The size of the project does not determine whether it will be a healthy work environment or not. The interview with the electrician on the Seattle tunneling project painted a grim picture of overall health and safety conditions on the project, not just those regarding silica dust. This is a very different image than the one scene further down the coast in Los Angeles. The interviews presented very different projects, yet the projects were extremely similar in size, union-affiliation, and project type (tunneling). The smaller projects certainly showed more violations than the large ones, but when one person doesn't perform a task with the proper engineering controls, it can create a lot more of a hazard than just that one instance.

Residential construction projects have a much different safety culture than commercial and civil projects. This is largely due to the level of management staff required for smaller residential projects. Oftentimes commercial and civil projects will have dedicated safety managers, whereas those don't exist on small residential projects where the same risks are prevalent. That is why it is essential moving forward that more education regarding silica and silicosis is made accessible to workers in the smaller residential construction industry, so that they can take the matter of controlling dust into their own hands.

The jobsite isn't silica safe unless everyone is silica safe. This was made especially apparent during the Minneapolis union project. The electrical subcontractor followed every rule in the silica standards carefully, yet the amount of dust created by the demolition contractor was still putting electricians at risk of high exposures. This brings up another question: *At what point should the management from one subcontractor step in to voice concerns over the actions of another, in order to protect its own workers' lungs?*

Air monitoring instruments are too expensive and inconvenient to be used by most contractors. They also really shouldn't be necessary if the contractor can follow all of the engineering, administrative, and PPE controls laid out in Table 1. Unique cases where there is still a greater amount of visual ambient dust can be reported, and health and safety authorities can come to the site to check with monitoring systems.

OSHA's Table 1 doesn't cover nearly enough activities. It leaves a lot of gray area in common practices that produce a lot of respirable silica dust, and it leaves companies with the responsibility of air monitoring to make sure they are complying within the right exposure levels. Hand-mixing concrete, mortar, grout, etc. is a seriously overlooked method of silica exposure, and happened on all of the jobsites in these case studies.

Having a 3rd party health and safety authority visit the jobsite is a highly effective way to make sure contractors are enforcing regulations. The prime safety manager at the Los Angeles tunneling project stated that the everyday site visits from CalOSHA reps had him running a tighter ship than he would have. This was one also the one differing factor from this project to all others, and it was the only project that was observed to follow every rule in OSHA's silica standards.

It's important to note that the one area where the Los Angeles residential project was legitimate was that it was okayed by the city, and a structural inspector would come out to the site once a month to inspect the progress and rebar. Concrete samples from every pour were taken to testing facilities. If government representatives were sent out to inspect the structural integrity of the project, then why couldn't the same have been done for the worker health and safety on the project?

If the city is aware about the LA residential project through permits and structural regulations, and made it mandatory to send an inspector to check the constructability, why couldn't it also be mandatory to send a health and safety official, if even once or twice a year? ***Having a 3rd party health and safety authority visiting every jobsite in the US would be highly impractical, as health and safety professionals and inspectors are already stretched thin.***

More worker access to education and knowledge leads to an overall safer jobsite. *It should be stated again that the general contractor, the prime employer, should always be the one held responsible for the health and safety of the workers on the job.* This includes making sure each subcontractor is supplying their workers with sufficient respirators and engineering controls, as well as education. The easiest way for the general contractor to make sure it's subcontractors are educating their workers is to take the matter into their own hands.

Short video segments discussing the dangers of silica dust are readily available, easy to implement on large projects where safety videos are already required, and are highly effective at making workers aware of the dangers of silica dust. It could be expensive for a GC to have to purchase the proper PPE and engineering controls for all of the workers they indirectly employ, but it wouldn't be so expensive to include a section on silica dust in their required jobsite safety orientation video.

When workers are educated on a specific topic, they know when things are not as safe as they could be. Having that knowledge also gives workers greater confidence in their ability to approach management. Most workers had a general idea that breathing in concrete and rock dust was harmful to their lungs, but the vast majority could nott explain why they felt that way. Workers that had more knowledge had greater confidence in approaching their management about making changes.

When workers didn't know the harmful nature of silica dust, they also couldn't bring it up with their management, even if their management was approachable. The issue with the Seattle tunneling project was the lack of education. If the workers knew they were being exposed to dangerous amounts of dust, they would have had no problem bringing it up with their supervisor, and the problem surely would have been resolved in a reasonable amount of time.

All jobsites, large and small, should have a silica-safety plan. Safety plans are the starting point for developing a silica-safe worksite. Without it, there is a chance that none of the laboring staff know how to protect themselves and their staff from silica dust. In terms of the projects in these case studies, the jobs with better silica-safe protections generally had more in depth written plans.

Tool rentals with the appropriate engineering controls can help small contractors stay silica-safe, and save money on expensive tools. This was made apparent in the case of the small contractor in Minnesota. Had the contractor gone out and bought a tool for the job, it may have been wildly more expensive to purchase one with the correct engineering controls. Being able to rent a tool not only saved him expenses on purchasing a new piece of equipment that he would use once or twice a year and then pay for storage, he was able to rent one for a cheaper cost with the correct water integrated delivery system.

If half-mask respirators require a clean shave for a proper fit, then most of the construction industry won't have a proper fit. Of all the people interviewed for this thesis (including women), 70% had facial hair for the majority of the year. This is a problem because it severely limits the amount of dust that a properly fitting respirator could filter out. Beards are part of an identity for a lot of construction workers, and it might make sense for OSHA to search for other ways around this seal problem.

There are still many jobsites around the U.S. that put millions of worker's health and safety at risk by following illegal and irresponsible procedures. The silica dust observed in these case studies was just a small portion of the unhealthy and unsafe practices of the construction sites at large. From multi-billion dollar projects to home improvements, there is a lot of work to be done on improving the wellbeing of construction workers.

Appendix A: Tables and Charts

Table 8: *Project Codes*

Project Name	Project Code	Color Code
LA Tunneling Project, union	LA - U	
LA Residential Project, non-union	LA - NonU	
Seattle Tunneling Project, union	SEA - U	
MN Historic Renovation, union	MN - U	
MN Residential Project, non-union	MN - NonU1	
MN Climbing Gym, non-union	MN - NonU2	

Table 9: *Interview Questions*

Question Code	**Question**
years on project	How many years have you been working on the project? (rounded up)
yrs in field	How many years have you worked in the field? (rounded up)
respirator y/n	Do you wear a respirator at all at work?
resp provided	Do you have respirators provided to you at work? (answers coded based on a scale from Tables 6 & 11)
training y/n	Have you had any formal training on silica safe practices?
know "silica dust"	Have you ever heard the term "silica dust"?
know "silicosis"	Have you ever heard the term "silicosis"?
knowledge rating	How much do you know on the topic? (answer coded based on a scale from Tables 5 & 10)
felt unsafe y/n	Do you feel that you are breathing in a harmful amount of dust at your project?
felt protected y/n	Do you feel that your company is protecting you from breathing in harmful amounts of dust on your project?
felt you could approach y/n	Do you feel that you can approach your company management about concerns you have from breathing in too much harmful dust?

Table 10: *Silica Knowledge Scoring Table*

Rating	Description
0	● No prior knowledge of the terms "silica" or "silicosis.” ● No understanding that there is any danger involved in breathing silica dust.
1	● No prior knowledge of the terms "silica" or "silicosis." ● Slight understanding that respirating rock dust is harmful to the lungs. ● No knowledge of proper engineering controls and/or PPE.
2	● Prior knowledge of the terms "silica" or "silicosis." ● An understanding of why breathing silica dust is harmful to the lungs. ● Some knowledge of the proper engineering controls and PPE required.
3	● Prior knowledge of the terms "silica" or "silicosis." ● An understanding of why breathing silica dust is harmful to the lungs ● A strong understanding of the 2016 OSHA Silica Standards.

Table 11: *Scoring Table for Level of Respirator Provided*

Rating	Description
0	No respirator provided by management
1	One single-use APF 10 mask provided by management
2	Unlimited single-use APF 10 masks provided by management
3	Reusable APF 10 mask (or greater if task requires) w/ fit test provided by management

Table 12: *Interview Answers [1 = yes; 0 = no (unless answer is based on time or other scale)]*

	years on pr	yrs in field	respirator y/n	resp provided	training y/n	know "silica dust"	know "silicosis"	knowledge rating	felt unsafe y/n	felt protected y/n	felt you could approach y/n
L1	1	4	1	3	1	1	1	2	0	0	1
L2	1	15	0	1	0	0	0	1	1	0	0
L3	1	5	1	1	0	0	0	1	1	0	0
L4	1	8	1	1	0	0	0	1	1	0	0
L5	2	2	1	1	0	0	0	0	0	0	0
L6	1	1	1	1	0	0	0	0	0	1	1
L7	2	4	0	1	0	0	0	0	0	1	1
L8	1	2	1	1	0	0	0	1	1	0	0
L9	1	5	0	1	0	0	0	0	0	1	0
L10	1	5	1	3	1	1	1	3	1	1	1
L11	1	23	0	3	1	1	1	3	0	1	1
L12	1	1	0	0	0	0	0	1	0	1	0
L13	1	2	0	0	0	0	0	0	0	1	0
L14	1	1	1	1	0	0	0	1	1	0	0
L15	2	8	0	1	0	0	0	1	1	0	1
L16	2	8	0	1	0	0	0	0	1	0	0
M1	3	3	0	1	1	1	1	2	0	1	
M2	3	20	0	1	1	1	1	3	0	1	
M3	2	20	0	n/a	0	1	0	0	0	1	
M4	1	5	0	1	1	1	1	3	1	0	
M5	1	7	0	1	0	1	0	1	1	0	
M6	1	15	0	1	0	1	0	1	1	0	
M7	1	18	0	1	0	1	0	1	1	0	
M8	1	22	0	1	0	1	0	1	1	0	
M9	1	30	0	0	1	1	1	1	0	1	
M10	2	20	0	1	0	1	1	1	0	1	
M11	2	17	0	1	1	1	1	1	0	1	

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