Masonry Dust Risk Control Practices and the Barriers to the Adoption of Engineering Controls in Reducing Risk due to Dust Exposure in Masonry Work

N H Abas¹, M Mad Ali¹ and N A Abas²

¹ Jamilus Research Centre, Faculty of Civil Engineering and Built Environment, Universiti Tun Hussein Onn Malaysia, 86400 Parit Raja, Johor, Malaysia
² Kolej Kemahiran Tinggi Mara Sri Gading, Jalan Kluang, 86400 Batu Pahat, Johor, Malaysia
Corresponding author: nhaslin@uthm.edu.my

Abstract. The construction industry is known to be among the most vulnerable industries in terms of occupational safety and health. One of the riskiest activities in construction involves masonry, which reports several cases involving occupational health diseases due to the exposure to silica dust. Thus, this study aims to investigate the perception toward health risks due to exposure to dust in masonry work. A survey research method was adopted for this study, which involved the participation of 25 active construction contractors in Selangor and Kuala Lumpur. The findings reveal that respiratory problems and health diseases are the most perceived risks associated to dust exposure in masonry work. There are various barriers to the adoption of engineering control in masonry work such as high costs, lack of awareness of dust hazards, and workers’ attitudes. The current practical intervention methods used by contractor firms are respiratory protection, wet method, and sweeping compound. This study provides information on the current masonry work environment and the barriers of the adoption of engineering control technologies. Additionally, this study suggests that the key players in the construction industry should take an active part to increase the implementation of engineering controls in a construction project, and not rely solely on the use of PPE.

1. Introduction
The construction industry is known to be the most vulnerable in terms of personal safety and health [1,2]. This has been proven through the high number of accidents and fatality rates reported every year [3]. However, statistics emphasize on safety hazards, whilst the injuries due to exposure to health hazards are loosely reported. Managing the exposure to health hazards is equally important, as it is part of the employer’s compliance with existing occupational safety and health (OSH) legislations. For example, the manual published by the International Labour Office in Geneva [4] states that “The concerned work should be safe, and conditions on the construction site should not cause damage to life, health and professional skills”. The importance of ensuring a worker’s health is also highlighted in the Occupational Safety and Health Act (OSHA) 1994 – Section 15. The health and injuries reported indicate that the construction industry is a dangerous occupation at a high-risk environment, whereby employees are at a higher risk of injury and even fatality due to poor safety and health implementations [5]. With that, the occupational health hazards in the construction industry can be broken down into six categories: asbestos-related diseases, silica-related diseases, noise-induced hearing loss, hand-arm vibration syndrome, musculoskeletal disorders, and dermatitis [6].
Construction works such as masonry, drilling, sandblasting, crushing, tunnelling, and grinding increase personal exposure to silica [7]. Silica dust, also known as respirable crystalline silica (RCS), is created when working with silica materials like concrete, mortar and sandstone [8]. The effects of dust exposure in construction workers’ health are asthma, chronic obstructive pulmonary disease (COPD), silicosis, and lung cancer [8]. In the United Kingdom (UK), less than 100 cases were reported every year between 1996 and 2009, and among the cases reported were death from silicosis [9]. In Australia, about 587,000 workers were exposed to silica dust while working and estimated that 5758 of these workers will develop lung cancer over their lifespan [10]. While in Malaysia, in 2019, about 101 cases of occupational lung diseases have been reported, and 61 cases were confirmed as occupational lung diseases by the Occupational Health Division [11]. However, these record cases are general and not specifically caused by masonry dust.

There are several control measures commonly implemented at the construction site to minimize the effect of exposure to silica dust. Examples of dust exposure controls are a sweeping compound for clean-up activities, wet method, use of local-exhaust ventilation (LEV) and area ventilation, training, and PPE [12,13]. This includes controls such as substituting with less hazardous materials or processes such as, replacing concrete or brick to steel that can be determined during the design stage. Nevertheless, several researchers agreed that total substitution or elimination of silica from the construction process may not be a practical alternative [14].

The present study proposes the use of engineering controls to reduce the hazards and risk of exposure to silica dust as it is practical, more economical, and can be implemented at any stage of the construction progress. However, some studies reported that the implementation of engineering/design control is irregular and lack systematic adoption in the masonry sector [11]. Nij et al. [12] in their study revealed that even though engineering controls such as, wet dust suppression or local exhaust ventilation, can effectively reduce the respirable quartz exposure value (at more than 70% reduction factors), the use of a respiratory protection is the most widely used preventive measure in the construction industry. This is worrying because respiratory protection might not always reduce exposure sufficiently and should be combined with other control measure(s) to reduce exposures to an acceptable level [12].

Therefore, this study aims to investigate barriers to the adoption of engineering controls in masonry work, using the same survey research method by Ghosh et al. [11]. The survey research method that was adopted for this study involved the participation of 25 active construction contractors in Selangor and Kuala Lumpur. These participants were selected from the G6 and G7 contractor firms, who are registered under the Construction Industry Development Board (CIDB).

1.1. Intervention method for exposure to dust

Masonry workers are exposed to silica dusts while performing their work [15]. The risks came from operating on concrete and stone materials such as mortar, brick and asphalt that contain concentrated amounts of crystalline silica. The silica-containing dust is emitted and enters the workers’ respiratory system. Silica is a natural material found in most clay, rocks and sand and even in concrete and bricks. According to HSE [16], when masonry activities such as cutting, drilling, grinding, etc. are carried out, the silica produces fine dust called respirable crystalline silica (RCS). Workers may develop various lung diseases by breathing in RCS such as silicosis, lung cancer, chronic obstructive pulmonary disease (COPD) [16][17]. RCS can travel deep into workers’ lungs and cause silicosis, an incurable and sometimes deadly lung disease. Usually, construction workers who are affected, are not aware of the symptoms because of the risk triggered by long-time of silica exposure.

Several intervention methods have been introduced and commonly used in the construction industry to reduce the risks of exposure. Intervention may be designed to avoid hazards at any of the three locations, namely, at the source, in the path between the source, and at the receiver as shown in figure 1.
Ghosh et al. [12] stated that adopting an increased number of engineering controls can minimize the risk of dust exposure to workers. Common ways of reducing dust exposure in the construction industry are by using personal protective equipment (PPE), use of local exhaust ventilation system (LEV), removing wet dust by using (cooling water), and influencing worker behaviour through education and training [13]. Other than that, an old and reliable dust control technique is to wet or mist a surface that is to be cut or drilled [18]. For example, when using a jackhammer, wetting the surface with mist or spray of water helps to reduce the amount of airborne dust [19]. Several research have reported the reductions in respirable dust by either wetting a blade or sparing a surface [18,20].

Moreover, another tool to lower the masonry dust hazard is local exhaust ventilation (LEV). Based on WHS [17], LEV is a more efficient way to control highly toxic contaminants such as RCS dust, from the point or specific sources. A review article authored by Croteau et al. [21] has shown that the use of LEV can significantly decrease airborne particulate exposures caused by various construction-related activities. Based on short-term sampling, it has been shown that local exhaust ventilation (LEV) and wet techniques can reduce silica and respirable dust exposure by >90% [13]. Whereas, full-shift measurements, however, showed lower exposure reductions (<50%) when dust collection equipment was used [13].

The use of PPE as intervention at the receiver is considered the least desirable approach to controlling construction health hazards [12]. However, respiratory protection is primary. If the respirator is not used properly, the functions will be decreased. Research have shown that respiratory protection equipment is often not available or not used sufficiently and that it may not offer adequate protection from respirable crystalline silica for many tasks [13]. For instance, respirator protections are inadequate as it limits dust exposure only for the individual, while co-workers and nearby personnel are still exposed to it [18].

2. Methods
For this study, a survey research method was adopted. The overall research process of the study included the following four steps: (i) selecting the respondents; (ii) developing the survey instrument; (iii) conducting the survey and collecting data; and (iv) analyzing the data.

2.1. Respondent’s selection
Twenty-five (25) construction employees from the G6/G7 contractor firms in Selangor and Kuala Lumpur were selected as the number of interests. The reason for choosing construction projects in Selangor and Kuala Lumpur is because both the states record the highest number of domestic project
constructions. A total of 21 G7 contractors and 4 G6 contractors participated in this study, in which 72% of the firms had more than 30 years of experience in construction activity. The participating firms are currently undertaking construction projects such as residential, office, educational, highway, and railway projects. Residential projects comprise the majority of participating firms’ current construction projects, contributing to about 16 firms (64%). Meanwhile, office building, educational building, highways, and railways are the minority with 3 firms (12%), 4 firms (16%), and 1 firm (4%), respectively.

This study involved collecting data through a survey method distributed to each participant from each firm. Among the 25 participants who participated in the survey, 6 participants hold the Safety and Health Officer (SHO) position, 3 were project managers (PM), and 19 were engineers. Furthermore, the frequency distribution of the participants based on their working experience shows that 15 out of 25 of the participants have less than 5 years of working experience, 9 participants whose working experience range 6-10 years, and only 1 participant has working experience within the range of 11-15 years.

2.2. Survey instrument development
A survey method was applied in order to achieve the objective of this study. The individual survey form was composed of a combination of two types of question divided into three (3) parts as follows:

(i) Part A: Demographic information of the respondent. This part is concerned with the contractors’ firm and the representatives’ demographic information. It was a checklist question which comprised of information of contractors’ firm such as, firms’ CIDB registration grade; firms’ year of operation; number of employees in the firm; and types of current projects. On the representatives’ information, questions such as respondents’ position in the organization and working experience in the construction industry were asked.

(ii) Part B: Evaluating of the respondents’ perception of risk associated with masonry dust and types of dust control that firm applied in masonry work. In part B, the respondents were asked to indicate their perception of the dust risk and health impact of exposure to dust in masonry works. This is to evaluate more about respondents’ understanding of the dust risk. Then, respondents were also asked about the intervention method for controlling masonry dust implemented at their construction sites.

(iii) Part C: Identifying respondents’ perceptions of the barriers to the adoption of engineering control technologies in the masonry work. The purpose of this part is to gather information from the respondents’ perspective about barriers to the adoption of engineering control technologies in the masonry work.

2.3. Data collection
The surveys were conducted between August and October of 2019. The researcher contacted and asked the participants’ permission to participate in the research after explaining the objective and scope of study, before distributing the survey form. The surveys were held by a site visit to the construction projects and interviewing with different participants at different locations and times. The method took approximately 30 minutes for each participant. The survey began with a brief summary of the project objective, followed by a review of the consent information and assurance that respondent identities would never be linked to the responses and that only the aggregate data would be published.

3. Results and discussion
3.1. Respondents’ perception on dust risk and intervention method associated with exposure to dust hazards in masonry works
3.1.1. Awareness of dust risk in masonry activity. Most of the participants (88%) were aware about the dust risk in masonry activities, whilst the remaining 3 participants (form engineer group) were not aware about the risk. This might be due to their lack of working experience and their scope of work, which did not expose them to the hazards and risks. For example, an engineer may just carry out their
duty such as monitoring the construction activity and are not directly involved with the masonry dust. Overall, it is indicated that majority of the respondents are knowledgeable regarding the risk.

3.1.2. Health impact from exposure to dust in masonry work. The respondents were asked to indicate their opinion about the health impact from exposure to dust in masonry work, as shown in figure 2. A total of twenty-five (25) responses were identified, such as respiratory problem, health diseases, skin and eyes irritation, and fever. The respondents identified mainly of potential risk with dust exposure are 59% of respiratory problems such as asthma, in which 19 out of 25 respondents stated this. The next mainly health impact from dust exposure is health diseases such as lung cancer and silicosis (25%). This is in agreement with the finding by Akbar-Khanzadeh [22], which states that exposure to crystalline silica can result in both respiratory and non-respiratory health effects. The main dust-related diseases affecting construction workers are lung cancer, silicosis, chronic obstructive pulmonary disease (COPD), and asthma [8]. Other than that, 10% of the respondents answered that exposure to dust could also cause skin irritation and sore eyes.

![Health impact from exposure to dust in masonry works](image1.png)

**Figure 2.** Health impacts from exposure to dust in masonry works.

3.1.3. Intervention method that your firm implemented to prevent dust hazards. Figure 3 shows the respondents’ answers on the type of dust control that are implemented at their construction sites. Several methods were identified such as respiratory protection, wet method, and sweeping compound, in which most of the respondent’s answers are the combination of more than one method. It can be clearly seen that most of respiratory protection intervention method is being implemented at all construction sites. Meanwhile, 84% of the construction sites used the wet method, followed by sweeping compound (64%). It is identified that 14 out of 25 sites implemented the combination of respiratory protection, wet method, and sweeping compound.

![Types of dust control in construction site](image2.png)

**Figure 3.** Types of dust control in construction site.
According to NIOSH [7], engineering control and work practices provide the best protection for workers and must be implemented first, before respiratory protection is used. Answers pertaining to respiratory protection equipment (RPE) that was most frequently used by the respondents was to prevent worker exposure to dust hazard. However, majority of the respondents provided inappropriate RPE to their workers. For example, when the workers were exposed to masonry dust, they only wore dust masks, which are not suitable respiratory protection. Ghosh et al. [12] agreed that RPE is not used properly or not available, and that this may not provide sufficient protection from RCS for any tasks.

Respondents also answered that they applied engineering control such as wet method to minimize the dust generation in masonry work. For example, a worker used a jackhammer to chip concrete by using a water spray attachment to control dust emissions. Previous studies agreed that wet method is very useful in reducing dust level [14, 22, 20]. However, mist or spray of water must be in the right angle and applied constantly at the point where the jackhammer hits the surface. This method is to wet the dust before it can spread away and effectively reduce airborne dust. Moreover, employers should train workers on the proper use of wet methods to reduce visible dust [23].

3.1.4. Best controls for preventing exposure to dust hazard. With regards to the respondents’ perception of the best control for preventing exposure to dust effect in the workplace, most respondents opined that using appropriate PPE as the way to control workers exposure to dust hazard. This contradicts the principle of hierarchy of risk controls that state PPE should be is used when other control measures are not feasible and where additional protection is needed [24]. The PPE is to be used by the workers wearing the appropriate filters such as, P1 filters, that are for mechanically generated particulates like silica [25]. Meanwhile, NIOSH recommends the use of half-face piece particulate respirators with N95 or better filters for airborne exposures to crystalline silica at concentrations less than or equal to 0.5 mg/m3 [26]. Despite that, employers need to make sure that the RPE is suitable for work and fits the user's face.

Additionally, respondents also answered that job rotation or short working hours in administrative control is the best control for preventing exposure to dust hazard. This is because job rotation can reduce the time that workers are exposed to a hazard [24]. For example, respondents recommend masonry workers can be rotated in 4 hours to limit exposure to dust risk in a long time. HSE [27] stated that exposure should never normally exceed the silica maximum exposure limit (MEL) of 0.3 mg/m3 when measured or estimated for any 8-hour period, called a time-weighted average (TWA). Therefore, employers must reduce exposure to RCS dust as far as it is reasonably practicable below the MEL to make sure workers worked in a safe environment.

Other administrative measures mentioned by the respondents were to have a toolbox meeting or safety meeting before work commences. Based on Nawi et al. [28], a toolbox meeting is to discuss the health and safety matters which involve all the construction workers. Employers also need to make sure employees understand and do what they need to do when they are exposed to dust hazards. Hence, workers would be aware of the dust risk in masonry work if employers held daily health and safety briefings before the work commences.

In addition, answers pertaining to hazard identification, risk assessment and risk control (HIRARC) was identified as the way to control the exposure to dust hazard. DOSH [24] stated that the purpose of HIRARC is to enable employers to plan, introduce, and monitor preventive measures to ensure that the risks are adequately controlled at all times.

3.2. Respondents’ perception of the barriers to the adoption of engineering control in masonry work
Analysis of the open-ended questions revealed that the key barriers to the adoption of engineering control technologies in the masonry work that can be categorized under 3 emergent themes, namely due to expensive cost, lack of awareness to dust hazard, and worker’s attitude. The majority of respondents (47%) answered that to provide engineering controls such as LEV is expensive and not practical for construction activities. Expensive cost was also highlighted for providing appropriate type of PPE (such as RPE) compared to dust masks. Wong and Soo [29] reported that several construction companies in West Malaysia are reluctant to provide their workers with PPE and invest in safety
equipment. Hence, the protection at work is inadequate, allowing the workers to work with risk at their worksites [5]. Therefore, the contractor must take the responsibility to put allocation in providing appropriate PPE to the workers even though PPE is lease feasible in the hierarchy of risk control.

Other than that, 36% of respondents answered that the employers’ and employees’ lack of knowledge and awareness of the impact from exposure to dust hazards is one of the hindrances for adopting engineering control technologies in masonry activities. The effect of exposure to dust is latent/delayed, in which the worker can only experience the effect after several years. Therefore, it is a responsibility for employers to provide appropriate intervention methods to reduce the risk of exposure to dust. For the effective management of work-related safety and health risks and hazards, it is crucial to the ability to recognize and identify hazards [25]. When workers lack adequate safety and health education, hazardous risk on construction sites may not be identified by the workers. Safety practices at work are vital in promoting safety amongst themselves on the construction site [30,31,32].

In addition, 17% of the respondents also added that workers’ attitude is one of the obstacles in implementing Engineering control technologies in masonry work. Due to workers’ stubbornness, they refuse to wear respiratory protection as it is uncomfortable to work in. Feeling uncomfortable with the equipment when doing their work on-site and seeing it as a barrier to their work output are the reasons most employees refuse to wear PPE.

4. Conclusion
Based on the results, the majority of respondents identified and indicated the masonry risks such as respiratory problems and lung diseases such as silicosis and lung cancer. The findings of this objective revealed that the main hindrance for implementing engineering control technologies in masonry work are cost issues. Other than that, the respondents also stated that the lack of awareness from employers and employees about masonry dust risk is an obstacle to perform engineering control technologies. With high costs, and the lack of awareness and proper attitude has caused low adoption rates of engineering control masonry work. The most common intervention methods applied by respondents in construction sites are respiratory protection equipment, wet method, and sweeping compound.

This study also contributes to an understanding of the risk related to exposure to dust hazards in masonry work, which will increase the safety performance in the construction site. It is particularly important for the current masonry work environment that the barriers to the adoption of Engineering control technologies can be identified. Hence, the key players in the construction industry may take an active part to increase the implementation of engineering control in construction projects.

This study has several limitations. Firstly, it is only focused within 2 states in Malaysia, Selangor and Kuala Lumpur. The concentration of the study within Selangor and Kuala Lumpur may not be adequate. Next, this study only involved 25 respondents such as the project manager, the safety and health officers, and the engineers. Future study should be carried out by adding more respondents, for example, designers and masonry workers, to obtain more understanding of intervention methods implemented for dust risk and the barriers for adopting engineering control technologies in masonry work accurately. The different populations and working environments will also obtain a different outcome.

5. References
[1] Sarkam S F, Shaharuddin L S, Zaki B M, Masdek N R N M, Yaacob N J A and Mustapha M 2018 Factors Influencing Safety Performance at the Construction Site, International Journal of Academic Research in Business and Social Sciences 8 1057–1068.
[2] Nawi M N M, Ibrahim S H, Affandi R, Rosli A and Basri F M 2016 Factor Affecting Safety Performance Construction Industry, International Review of Management and Marketing 6 280–285.
[3] DOSH 2020 Occupational Accidents Statistics by Sector Retrieved on March 1, 2021 from www.dosh.gov.my
[4] International Labour office 2012 Safety, Health and Welfare on Construction Sites Technical Report (Geneva: International Labour Office Geneva).
5. Yakubu D M and Bakri M I 2013 Evaluation of Safety and Health Performance on Construction Sites (Kuala Lumpur), Journal of Management and Sustainability 3 100–109.

6. World Health Organisazation (WHO) 2001 Occupational health - A manual for primary health care workers. (Cairo: World Health Organization).

7. Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health 2002 Health Effects of Occupational Exposure to Respirable Crystalline Silica Retrieved on May 30, 2020 from https://www.cdc.gov/niosh/docs/2002-129/

8. HSE 2013a Construction dust. Health and Safety Executive Retrieved on October 10, 2020 from http://www.hse.gov.uk/pubns/cis36.pdf

9. Sen S, Mitra R, Mukherjee S K, Das P and Moitra S 2015 Silicosis in Current Scenario: A Review of Literature, Current Respiratory Medicine Reviews 12 56–64.

10. Cancer Council 2014 Occupational Cancer Risk Series Silica Dust (Australia: Cancer Council Australia).

11. DOSH 2021 Occupational Poisoning and Diseases Statistics 2019 Retrieved on August 8, 2021 from https://www.dosh.gov.my/index.php/statistic-v/occupational-diseases-statistic/3869-2019/file

12. Ghosh S, Langar S and Bhattacharjee S 2015 A Cross Sectional Study of the Perceptions of Large Contractors towards Prevention through Design Proceeding of the 51st ASC Annual International Conference (Texas)

13. Nij E T, Hilhorst S, Spec T, Spierings J, Steffens F, Lumens M and Heederik D 2003 Dust Control Measures in the Construction Industry, British Occupational Hygiene Society 47 211–218.

14. Muianga C V, Rice C H and Succep P 2009 Silica dust control in small-scale building/structure demolition operations using good work practice guidance J. Phys.: Conf. Ser. 151 012055.

15. Ertas A 2010 Prevention through Design: Transdisciplinary Process (Texas: The Academy of Transdisciplinary Learning and Advanced Studies. Texas) pp 1–52.

16. HSE 2013b Control of exposure to silica dust- A guide to employees (United Kingdom: Health and Safety Executive).

17. WHS 2013 Silica: Technical guide to managing exposure in the workplace, 2, 1–22 Retrieved on October 1, 2020 from https://www.worksafe.qld.gov.au/__data/assets/pdf_file/0008/83186/silica_managing_workplace.pdf

18. Lahiri S, Levenstein C, Nelson D I. and Rosenberg B J 2005 The cost effectiveness of occupational health interventions: Prevention of silicosis, American Journal of Industrial Medicine 48 503–514.

19. USDol 2017 Control of silica dust in construction- Jackhammers or Handheld Powered Chipping Tools.

20. Flynn M R and Susi P 2003 Engineering controls for selected silica and dust exposures in the construction industry- A review, Applied Occupational and Environmental Hygiene 18 268–277.

21. Croteau G A, Flanagan M E, Camp J E and Seixas N S 2004 The efficacy of local exhaust ventilation for controlling dust exposures during concrete surface grinding, Annals of Occupational Hygiene 48 509–518.

22. Akbar-Khanzadeh F, Milz, Ames A, Susi P P, Bisesi M, Khuder S A and Akbar-Khanzadeh M 2007 Crystalline silica dust and respirable particulate matter during indoor concrete grinding - Wet grinding and ventilated grinding compared with uncontrolled conventional grinding, Journal of Occupational and Environmental Hygiene 4 770–779.

23. US Department of Labour 2013 Controlling Silica Exposure in Construction While Operating Jackhammers Retrieved on June 30, 2020 from http://www.ehsdb.com/resources/Images/4/Silica_images/jack%20hammers.pdf

24. DOSH 2008 Guidelines for Hazard Identification, Risk Assessment and Risk Control (HIRARC) (Putrajaya: DOSH).
[25] Lingard H, Leifels K, Rahnama S, Fletche H and Harley J 2018 *Applying the hierarchy of control to occupational health risks in construction: Barriers to effective decision-making* (Melbourne: Centre for Construction Work Health and Safety Research, RMIT University)

[26] NIOSH 2008 *Respiratory Protection Recommendations for Airborne Exposures to Crystalline Silica* (Washington DC: Department of Health and Human Services)

[27] HSE 2001 *Controlling Exposure to Stonemasonry Dust* (United Kingdom: Health and Safety Executive).

[28] Nawi M N M, Ibrahim S H, Affandi R, Rosli A and Basri F M 2016 Factor Affecting Safety Performance Construction Industry, *International Review of Management and Marketing* 6 280–285.

[29] Wong S S and Soo A L 2019 Factors influencing safety performance in the construction industry, *Journal of Social Science and Humanities* 16 1–9.

[30] Mohammed Y., Shamsul B M T and Bakri M I 2017 Assessing Workers Safety Management Knowledge on Construction Site, *International Journal of Engineering Research and Science* 3 20–26.

[31] Kerry T V, Abas N H, Mohd Affandi H and Md. Amin S 2021 Stakeholder’s perceptions on the significant factors affecting safety management implementation at construction sites, *Malaysian Construction Research Journal Special Issue* 13 68-80

[32] Abas N H, Yusuf N, Rahmat M H and Tong Y G 2021 Safety Personnel’s Perceptions on the Significant Factors that Affect Construction Projects Safety Performance, *International Journal of Integrated Engineering* 13 1-8