

Article

Mitigating Dust Pollution from Construction Activities: A Behavioural Control Perspective

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Abstract: Construction sites constitute major sources of pollutants creating negative impacts on the environment. Sustainable construction aims at mitigating these negative externalities while promoting economic and social outcomes. Dust pollution in construction sites is an invisible hazard, which is often ignored as little more than a nuisance. Although behavioral control is a popular way of preventing dust generation, past research has paid little attention to worker behavior regarding dust mitigation. This study aims to test a model that predicts intentions to alter the conduct of workers towards dust control in construction activities. This study adopted a questionnaire survey design with construction participants in Sri Lanka, using structural equation modelling to test several hypotheses based on the Norm Activation Model. The results proved that awareness of consequences and ascription of responsibility could have a positive impact on personal norms, which in turn could influence the behavior of site employees. The study also provided new insights on employees' awareness of dust hazards, their sense of responsibility for its control, and the importance of their company. Policymakers and practitioners are recommended to pay more attention to how to harness worker's support to mitigate dust pollution, and construction companies should initiate educational campaigns to raise awareness about environmental impacts, to influence personal norms of the workers in building sites. This research contributes to the body of knowledge by enhancing our understanding of factors influencing employees' dust control behavior.

Keywords: dust pollution; workers' behavior; Norm Activation Model; health hazards; construction site



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1. Introduction

Sustainable construction aims at reducing negative externalities while increasing economic outcomes, comfort, and social justice of projects [1]. Nevertheless, construction projects are renowned for their role in environmental pollution due to noise, waste, dust, and hazardous emissions [2]. These negative impacts are highly visible on projects undertaken in cities, making an undeniable mark on the nearby communities, especially where rapid urbanization takes place over a long period of time [3]. Environmental protection measures such as certification systems, assessment methodologies, and environmental management guidelines were proposed over the years to mitigate the adverse impacts during construction activities with mixed results [4].

Dust pollution is one of the serious environmental impacts of construction activities, mainly when undertaken in high-density urban areas [5]. It not only threatens the health of site workers, but also affects the health and welfare of neighboring communities [6]. Yang et al. [7] and Song et al. [8] found that the calcium elements in the air could be traced back to construction activities nearby. Dust-emissions from construction sites were found to aggravate the notorious haze pollution experienced in some Chinese cities in recent times [9]. According to Zuo et al. [6] and Wu et al. [10], the main sources of dust pollution

on construction sites are: excavation and earthwork; grinding, cutting, and drilling; traffic on unsealed roads; earth stockpiles; street sweeping; demolition; loading and unloading; cement and lime stabilization; asbestos removal and soil transportation. Dust pollution at sites is aggravated by wind, dry weather, emission of silt particles, and mechanical disturbances.

Control of the generation and discharge of dust during construction operations has been a general research interest for a long period [11–19]. Regulations and engineering control methods were frequently used to deal with construction dust pollution in the past [7,20,21]. These measures are either expensive or difficult to implement due to resource constraints [10,21,22]. However, behavioral control methods are found to be less expensive and effective than regulatory and engineering control methods in many areas of environmental pollution. Although past studies on waste and work health and safety management in construction have shown behavioral control methods can be very effective [23–25], behavioral studies related to dust pollution on construction remains limited.

A study by Zuo et al. [6] investigated construction managers' dust pollution control behavior and found that their perception of dust pollution as a trivial discomfort has huge negative impacts on their self-responsibility for its control. One of the limitations of Zuo et al. [6] is its narrow focus on managers' perceptions without consideration of the views of the workers whose activities are the principal source of dust generation. What motivates construction workers to consider reduction of dust pollution in their work site? Do they prioritize collective interest of their fellow workers and the neighboring community over self-interest? Past studies have revealed that normative considerations play an important role in pro-environmental behavior of people [26]—is this applicable to construction workers in situations of dust pollution generated by their own activities? Can the company play a role in motivating workers to behave in a certain way? These are some of the questions that arise when one look at behavioral control as a solution to some of the endemic environmental issues facing the construction industry.

It is important to understand how, and which normative considerations can influence the behavior of a construction worker in situations involving dust pollution. Such an understanding will further the development of strategies to encourage behavioral changes in workers while providing necessary wherewithal to companies on how its own behavior should be moderated. Norm Activation Model (NAM) is a prominent theory that explains people's pro-environmental behavior, particularly how normative considerations translate into actual behavior. NAM postulates that people are more likely to behave in a certain way when they feel morally obliged to do so. Using NAM, this study aims to explain the construction worker's dust pollution control behavior, and in particular, whether workers would be more likely to consider reduction of dust pollution when they experience a strong personal norm to do so. According to NAM, two factors are responsible for the activation of personal norms: firstly, they should be aware of the negative consequences of dust pollution and secondly, a feeling of discomfort from not taking action to reduce dust pollution.

Without understanding the motivation of workers, the potential for behavioral control regarding dust pollution cannot be assessed. Hence, this study proposes and tests a model that predicts intentions to alter behavior of workers in order to control dust generation in construction activities. Given the above context and importance of understanding factors affecting worker behavior, the objectives of this study are as follows:

1. Building a theoretical model of construction workers' dust pollution control behavior by integrating factors affecting personal norms in an environmentally responsible work setting.
2. Testing the applicability of the extended norm activation framework when a company's environmental responsibility is included.
3. Uncovering the relative importance of study variables in determining behavior intention.

4. Testing the mediating impact of a company's environmental conduct in the proposed theoretical framework. The intention is to understand how the perception of the worker about the company's environmental credentials could potentially affect their personal norms and behavior.

To achieve above objectives, this study developed hypotheses regarding construction workers' dust control behavior influence paths using the Norm Activation Model. Based on a questionnaire survey administered among construction workers, the study verifies those hypotheses while gathering a body of information surrounding workers' awareness and self-responsibility. The study incorporated company's environmental conduct, particularly its position on dust pollution control, as an antecedent of worker behavior. This paper is organized as follows: First, a literature review is presented on dust pollution and its control in construction sites. The concepts of environmental behavior and norm activation model are then introduced in order to help understand the constructs used to represent the operational aspects of this study. This is followed by a justification of the method used to collect data. Consequently, the results of the study are discussed, with an outline of the implications for construction organizations and practitioners.

2. Literature Review

2.1. Dust Generation and Its Impact

Construction works emit large quantities of dust into the environment causing serious health issues to the workers and people living nearby [27]. Most cutting, drilling, and grinding operations generate high levels of particle emissions and cause health impacts due to inhalation [13,28–30]. On demolition sites and recycle yards, breakage of stone and concrete produce fugitive silica dust, which causes lung cancer [21,31]—silica is the second most harmful substance for lung cancer after asbestos. Other than lung cancer, another serious health issue caused by silica is silicosis, which is the scarring of lungs by inhalation of small dust particles, as is well recorded in the literature. Tuberculosis, which is a severe infection, is aggravated by silicosis [32]. Excavation, filling, stockpiling, and haulage operations generate huge volumes of dust containing silica that could spread beyond the site limits as dump trucks transport these materials to disposal sites [33]. Vehicle movement on unpaved roads, which is typical of temporary roads within construction sites, also creates large quantities of dust [34]. Dust generated by temporary road surfaces during construction is the most prominent source of air pollution followed by emissions from storage of bulk material and construction equipment. Detailed monitoring results showed PM₁₀ is the most prevent pollutant compared to CO and NO_x, the former is mainly generated through soil disturbances and unsealed temporary roads while the latter mainly due to equipment use [34]. Dust generated during urban construction activities is initially deposited in nearby roads, which are subsequently re-suspended due to vehicular traffic. According to a study by Ma et al. [35] in China, such pollution also contains heavy metals that are harmful to nearby residents. In addition to these health impacts, past research has highlighted a range of social impacts of construction dust, including: damage to neighboring properties and streets, nuisance, poor visibility, air pollution, skin and eye irritation, damage to reputation of the builder, and compliance issues with regulatory requirements [6,36–38].

2.2. Dust Pollution Control on Sites

In recent years, research on health damage caused by construction dust is gradually attracting the attention of scholars [39,40]. There are a number of past studies on dust pollution during construction, including the exploration of dust emission factors, dust dispersion methods, dust detection technology, dust pollution characteristics, dust control technology, health damage assessment, air quality impact, etc. [10,17,26,41–44]. To avoid negative impacts of construction dust pollution, regulatory and engineering control measures have been proposed by most of these studies. Very few studies have investigated the way to avoid or reduce the generation of dust [21,45–47]. A summary of the solutions

proposed by past studies is presented in Table 1, classified by three main categories. Prevention or reduction of dust by changing work patterns or behavior is far superior to other two methods because it solves the issue at the source. However, that strategy may not be suitable for all construction activities.

Table 1. Strategies for controlling dust pollution.

Category	Control Measure
Prevention or reduction of dust generation	<ul style="list-style-type: none"> • Change of worker behavior • Change of work methods (examples: use of ready-mixed concrete in place of site mixed; pre-fabrication and modular construction) • Ground surface hardening • Greening • Control of load capacity • Cover dump trucks that transport excavated material • Control of driving speed • Control during loading operations such as horizontal loading • Provision of sealed roads within construction sites • Implementing appropriate material stacking and stockpiling heights
Administrative control	<ul style="list-style-type: none"> • Third party supervision, dust monitoring, dust auditing etc. • Education and training • Introduce environmental plans • Introduce appropriate charging schemes • Introduce dust mitigation regulation • Use of personal protective gear • Work indoors during dust breaks • Suspend outdoor activities during dust breaks or windy/dry days
Engineering control	<ul style="list-style-type: none"> • Use of dustproof cover, net or screens • Dust collection systems • Wet dust suppression systems • Wheel washing of vehicles • Dilution using fresh air • Using windbreaks/hedges • Use of local exhaust ventilation • Use of chemical agents • Use of electric sweepers

Source: Wu et al. [10]; Zuo et al. [6]; Noh et al. [21]; Xing et al. [45]; Cao and Zhang [46]; Li et al. [47].

In situations where prevention is not feasible, administrative and engineering control measures could help reduce the magnitude of the issue and the degree of exposure. Out of these, water suppression to mitigate the spread of dust is the most popular [6,17,20]. Maintaining standard heights for stockpiling, wetting objects before cutting or grinding, and wetting while sweeping are very easy methods to control some of the dust generated at sites. Use of chemical agents, electrical sweepers, dust screens, local exhaust ventilation, etc., are some technologies that are available for the construction companies to manage dust pollution. The effectiveness of some of these control methods, particularly that of water suppression, was found to be very high [28]. For example, water suppression combined with dust collecting devices was able to reduce workers' exposure to dust by about 90% and 70%, according to the studies of Thorpe et al. [28] and Tjoe et al. [11], respectively. However, countries or regions that experience water shortage find this technique to be expensive and morally inappropriate. A study commissioned by the US Department of Energy found water suppression to control dust has several negative impacts, including

ground water contamination [33]. Overall, behavioral control methods are a promising alternative to the engineering control methods as it deals directly with dust generation. Zuo et al. [3] found behavioral control methods to be well suited for dust pollution, though most construction workers consider dust as a nuisance rather than a serious health risk.

2.3. Dust Control Behavior

Environmental and social psychologists demonstrated that behavior is influenced through attitudes, beliefs, and values of people [48]. Values, beliefs, and behaviors are transmitted through generations by shared experiences [49]. According to Braungart [49], the construction industry needs a holistic approach encompassing a cultural shift of behaviors and attitudes of various project participants to overcome endemic environmental issues facing the industry. Therefore, complete transformation of actions and mindset can be achieved from changes happening in practices and behaviors [23,50]. Wong and Yip [51] highlighted that behavioral and attitudinal changes of builders are more significant than adapting new technologies to mitigate environmental issues faced by the construction industry. For example, Li et al. [52] developed taxonomy of performance shaping factors for tunneling operations and found dust and fumes to be very important factors for human behavior modeling and simulation.

Environmental researchers have been investigating the relationship between attitudes and behaviors, which gave rise to several theories. Among them the Norm Activation Model (NAM) and the Theory of Planned Behavior (TPB) are very popular [26,53,54]. NAM asserts that pro-environmental behavior depends directly on the activation of altruistic moral norms rather than general environmental concerns [55]. A person develops a sense of moral obligation if he or she feels responsible for mitigating a consequence arising out of an action and if that person expects serious negative outcomes for others. Thus, Schwartz and Howard [56] explained that acceptance of personal responsibility and intensity of awareness of consequences lead to the activation of personal norms within a person. The TPB is the modified version of the Theory of Reasoned Action (TRA), and it consists of a new variable, Perceived Behavior Control (PBC), in addition to the variables such as attitude toward the behavior, subjective norm, and intention [53,55,57]. Previous behavioral studies in construction demonstrated the strong influence of personal norm in workers' behavior. Liu et al. [58] found safety citizenship behavior of construction workers is positively related to personal norm. Similarly, knowledge-sharing behavior of construction project participants was investigated by Ding and Ding et al. [59] and Zhang and Ng [60] using TRA. Furthermore, TPB was used by researchers to evaluate construction workers' waste behavior [24,61–64] as well as safety behavior [65,66].

3. Methods and Materials

3.1. Model Conceptualization and Hypothesis Development

NAM has been widely used by researchers to study individual's pro-social behavior. It postulates that one's intention or behavior is influenced by moral norms, which are also referred to as personal norms [55]. In this theory, norm activation begins with an individual's awareness of detrimental consequences of the status quo and their ascription of responsibility for not acting pro-socially. This awareness activates a personal norm that determines whether that individual should act in a certain way to prevent or mitigate that harmful consequence [67]. From a dust pollution perspective, a construction worker's awareness of its consequence and ascription of responsibility for not resorting to control measures should trigger personal norms that guide the worker's intention or behavior regarding pollution control. In this model, awareness of consequences deals with whether the worker is aware of the consequences to the fellow workers and the neighboring community when not implementing a specific action to control it [68]. Ascription of responsibility refers to the feeling of responsibility for not taking action to control pollution [68]. Personal norms indicate a moral obligation to perform dust pollution control measures during construction

operations. In this context, personal norms are referred to as feelings of “moral obligation to perform or refrain from specific actions” [55], p. 191.

NAM has been applied in different sectors with a view of initiating changes in people’s intention or behavior. One such very popular application is the energy saving behavior of people. Van der Werff and Steg [26] used NAM to predict factors influencing household energy saving behavior, investigating what motivates people to reduce energy consumption even if that means sacrificing self-comfort. Zhang et al. [54] used it to understand what motivates an employee’s energy saving behavior in organizations. Unlike in households, there is no financial incentive for employees to save energy in their workplace; they do it purely on altruistic motives, which are heavily underpinned by their personal norms [47]. A feeling of moral obligation is found to trigger this pro-environmental behavior, which is strongly influenced by the organization’s environmental climate. The findings of Zhang et al. [54] are very useful for the current study as it deals primarily with worker behavior and also investigates the role of the company in shaping such behavior.

A recent study by Song et al. [69], which is somewhat related to the present study, investigated the role of China’s notorious haze pollution on people’s energy saving behavior. The underlying assumption that the purchasing behavior of energy saving appliances could help conserve energy as well as reduce emissions was tested using NAM. The study found strong evidence that personal norms could be used to alter people’s behavior, and the government should be using social networks and social media to propagate the current environmental conditions and the negative consequences of using non-energy saving appliances and its impact on haze pollution. The works of Steg and De Groot [70] and Shi et al. [71] are of interest to the current study as their focus was on the willingness of car users to take action to reduce particulate emissions.

Based on the extensive NAM literature, a conceptual model, as shown in Figure 1, was developed to operationalize this research. It is intended to explain employees’ dust pollution control behavior in construction organizations. According to NAM, an individual’s pro-social behavior is positively influenced by one’s personal norm [54], hence, we postulate the following hypothesis regarding dust pollution control behavior of construction workers of an organization.

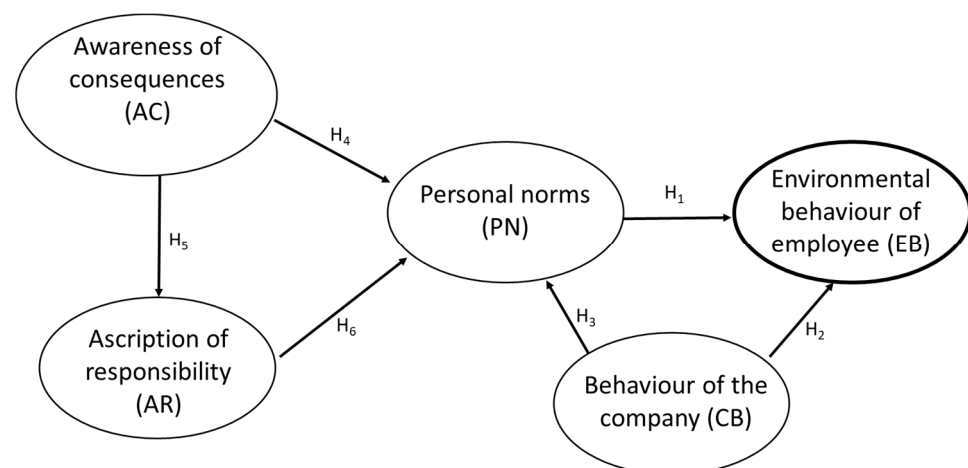


Figure 1. Conceptual Model.

Hypothesis 1. *Personal Norm significantly and positively affects the environmental behavior of employees.*

In addition to personal norms, there is evidence that an organization’s environmental practices could influence its workers’ environmental behavior [72]. Whether the construction company has adopted dust control measures in the past and maintains an environmentally conducive work environment will have a bearing on employees’ individual dust

control behavior [3]. Employees of civil engineering projects felt the preparedness and company's commitment to dust pollution control more than that of building companies, which in turn helps form a positive behavioral intention among managers of civil construction companies towards pollution control compared to those from building companies [6]. Zhang et al. [54] found strong evidence to suggest a company can influence its workers' energy saving behavior in the workplace. It was motivated by a common goal and a sense of moral obligation, which were not based on personal gains [73]. The construction company's environmental conduct and credentials were included as a predictor of workers' behavior in this study. Hence, the second hypothesis of this research is based on the premise that a company's behavior could influence the workers' individual behavior as follows.

Hypothesis 2. *A company's behavior significantly and positively affects the environmental behavior of employees.*

According to the social exchange theory, when the construction company shows its sense of responsibility to other stakeholders of the environment and takes dust control actions seriously, the employees of that company will foster their awareness of dust hazards and sense of responsibility for dust control because of their identity as organizational members [69]. Therefore, a construction company can influence not only the behavior but also employees' personal norms regarding dust pollution control. This aspect is reflected in the third hypothesis developed for this study.

Hypothesis 3. *A company's behavior significantly and positively affects the personal norm of employees.*

According to NAM, one's personal norm is activated by one's awareness of consequences and ascription of responsibility. Awareness of consequences is defined as awareness of negative consequences to others or to the environment due to an action (or non-action) of a person [68]. The awareness of health hazards to workers and people living closer to a construction site and other impacts to the neighborhood will trigger personal norms within a worker that dust pollution should be mitigated. Ascription of responsibility is described as a feeling of responsibility when not acting pro-socially to mitigate negative consequences [68]. This sense of responsibility for one's action (or non-action) should activate personal norms about the environmental issue in question. The relationship between personal norm and these antecedents is often interpreted in two different ways in the norm activation model.

The popular version out of the two, called the moderator model, defines both awareness of consequence and ascription of responsibility directly impacting personal norms (awareness of consequences and ascription of responsibility > personal norms > behavioral intention/behavior). This version is often used by researchers who investigate pro-environmental behavior of people. The alternative interpretation, which is called the mediator model, uses a sequential relationship in which awareness of consequences affects ascription of responsibility that in turn triggers personal norms [56,70]. This version could be portrayed as: awareness of consequences > ascription of responsibility > personal norms > behavioral intention/behavior. The proponents of this version argue that a person tends to be aware of the negative consequences of an action or inaction prior to feeling responsible for it [74]. However, in the former version, there is no direct link observed between awareness of consequences and ascription of responsibility. Han et al. [75], using lodging decisions of convention attendees, compared the two versions of NAM and found the sequential model to be more effective in predicting the pro-environmental decision making. This is because only when people become aware of negative consequences do they assign these to themselves and feel responsible for their impacts. As predictors of the personal norm of employees in a construction organization, the study tested three hypotheses as follows.

Hypothesis 4. *Awareness of consequences significantly and positively affects the personal norm of employees.*

Hypothesis 5. *Awareness of consequences significantly and positively affects ascription of responsibility of employees.*

Hypothesis 6. *Ascription of responsibility significantly and positively affects the personal norm of employees.*

3.2. Data Collection and Analysis

A survey method was used to collect data for model testing due to its suitability for obtaining individual beliefs and perceptions. A questionnaire survey was administered among a sample of employees working in construction sites in Colombo, Sri Lanka. A survey is a systematic way of collecting primary data, which can be efficiently utilized to suggest possible reasons for relationships in a model comprised of key variables [76]. Further, in a quantitative research approach, the problem is best addressed by understanding what factors or variables influence an outcome [77]. Moreover, a quantitative research approach is suitable for testing objective theories by examining the relationship(s) between different variables [78]. Therefore, this strategy is well suited for this research, by its very nature to test the relationships postulated in the conceptual model.

The supporting facts of the literature synthesis were used to develop the structured questionnaire survey under two sections. The purpose of Section 1 is to identify the demographics of the research respondents. Section 2 of the questionnaire survey was developed to identify the environmental behavior of employees based on the conceptual model. A 5-point Likert scale anchored by “strongly disagree –1” to “strongly agree –5” was given to the respondents to identify the level of agreement with each indicator used to measure the various constructs included as latent variables.

The sample was selected from the SC1 and SC2 graded contracting companies in Sri Lanka. The grading system is administered by the Construction Industry Development Authority (CIDA), which is a government agency entrusted with the regulation of the construction industry. It should be noted that SC1 and SC2 construction firms are the largest in Sri Lanka according to this grading system, which is based on the firms’ financial capacity, human resources, experience, etc. Therefore, the environmental management systems used by those companies are far superior to the lower ranks and their employees are well qualified and capable of answering the questions contained in the study. A combination of purposive and random sampling techniques was used to select the sample from the population of workers based at construction sites of these SC1 and SC2 construction companies. A purposive sample of current projects implemented by those companies in Colombo, the capital city of Sri Lanka, was selected. The questionnaire survey was administered in those sites and the responses were collected using a drop box to make it anonymous. The respondents consisted of project managers, engineers, health safety and environmental managers, site managers, quantity surveyors, technical officers, tradesmen, plant operators, and unskilled workers, as shown in Table 2. The reason for selecting these wide-ranging roles is because they have a major influence on the environment as they design and plan project operations, execute and monitor work, and are responsible for project outcomes. Therefore, the sample had both managers and workers, representing both aspects of construction operations. The sample size for this study was based on a rule of thumb generally employed for Partial Least Squares Structural Equation Modeling (PLS-SEM), in which the minimum sample size should be equal to ten times the largest number of formative indicators used to measure a latent construct. By considering these guidelines, 100 respondents were determined as sufficient for the sample.

Table 2. Profile of Respondents.

Role	Work Experience (yrs.)				Total
	<5	5–10	11–20	>20	
Project Manager	2	1	4	5	12
Engineer	10	2	2	1	15
Quantity Surveyor	7	7	3	-	17
Site Manager	4	8	2	2	16
Technical Officer	7	4	3	1	15
Tradesmen	6	14	12	4	36
Health Safety and Env. Manager	3	3	4	-	10
Plant Operator	12	4	2	-	18
Unskilled Worker	5	12	17	6	40
Total	56	55	49	19	179

Data obtained from the survey, which had a 1–5 Likert Scale, were analyzed using descriptive statistics to find behavioral perspectives and passed through the Structural Equation Modeling (SEM) technique for validation of the model. The mean of the descriptive analysis was used with a scale that has been employed in the study of Kazaz and Ulubeyli [79]. Accordingly, the scale from a difference of 1–5 and intervals with 0.8 was developed to determine the degree of central tendency based on following categorizations:

- <“Strongly disagree” ≤ 1.80 ;
- $1.80 < \text{“Disagree”} \leq 2.60$;
- $2.60 < \text{“Neutral”} \leq 3.40$;
- $3.40 < \text{“Agree”} \leq 4.20$; and
- <“Strongly agree” ≤ 5.00 .

Kazaz and Ulubeyli [78] have also used a similar approach that comprises intervals of the study for investigating the drivers of productivity among construction workers. The rank is defined when there are two or more variables that have the same mean values; the priority is assigned to the variables according to a descending order of standard deviation or coefficient of variation (CV) [79]. Based on the central tendency, a benchmark mean score of 4.2 was assigned to filter the “strongly agree” factors while 3.4 assigned as a benchmark for filtering “agree” factors.

The questionnaire comprised of a total of 23 items categorized under general information, demographics, variables of environmental behavior (awareness of consequences, ascription of responsibility and personal norms), and environmental behavior of the construction company. To ensure the content validity, the items were developed using literature and definitions of variables were assigned accordingly. Three items were developed to measure the awareness of consequences, one for ascription of responsibility, four for personal norms, three to observe company behavior, and two to represent the employees’ dust pollution behavior. Moreover, Composite Reliability (CR) was used to check the reliability and internal consistency. The survey instrument and model validation tools are elaborated in Section 4.2.

4. Results

4.1. Employees’ View on Their Responsible Behavior

The profile of respondents to the questionnaire survey is given in Table 2. Female representation of the sample accounted for approximately 6% of the respondents. A reasonably balanced distribution could be observed between managers (48%) and workers (52%). The age of the respondents was between 25 and 39 years and their experience ranged from less than 5 years to more than 20 years.

Table 3 presents the descriptive results of the analysis of the 13 responsible behaviors of respondents towards dust pollution factors.

Table 3. Views on responsible behavior of respondents towards dust pollution control.

Code	Item	Mean	SD
AC-1	The dust pollution in construction sites causes serious health impacts to workers	4.49	0.752
AC-2	I am aware of the negative influence of dust pollution on my site and on the public	4.13	0.765
AC-3	The dust pollution in construction sites causes nuisance and discomfort to the neighborhood	4.17	0.873
AR-4	I feel I am jointly responsible for the impacts of dust pollution on workers' health and safety	3.99	0.909
PN-1	It would be against my moral principles not to act against dust pollution issues in my site	4.18	0.961
PN-2	I have a moral obligation to protect the environment from dust pollution arising out of my site	4.45	0.780
PN-3	I would feel guilty about not acting against dust pollution arising of my sites	3.83	0.970
PN-4	I feel obliged to protect the environment from dust pollution from my site	4.08	0.669
CB-1	My company partners with environment friendly suppliers and subcontractors	3.80	0.688
CB-2	My company participates in/sponsors projects/events in the community to improve the environment	3.86	0.616
CB-3	My company take measures to control dust pollution on sites	4.42	0.660
EB-1	I help reduce dust pollution in my site	4.24	0.781
EB-2	I am very concerned not to generate dust in my work. If it is unavoidable, I take precautions to minimize it	4.43	0.749

As shown in Table 3, the overall mean scores for the constructs used to measure the latent variables affecting dust pollution control behavior, range from 3.80 to 4.49. Four constructs were rated as strongly agree, which consist of one each from awareness of consequences, personal norms, company behavior, and environmental behavior. The rest of the constructs were rated as agreed. In all constructs, except CB-2 (mean rank of 90.73 for managers compared to 89.32 for workers), workers' mean rank scores were higher than that of managers. The Mann–Whitney U test showed that there were statistically significant differences in perceptions between the managers and workers for AC-1, AR, PN-1, PN-2, PN-3, CB-3, EB-1, and EB-2. In general, it shows that ascription of responsibility, personal norms, and environmental behavior are significantly different between the two groups, where workers are more sensitive to dust pollution, ready to accept responsibility for its consequences, and alter behavior accordingly.

4.2. Model Validation

Studies that employed Structural Equation Modeling (SEM) such as Zailani et al. [80] and Abdullah et al. [81] considered its capability to perform a full test of concepts and theories [82]. Hair et al. [83] suggested that PLS-SEM is superior to CB-SEM for exploratory studies. Thus, PLS-SEM was used for this study since it is exploratory in nature as the effect of awareness of consequences and ascription of responsibility on the environmental behavior of construction employees have not been tested previously.

The model was tested by applying a two-step approach followed by Hair et al. [84] to evaluate reliability and validity of the indicators prior to validating the structural relationship. The first step is to analyze the measurement model, followed by the analysis of structural relationships among the latent constructs using the structural model.

4.2.1. Evaluation of Measurement Model

Firstly, the internal consistency, reliability and validity of constructs were assessed. Table 4 presents the summary of the loadings, Composite Reliability (CR) and Average Variance Extracted (AVE) of all indicators.

Table 4. The factor loadings, CR and AVE of the PLS algorithm.

Construct	Indicators	Factor Loadings	CR	AVE
Awareness of Consequences	AC-1	0.778	0.830	0.619
	AC-2	0.784		
	AC-3	0.799		
Ascription of Responsibility	AR-4	1.000	1.000	1.000
Personal Norms	PN-1	0.819	0.878	0.645
	PN-2	0.889		
	PN-3	0.691		
	PN-4	0.801		
Environmental Behavior	EB-1	0.918	0.931	0.871
	EB-2	0.948		
Company Behavior	CB-1	0.617	0.782	0.552
	CB-2	0.669		
	CB-3	0.911		

The loadings of all indicators were above 0.6, thus, signifying satisfactory indicator reliability [80]. The internal consistency reliability of all constructs evaluated using CR were above 0.7 and convergent validity of constructs, which were evaluated using AVE, were above 0.5, hence, a satisfactory degree of compliance to the rule of thumb postulated by Hair et al. [85] could be observed.

Discriminant validity was assessed using two approaches. Firstly, cross loadings were examined to validate that the opposing constructs are higher than the loads of indicators. Secondly, as shown in Table 5, according to the Fornell and Larcker criteria, the discriminant validity of each latent construct is higher than the construct's highest squared correlation with other constructs of the model. Therefore, both above analyses confirm the discriminant validity of all constructs.

Table 5. Construct correlations versus square root of AVE.

	AC	AR	CB	EB	PN
AC	1.000				
AR	0.379	0.787			
CB	0.390	0.160	0.743		
EB	0.511	0.287	0.475	0.933	
PN	0.570	0.552	0.346	0.571	0.803

Note: Diagonals represent square root of the AVE.

4.2.2. Evaluation of the Structural Model

The outcome of the structural model is given in Figure 2. The explanatory power of the model was assessed using the Coefficient of Determination (R²). The results show that the model is capable of explaining 41.3% of the dependent variable from the independent variables. The predictive relevance (Q²) value of (0.329) was larger than zero indicating that the model has satisfactory predictive relevance [80]. The bootstrapping with 5000 bootstrap

samples was applied to assess the path coefficients' significance. Table 6 represents the path coefficients and bootstrapping results of the structural model.

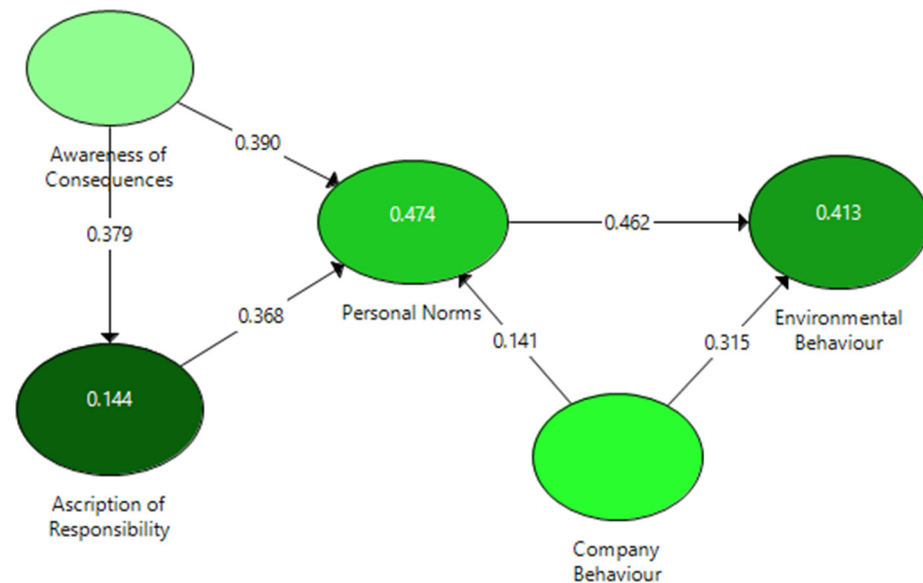


Figure 2. Path coefficients of the structural model.

Table 6. Path coefficients and bootstrapping results of the structural model.

Hypothesis	Relationship	Path Coefficients	Decision
H1	Personal norms significantly and positively affect environmental behavior of employees	0.462 ***	Supported
H2	Company behavior significantly and positively affects environmental behavior of employees	0.315 ***	Supported
H3	Company behavior significantly and positively affects personal norms of employees	0.141 *	Marginally Supported
H4	Awareness of consequences significantly and positively affects personal norms of employees	0.390 ***	Supported
H5	Awareness of consequences significantly and positively affects ascription of responsibility	0.379 ***	Supported
H6	Ascription of responsibility significantly and positively affects personal norms	0.368 ***	Supported

Notes: *** $p < 0.001$; * $p < 0.1$.

Hypothesis 1 posits that personal norms significantly and positively affect environmental behavior. From Table 6, it can be observed that the path coefficient is 0.462 ($p < 0.001$), hence, supporting Hypothesis 1. Hypothesis 2 claims that company behavior significantly and positively affects environmental behavior and is supported by the study results ($\beta = 0.315$, $p < 0.001$). Hypothesis 3 posits that company behavior significantly and positively affects personal norms and this hypothesis is only marginally supported ($\beta = 0.141$, $p < 0.1$). Moreover, awareness of consequences significantly and positively affects personal norms ($\beta = 0.390$, $p < 0.001$) and ascription of responsibility ($\beta = 0.379$, $p < 0.001$), which confirms Hypothesis 4 and 5 of the study. Ascription of responsibility significantly and positively affects personal norms ($\beta = 0.368$, $p < 0.001$), thereby confirming Hypothesis 6.

5. Discussion and Implications

Four parameters, including awareness of consequences of dust hazards, sense of responsibility for its control, personal norm, and the construction company's dust control

behavior, were adopted as latent variables of the SEM analysis of this study. These latent variables are expressed by several observable variables. This research was able to enlighten the role of personal norms and organizational environmental practices on employees' dust pollution control behavior. The results suggest that personal norms are strongly associated with dust pollution control behavior of employees of construction organizations. While the effect of the organization's environmental practices on worker behavior is strong, its effect on personal norm is moderate. This was similar to the results of Zhang et al. [54], where the energy saving behavior of employees in organizations was found to be strongly influenced by personal norms while the impact of organization's energy saving climate is only partially mediated by personal norms. Results also very clearly indicated that awareness of the consequences of dust pollution and a sense of responsibility for control are related to dust control behavior through the personal norm. "Dust pollution in construction sites causes serious health impacts to workers" is rated highest by the respondents, indicating its importance in creating awareness and triggering personal norms among workers. Awareness of consequences was found to influence the ascription of responsibility as indicated by the acceptance of hypothesis H5. These outcomes were similar to that of past studies that highlighted the role played by personal norm in environment friendly behavior by workers [54,85].

By including workers in addition to managers in the sample, this study further explored the findings of Zuo et al. [6] that managers of construction organizations rarely connect dust pollution to serious health implications due to the perception that it is trivial and only a discomfort. According to Zuo et al. [6], this perception is very difficult to change as managers rarely see someone suffering from a serious health injury directly related to dust pollution. Zuo et al. [6] also argue that dust is not visible most of the time, unless it is a dust outbreak. Therefore, it is difficult for managers to accept it as a serious hazard. Contrary to these findings, the results of the current study very clearly indicated that health hazards of dust pollution are critical in triggering personal norms for its control, particularly among the workers compared to the managers. The differences of perception between the workers and managers were found to be statistically significant (the mean ranks of workers and managers were 100.64 and 78.60; Mann–Whitney $U = 3019$; $n_1 = 93$ and $n_2 = 86$; $p < 0.05$ two-tailed). Among the observable variables to express the awareness of dust hazards, "the dust pollution in construction sites causes nuisance and discomfort to the neighborhood" has received the highest standard deviation among the three parameters included, which shows that respondents are not in agreement with this factor compared to the other two.

The study showed that worker behavior is influenced more by a greater awareness of the hazards of dust pollution rather than a sense of responsibility for control. The mean value obtained for ascription of responsibility is relatively low (3.99 with $SD = 0.909$), which is an indication that while employees are acknowledging the awareness of impacts of dust pollution, they are not ready to accept responsibility for its generation. This also revealed a statistically significant difference in the perception between workers and managers. A similar result was obtained about personal norm of employees. Three out of four constructs used for personal norm saw statistically significant differences between workers and managers. While managers perceive a high moral obligation for control of dust pollution, when it comes to action, they do not echo the same sentiments. The statement "I would feel guilty about not acting against dust pollution arising out of my sites" scored the lowest mean value of 3.83 for all employees with the highest standard deviation of 0.970 among the four constructs used to measure personal norms.

The company's environmental behavior was found to influence the behavior of employees; however, it was not strongly manifested in the relationship between the company's behavior and the personal norm of an employee. This is an interesting observation, as the company behavior found to negatively moderate the effect of personal norm of an employee. It could be explained by the fact that when an employee see that the company is doing well in dust pollution control, that employee's moral obligation gets weakened.

A positive environmental behavior by the company can crowd out the need for a strong personal norm that is guided by a sense of very strong moral obligation for an employee. On the contrary, if the company's environmental behavior is weak, then the employee is tempted to have a stronger moral obligation to protect fellow workers and the neighborhood from adverse impacts. This observation was very similar to that of Zhang et al.'s [54] study, which investigated the employees' energy saving behavior in organizations as opposed to their households, where the role of company behavior become prominent.

This study contributes to sustainable construction literature in several ways. It builds a theoretical model to study dust pollution, one of the serious environmental concerns of construction activities, by investigating the antecedents of employee behavior towards its control. Although many construction companies are keen to reduce dust pollution on their sites, studies investigating behavioral control methods are at infancy, with only a few research works having been done in the past [6,10]. By contrast, previous dust pollution research mostly focused on engineering and regulatory control measures. For developing countries such as Sri Lanka, deploying engineering control methods to curb environmental pollution would be infeasible due to the added cost. In addition, the regulatory framework of those countries is not well developed. Hence, behavioral control methods provide a very effective alternative to mitigate environmental pollution. This research, thus, contributes to the literature by building a theoretical model of employee dust control behavior and empirically testing it in a developing country, considerably enhancing our understanding of factors influencing such behavior. Though this model focuses on dust pollution, its applicability to other environmental issues such as noise, water pollution, waste, etc., could be investigated using a similar method. Hence, its methodological contribution to construction literature is also noteworthy.

Some implications to policy and construction practice are proposed according to the findings of this research. Firstly, employees constitute an important target group for pollution mitigation. Policy makers and practitioners should realize the role employees can play in environmental issues and focus more attention on how to harness their support. This is an important means to mitigate endemic environmental issues facing the construction industry not only in developing countries but also in developed countries. Secondly, the study demonstrated a strong link between behavior and personal norm. Personal norm was found to be positively influenced by awareness of consequence and ascription of responsibility. Construction companies could take measures to promote personal norm, awareness of consequences, and ascription of responsibility among their employees. Companies should initiate campaigns targeting environmental pollution to influence the personal norm of the employee. Companies should make use of every opportunity to educate the employee about negative consequences of environmental pollution. It is also very important to realize their employees' responsibility for not taking mitigation measures and its negative impacts on the fellow workers and the neighboring community. Once employees' personal norms are established, they may be more likely to follow proper control procedures under the influence of moral obligation. Thirdly, this research specifically included a company's environmental practice as an antecedent of worker behavior as well as the personal norm and empirically tested its relevance.

The role of a company shaping environmental behavior of its employees has been well documented in the literature. It is being extended by some researchers to cover construction organizations [62,63]. Researchers also found that pro-environmental behavior of construction companies are directly linked to their competitiveness [86]. However, its influence on dust pollution control behavior of its workers has not been studied. This research, thus, contributes to the construction management literature by developing the concept of environmental behavior of organizations and empirically examining the ways in which it influences employee environmental behavior. This research confirms those past findings and highlights the importance of the role further. Past studies found workers belonging to large companies to have developed a stronger sense of responsibility than those who work in smaller companies [62,63]. Similarly, younger workers were found to

be more responsive to dust pollution control measures than older workers [11]. Companies can influence the worker behavior through many initiatives, researchers have highlighted the following as effective methods: training; promotional campaigns; incentives; prompts (signage); communication; and commitment [51,87,88]. While large companies can take a lead on some of these activities, all companies can start dust monitoring and audits in their sites so that workers see these positive initiatives as serious commitments from the company to protect workers and the public. In addition, the importance of targeting personal norm, awareness of consequences, and ascription of responsibility of workers cannot be underestimated. Construction companies need to actively invent sustainability practices and policies and implement them into management and operations of their work sites.

6. Conclusions

Dust pollution generated by construction activities could have serious health implications on workers as well as the neighboring community. Though it is perceived as a nuisance rather than a health hazard, control of construction dust occupies a high priority among construction managers. While regulatory and engineering control measures are commonly used to control dust pollution on sites, behavioral control measures prevent dust generation in the first place. Hence, behavioral control is increasingly being preferred for many endemic issues faced by the construction industry due to its effectiveness and longevity. While a considerable research effort could be found on worker behavior in regard to workplace health and safety, waste and environment of construction sites, very little is known on the dust pollution and its control. Hence, this study investigated the factors influencing the behavior of dust pollution among construction workers based on the Norm Activation Model.

Using a questionnaire survey, workers awareness of consequences of dust hazards and sense of responsibility for its control were evaluated along with the assessment of the construction company's dust control behavior. These variables were used to explain how a worker perceive dust pollution and its control in view of help manage its generation as well as discharge in the day-to-day work environment. To facilitate a robust data analysis, structural equation modelling approach was used. The study confirmed awareness of consequences of dust pollution among site employees trigger personal norms for its control. Awareness of dust hazards found to be highly influential in changing worker behavior. The workers' moral responsibility and the company's dust control behavior were also found to be related to a worker's dust control behavior. Though it influences the workers' behavior, company behavior was found to have a weak relationship with the personal norm of workers. It shows that when a company is active in the environmental space, workers do not feel a very strong moral obligation to take precautionary action. This crowding out effect could be further investigated in future studies.

Based on the results, few practical measures to influence worker behavior regarding dust pollution control is proposed. These recommendations could be included in future revisions of the environmental guidelines or code of practices used by the industry. While this study exposed a rather neglected area of dust pollution on construction sites, use of a single tool (questionnaire survey) for data collection is a major limitation. Further research involving a mixed-methods research design could allow an extended investigation of factors unearthed from the questionnaire survey, vis-à-vis, awareness of dust hazards, ascription of responsibility, and a company's role in promoting dust control behavior among employees. Another limitation of this study is not investigating the influence of a company's behavior on employees' awareness of dust hazards as well as ascription of responsibility. The present study only looked at the influence on employees' personal norm. Therefore, we recommend a future study, which could investigate a company's influence on all facets of dust pollution control behavior using the Norm Activation Model. Notwithstanding the above limitations, this study contributes to the body of knowledge on construction worker behavior from an environmental perspective.

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