EXPOSURE OF INHALABLE DUST AND RESPIRATORY SYMPTOMS AMONG WORKERS IN CONSTRUCTION INDUSTRY

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Thesis submitted in fulfillment of the requirements
for the award of the degree of
Bachelor of Occupational Safety and Health with Honors

Faculty of Engineering Technology

UNIVERSITI MALAYSIA PAHANG

JANUARY 2019

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Dedicated to my beloved parents and siblings

Respectful lecturers,

My friends that inspired me through my degree journey

ACKNOWLEDGEMENTS

Finally, I had completed my final year project. With full of appreciation and honors, I would like to express my gratitude to my supervisor, Dr. Norazura binti Ismail for her germinal ideas, continuous and constant guidance throughout the process in finishing final year project. She has impressed me with her outstanding professional conviction and experiences. I am really grateful for her consistent support and also thanks for the time spent correcting many of my mistakes.

My sincere thanks go to our faculty's Science Officer, who had helped to understand the procedures on how to use the instrument during the process to complete my study. In addition, I also would to thanks the Site Safety Supervisor of construction site in Gambang for giving me permission to conduct my study there. I want to express my gratefulness to him for providing me enough information about the site and also helping me to ask cooperation from the workers in completing the study.

I would like to express my thankfulness to all my classmates and friends who had been supporting me and helping each other during this study. My sincere thanks to them for making this long degree journey to become really memorable and enjoyable to me.

I acknowledge indebtedness and express my gratitude to both of my parents Mr Wan Mohammad Roslan bin Wan Husin and Mrs. Normimah binti Zun who had given fully support and encouragement to me during my hardest time to complete this final year project. I also want to thank to my siblings Wan Hazwan and Wan Hawani for their advices, suggestion and critics during the completion of this project.

Thank you also to everyone who had been involved to help and support me in throughout the study.

ABSTRACT

The air pollution in construction site had become great concern to the workers as it can significantly affect their respiratory health. The aim of this study was to investigate the inhalable dust exposure and its effect toward respiratory system among workers in construction industry. There were 13 workers randomly selected for indoor activities which include concrete breaking, hacking of wall and drilling. Meanwhile, another 13 workers participated as respondents for outdoor construction activities such as operation of backhoe and dump truck, housekeeping activity and construction of drain. Personal air monitoring was conducted using air sampling pump with flow rate of 1 L/min. All the workers were interviewed by using St George Respiratory Questionnaire (SGRQ). Results show that the average concentration for outdoor activities was higher (mean= 4.98mg/m^3; SD= 2.72mg/m^3) than indoor activities (mean= 4.19mg/m^3) (SD= 2.22mg/m^3). Most of inhalable dust concentration in the construction site were below the OSHA (15 mg/m^3) and ACGIH (10 mg/m^3) standard limits except for operation of heavy vehicles activity (backhoe =10.56 mg/m^3). The prevalence of respiratory symptoms was in the range of 30.8% to 92.3% among indoor workers, while outdoor workers ranged of 23.1% to 76.9%. There was a significant correlation between personal concentration of inhalable dust and respiratory symptoms. Even though the concentration of inhalable dust below the exposure limit, however, workers still experience some of the respiratory symptoms such as coughing, phlegm secretion and shortness of breath. Therefore, the employer must provide appropriate respiratory protective equipment (RPE) with assign protection factor (APF) of 20 for the construction workers. Rescheduling and limit the working time for workers with respiratory symptoms can also be practiced in order to reduce the risk.

ABSTRAK

Pencemaran udara di tapak pembinaan menjadi masalah besar kepada pekerja kerana dapat memberi kesan buruk kepada kesihatan pernafasan mereka. Tujuan kajian ini adalah untuk menyiasat pendedahan udara dan kesan terhadap sistem pernafasan kepada pekerja dalam industri pembinaan. Terdapat 13 pekerja yang dipilih secara rawak untuk aktiviti kawasan tertutup termasuklah aktiviti pecah konkrit, penggubahsuaian permukaan dinding dan penggerudian. Sementara itu, 13 pekerja lain mengambil bahagian sebagai responden untuk aktiviti pembinaan kawasan luar seperti operasi trak pengorek , lori sampah, aktiviti pengemasan dan juga pembinaan longkang.Pemantauan peribadi untuk tahap udara dilakukan menggunakan pam pensampelan udara dengan kadar aliran 1 L/min. Semua pekerja juga ditemubual dengan menggunakan Soal Selidik Respiratory St George. Keputusan menunjukkan bahawa kepekatan purata untuk aktiviti kawasan luar adalah lebih tinggi (mean= 4.98mg/m3) (SD= 2.72mg/m3) daripada aktiviti kawasan tertutup (mean=4.19mg/m3) (SD=2.22mg/m3). Kebanyakan kepekatan debu di tapak pembinaan berada di bawah tahap piawaian OSHA (15 mg/m^3) dan ACGIH (10 mg/m^3) kecuali aktiviti operasi kenderaan berat (trak pengorek= 10.56mg/m3). Kelaziman simptom pernafasan adalah dalam lingkungan 30.8% hingga 92.3% untuk aktiviti kawasan tertutup manakala pembinaan kawasan luar dalam lingkugan 23.1% hingga 76.9%. Terdapat perkaitan yang tinggi antara kepekatan debu dan gejala pernafasan. Walaupun kepekatan debu di bawah tahap piawaian, bagaimanapun, pekerja masih mengalami beberapa gejala pernafasan seperti batuk, rembesan kahak dan sesak nafas. Oleh yang demikian, majikan mestilah menyediakan peralatan perlindungan pernafasan dengan menetapkan faktor perlindungan sebanyak 20 untuk pekerja buruh binaan. Penjadualan semula dan pengurangan waktu kerja bagi pekerja yang mengalami gejala pernafasan boleh dipraktikkan untuk mengurangkan risiko tersebut.

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μm	Microns in diameter
$PM_{2.5}$	Particulate matters with size 2.5 microns in diameter
PM_{10}	Particulate matters with size less than 10 microns in diameter
ppm	Parts per millions
Mg/m^3	one milligram per cubic meter
%	Percent
R^2	The coefficient of determination

LIST OF ABBREVIATIONS

PM	Particulate Matters
VOC	Volatile Organic Compound
COPD	Chronic Obstructive Pulmonary Disease
HSE	Health and Executive
FEV1	forced expiratory volume in one second
FVC	forced vital capacity
FEV1/ FVC	ratio of forced expiratory volume in one second & forced vital capacity
EEA	European Environment Agency
OSH	Occupational Safety and Health
EPA	Environment Protection Agency
USEPA	US Environmental Protection Agency
PEL	Permissible exposure limit
NAAQS	New Ambient Air Quality Standard
ACGIH	American Conference of Governmental Industrial Hygienists
DOE	Department of Environment Malaysia
UMP	Universiti Malaysia Pahang
TPS	total suspended particulate
SPSS	Statistical Package for Social Science
NIOSH	National Institute for Occupational Safety and Health
NMAM	NIOSH Manual Analytical Method
RPE	Respiratory protective equipment
SGRQ	St George Respiratory Questionnaire
OSHA	Occupational Safety and Health Administration
SPSS	Statistical Package for the Social Science

CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION

This chapter served to introduce the study about the exposure of inhalable dust and lung function impairment among workers in construction industry. Some of the elements include in this chapter are background of study, research objectives, research hypothesis, and significance of study and scope of study. It is hope that from this chapter, readers can get a brief idea and can understand more about this study.

1.2 BACKGROUND OF STUDY

Inhalable dust can be generated from various human anthropogenic activities. The sources of exposure for particulate matter are associated with many industries such as restaurant, manufacturing industry, agriculture and also construction industry that can contribute to a high risk of emission for inhalable dust. Construction industry can contributes about 4% of particulate emissions that include pollution for air, water and soil (Gray, 2017). Air pollution usually attributed with construction site which can significantly affect worker's health.

The activities in construction site can release dust particles with size small in diameter and invisible to the naked eye which include inhalable dust [particles diameter <100µm], coarse particles [aerodynamic diameter <10µm] and fine [aerodynamic diameter < 2.5µm] (Abdullahi et al., 2013). The exposure of inhalable dust can effect construction workers which working indoors and outdoors. Usually, the dust emission exposure to workers for indoor and outdoor construction can be different based on the environment. This emission of particulate matter usually varying in degrees, different durations and frequencies For outdoor construction, the exposure to dust can be high due to the sources from several type of activities such as operation of heavy vehicles such as tractor, loader and backhoe, mechanical activities like grinding or drilling and also transportation of building equipment and materials within the site. Meanwhile, the exposure for indoor construction activities can be high due poor air ventilation from dust emission of several construction activities. Those construction activities usually involved housing or building modifying work such as hacking of concrete, brick or stone crushing, tiles cutting or also installation of piping system (Government Quality, 2001) which can cause the release of pollutant emission to the air. All the construction activities of indoor and outdoor can cause the exposure of particulate matter such as fumes, aerosol, smokes and combustion particles which can pollute the surrounding air.

Some previous studies stated the sources and impact of dust from the activities in construction industry which are study from Boumann et al, (2017), Kromhout et al, (2009) and Robert et al, (2018) had explained about the relevant of exposure dust to construction workers. As construction workers usually working in a long duration at the construction site until the building project finished, the risk of exposure to particulate matter will become very high. The emission of total inhalable dust can affect the health of people living and working in the surrounding area of the site.

Moreover, it has been found that particulate matters have a great impact on human health (Xing et al, 2016). Construction workers can be infected by various respiratory diseases that are bronchitis and cancer but the most common respiratory illness is chronic obstructive pulmonary disease (COPD) and asthma. Workers at construction site can high risk of exposure to COPD disease and occupational asthma which cause from the emission fume, aerosol and dust from construction activities. There are many previous studies showed the relevance of dust exposure at construction site with these two respiratory illnesses. Construction workers can get severe health problem of asthma when they breathe in or having skin contact with dust, gases, fumes, and vapours (Walton, 2017). According to Health and Executive (HSE), (2017), occupational asthma is an allergic reaction which workers will experience when exposed to certain substances in the workplace such as construction dust. Moreover, a study from Bergdahl et al., (2004) found that the mortality among construction workers can increases due occupational exposure of chronic obstructive pulmonary disease (COPD), even though the workers were never smoke. Construction workers experience a wide spectrum of exposures and are at increased risk for COPD and COPD- related mortality (Dement et al., 2015). Construction workers are also exposed to non-specific construction dust and therefore potentially exposed to inhalable dust above the occupational exposure limit and may have an increased risk of developing COPD (Borup, 2017).

Workers in the construction industry could be exposed to particulate matter which cause from various activities associated with environmental air which polluted from the emission of construction heavy vehicle and other equipment. Actually, this emission of particles can be harmful to the workers as when the inhalable dust were breath in too frequently, they will get lung function impairment. This is because construction workers usually will be at construction site in a very long duration until the building project finish. Therefore, in this study, the levels of exposure of inhalable dust along with the lung function status were investigated. From the research, the control and management option of inhalable dust will be investigated so that the exposure later can be reduced.

1.3 PROBLEM STATEMENT

Nowadays, as the urban development and modernization accelerated significantly, air pollution become worse and its impact on human health has become primary research topic. The air pollution which consists of particulate matter had also become worse in construction site. It has been reported that the air pollution cause by dust in the atmosphere from construction concentrations would be responsible for 0.54 attributable deaths which are 0.13 cardiovascular and 0.04 for respiratory illness (Boumann et al., 2017). This shows that construction workers which exposed to dust concentration that exceed the limits have high chance of getting the respiratory disease which can lead to premature death. Furthermore, usually, indoor construction exposure levels are not considered as high as outdoor construction, but, actually it may give greater effect to the workers. Although indoor construction did not exposure to high emission of dust, unlike outdoor construction, but, the poor air ventilation can make the exposure level become high.

Inhalable dust emission which generate in construction industry can pose a health concern to human as they can be inhaled into the lung and accumulate in the respiratory system. Particulate matter usually attributed with the air pollution in construction industry. They are small size particles that could effectively act as a gas and could pose great health concern because the fine particles can penetrate deep into the lungs. The main problem is the exposure to high concentrations of dust can result in numerous health impacts such as chronic obstructive pulmonary disease (COPD) and aggravation of asthma (Süring et al., 2016). This is because various construction activities can cause the emission of dust, fumes, smoke and aerosol which contain in the dust. Many previous research had identify this problem that were in the study from Dement et al., (2015), Bergdahl et al., (2004), Borup et al., (2017), Walton, (2017), Health and Executive (HSE), (2017) which emphasize about construction activities that related with respiratory disease.

As construction workers spend long duration with environment polluted with dust, they can easily expose to COPD and occupational asthma. Construction workers usually did not aware of the dangerous effect of inhalable dust to human health as this matter was not taken seriously by them. Workers in this industry had get use working under the environment which exposed to the polluted air that make them tend to ignore the fact that they could get significant health effect from the exposure of this inhalable dust. Some of symptoms which associated with COPD are breathing difficulty, wheezing, cough and sputum production (Mayo Clinic, 2018) while for occupational asthma are asthma attack, such as breathing difficulty, coughing, chest tightness and shortness of breath (Web Medical, 2015). Furthermore, most of the study about air pollution in construction industry only associated with silica exposure from mechanical activities such as grinding the rocks or brick, jack hammering, rock drilling, concrete drilling, grit blasting and concrete block cutting or sawing but only a few studies can be found for the exposure of inhalable dust. This is because many people only aware the fact of the silica particles which can cause silicosis among construction workers (Ediagbonya, 2015). That research was about particulate matter emission from construction industry still not widely been study yet. The problem of inhalable dust exposure within construction industry can be associated directly to the use of construction equipment and machinery which release exhaust diesel emission. It is also can be related to several construction activities which include the use of this equipment and heavy vehicle such as earthworks activities, materials handlings, mechanical activities using light equipment or transportation building materials within the site.

Therefore, the focuses of this study are to identify the level exposure of inhalable dust in construction industry and also to investigate lung function impairment through FEV1 & FVC. From that, the correlation between of the inhalable dust exposure in construction industry and respiratory diseases can be concluded.

1.4 RESEARCH QUESTIONS

1. Which type of construction activities between indoors or outdoors construction activities will produce higher exposure level of inhalable dust among the workers?
2. Do the workers which exposed to inhalable dust in the construction site have the symptoms of respiratory disease?
3. What is the lung function status (FEV1 and FVC) among construction workers?
4. Is there any correlation between level of inhalable dust and lung function impairment?

1.5 RESEARCH OBJECTIVES

1. To compare the exposure level of inhalable dust among workers from indoor construction activities and outdoor construction activities.
2. To determine the prevalence of respiratory symptoms among workers exposed to in the construction site.
3. To assess the correlation between the level of inhalable dust and respiratory symptom among construction workers.
4. To assess lung function status (forced expiratory volume in one second (FEV1) and (forced vital capacity (FVC)) among construction workers.
5. To assess the correlation between the level of inhalable dust and lung function status (FEV1 and FVC) among construction workers.

1.6 HYPOTHESIS

1. Outdoor construction activities generated higher exposure level of inhalable dust among the construction workers compared to indoor construction.
2. There is significant correlation between level of inhalable dust and respiratory symptom among construction workers.
3. There is a significant correlation between the level of inhalable dust and lung function impairment among construction workers.

1.7 SCOPE OF STUDY

This study will be a significant endeavour in investigating the exposure level of inhalable dust among construction workers. The study only limits the scope at construction site only. Although there are many other industries which produce particulate emission of inhalable dust, but construction industry is one of the common industry in Malaysia that known for the release of dust and contribute to poor air quality. Actually, there are lots of sources in construction site which might release emission of dust but in the study will cover only activities which are for indoor and outdoor construction. Therefore, in order to identify the highest exposure level of the inhalable dust, personal air monitoring will be conduct. From the monitoring, the level of dust particles can be identify whether it is still in controllable amount of dust or exceed the permissible exposure limit by New Malaysia Ambient Air Quality Standard.

Moreover, the study also aims to determine the respiratory symptom among construction workers. Particulate matter can dangerously affect human respiratory system when the worker inhale air which contain the inhalable dust. As the size of inhalable dust is smaller than 100μm, it can deposit into the lung and affect human respiratory system. Therefore, in this study, the lung function status of the worker will be identifying by using spirometer. Spirometry test can be used to monitor the lung condition and the test can assess how well lungs work by measuring how much air inhale, exhale and how quickly can exhale. Questionnaire will be conduct limit to construction workers to identify the condition of respiratory symptom.

Furthermore, the scope of study will cover the lung function status (forced expiratory volume in one second (FEV1) and forced vital capacity (FVC)) among construction workers. The FEV1 and FVC will be measure to identify the lung function status among the construction workers. The lower the measurement of FEV1 and FVC, it means that the workers had suffered respiratory illness. Next, the study also investigates the correlation between the level of dust and lung function status (FEV1 and FVC) among construction workers. This is very important to know whether the exposure level of inhalable dust can affect lung function status among workers in construction industry.

1.8 SIGNIFICANCE OF STUDY

As nowadays people already aware of the human health effect from the exposure of inhalable dust, many researches had been conducted to identify about this problem. Although lots of previous research had already find out about lung function impairment from exposure of airborne particles, but most of the study did not focus to inhalable dust exposure and lung function effect to construction workers. So, in this study, the level of inhalable dust and lung function status will be measure among construction workers. Actually, this matter had been widely investigated through the world before. However, in Malaysia, the research about inhalable dust exposure and respiratory disease from construction industry were not widely studied yet.

Moreover, most of previous research in construction filed conducted to identify the silica dust pollution from construction site (Silica, 2014) and only a few study can be found about the release of inhalable dust in construction industry. The silica dust usually associated with mechanicals activity such as grinding of the brick, concrete drilling, grit blasting and concrete block cutting. However, the emission of particulate matter of total inhalable dust usually produces from the emission of construction machinery of heavy vehicle and also equipment and also emission from other activities. Most of the activity can exposed workers to particles of the inhalable dust. So, from this study, level of dust from various activities at construction site can be identified clearly.

Next, the significant of the study can find out whether the exposure level at construction industry along with the activities still in control or not that are below the permissible exposure limit. This matter is very important to make sure that worker's health can still be maintain, so they did not easily infected to lung function impairment such as occupational asthma and chronic obstructive pulmonary disease (COPD). Therefore, this study can contributed to ensure that construction worker's health not affected from the exposure to high concentration of dust particles.

1.9 CONCEPTUAL FRAMEWORK

Figure 1.6 shows the conceptual framework of this study. There are two type of construction which are building construction and road construction but in this study will only covers the exposure of inhalable dust from building construction.

Building construction can be indoor and also outdoor. The activities for indoor and outdoor can be different as indoor construction activities involved mechanical activities such as drilling the wall, block breaking, hammering, plumbing and piping system. Meanwhile, for outdoor construction usually involved activities which use heavy vehicles such as backhoe dump trucks and semi tractor trailer. Housekeeping activities in construction also can be categories as outdoor as the workers also exposed to inhalable dust while keeping the construction area clean.

All of these activities can release inhalable dust into the air. As example, the operation of heavy vehicle can produce diesel exhaust emission which contents in dust particles. Moreover, the use of construction equipment such as drilling machine, blasting and concrete cutting can release the emission of smokes or fumes which will contaminate the air which can mix up with the environment air.

These activities can affect workers when they inhale the polluted air. This can significantly impact the health of worker which can cause lung function impairment. Usually, lung function impairment can be categorized into obstructive and restrictive. Obstructive is when greater pressure need when breathing rapidly to overcome the resistance to flow while restrictive is when the decreased in compliance of the lung which can cause the increases of stiffness for the lung and limits expansion. Obstructive lung disease includes asthma and chronic obstructive pulmonary disease (COPD).

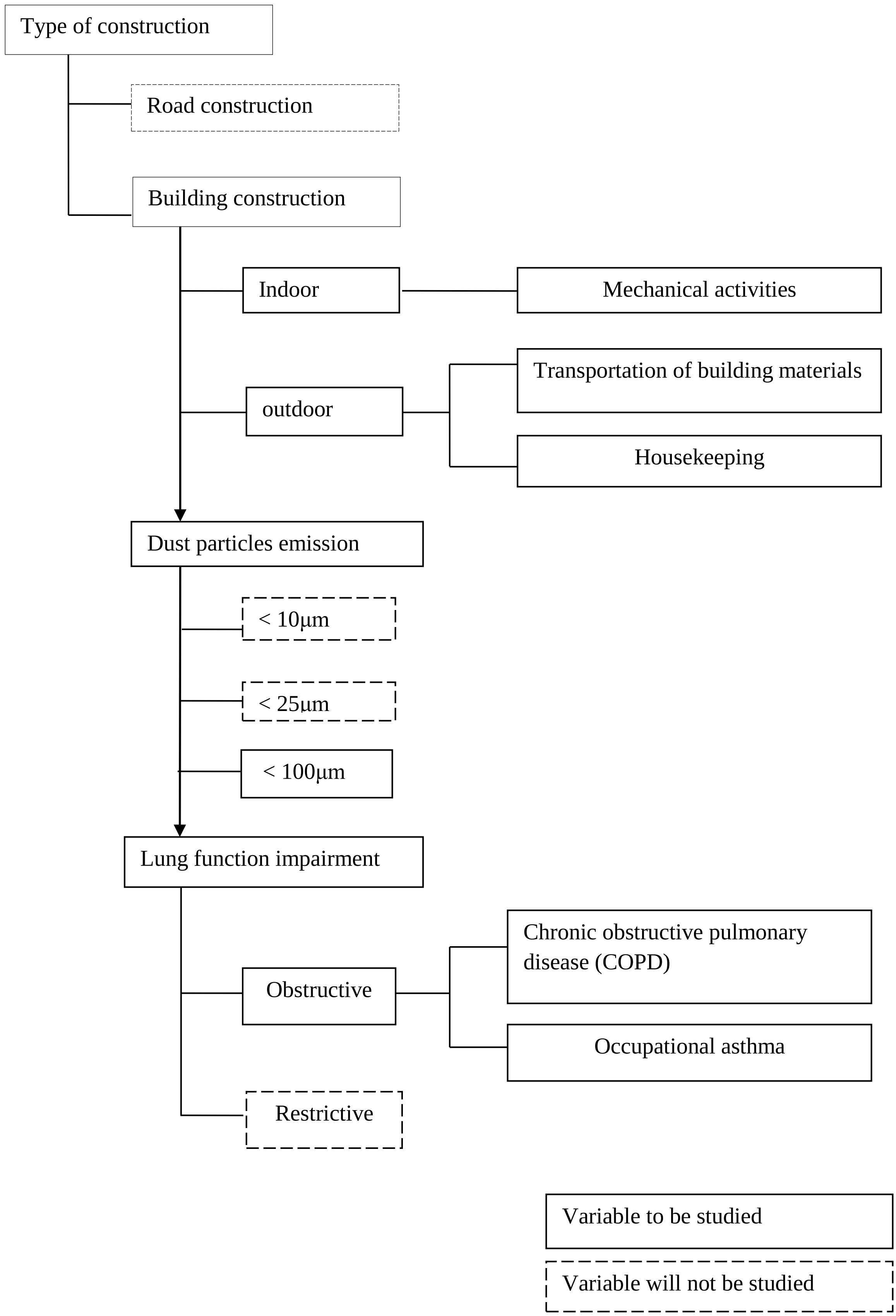

Figure 1.6: Flow chart of conceptual framework

1.10 CONCEPTUAL AND OPERATIONAL DEFINITION

i. Particle emission

Particle emission refers to the rate of emission of the particle number concentration of dust. In this study, the particle emission come from several construction activities like vehicle movement in construction site and other construction process such as earthmoving, demolition, grit and sand blasting or spray painting (Government & Quality, 2001).

ii. Road construction

Road construction which required production of bonded pavement of structure. The processes of road construction are quite the same with building construction which requires earthwork, area scrapping and also grazing. Road construction also involved the use of construction heavy machinery (Neil, 2002)

iii. Building construction

Building construction is a process that involved adding construction to a building or construction of that building. It can be either big construction or small construction project. Small scale construction only makes small renovation such as adding a room or bathroom while big scale construction involved commercial building construction or residential construction practice. This type of construction uses several types of equipment and machinery during the building process (Swenson, 2017).

iv. Indoor and outdoor construction

Indoor constructions are activities which are done in enclosed space. Usually, indoor construction is after the construction during the stages between superstructure and infrastructure which involved mechanical activities. Indoor construction also done during modify of building (Yuan et.al, 2018).

Outdoor construction are the activities which done at open space. Usually, outdoor construction involved activities which use heavy vehicles such as backhoe, dump truck or semi-tractor trailers to transport building material and equipment to the construction site (Canadian Cente OSH, 2018). Housekeeping activities also involved in outdoor construction as they also exposed to inhalable dust from this sources.

v. Mechanical activities

The examples of mechanical activities are grinding, drilling, blasting and block breaking. Usually, these activities only involved the use of construction machine. The machine use in mechanical activities also can contribute to the release of dust particles to the air (Government Quality, 2001).

vi. Transportation of materials

Transportation of materials and supplies within the site involved operation of heavy vehicles. As the heavy vehicles carries the materials around construction site, the release of particulate matter to the air can cause harmful effect to workers in the site because it can release diesel exhaust fumes or soot which contains particulate matter (Government Quality, 2001). This condition will pollute the surrounding air.

vii. Housekeeping activities

Housekeeping activities in construction site refer to the management measurements which are to design and implementation for reducing the discharge of pollutants from the site. Some examples of housekeeping activities are to keep work areas neat and clean, by removing waste materials at the heavy vehicles route and also maintain the construction site place free of slip and trip hazards. (Canadian Cente OSH, 2018)

viii. Exposed workers

Exposed workers are workers who are fully exposed to the emission of particulate matter of total inhalable dust at the site (Pocock, 2012). The type of construction included construction site labourers, site operators and also site managers or engineers. Usually, exposed workers are workers who working within the construction site for 8 hours or more.

ix. Lung function impairment

A term used to describe any loss or abnormality of psychological, physiological or anatomical structure or function on the lungs work in helping a person breathe (Sheena and Carter, 2018). During breathing, oxygen is taken into the lungs, where it passes into the blood and travels to the body’s tissues. Carbon dioxide, a waste product made by the body’s tissues, is carried to the lungs, where it is breathed out (NCI Dictionary of Cancer Terms, 2017). Lung function impairment is the problem occur when people breathing.

x. Respiratory system

Respiratory system is a system which carries out respiratory functions, based on gaseous exchanges. It allows the intake of air, to deliver oxygen to organs and tissues, and the expulsion of carbon dioxide. The respiratory system begins at the mouth and nose, and then passes through the pharynx, larynx, and trachea, ending in the bronchial tubes and pulmonary alveoli, which control the exchange between oxygen and carbon dioxide (Respiratory system, 2013).

xi. Obstructive Lung Diseases

Obstructive lung diseases (OLD) describe progressive lung diseases which include in the Chronic Obstructive Pulmonary disease (COPD) and asthma. The respiratory diseases characterised by characterized increasing breathlessness characterized by persistent airflow restriction and chronic airway inflammation (Vieira et al, 2016).

xii. Restrictive Lung Disease

Restrictive lung disease might become problems to workers when they are having difficult time to fill the lungs with air as the lungs are restricted from fully expanding. The symptom of restrictive lung diseases is delicate lung tissue stiffens will occur most of the time. This sometimes happens because of the excessive stiffness in the chest wall, weak muscles or damaged nerves (Lung Institute, 2018).

xiii. Forced expiratory volume in one second (FEV1**)**

The measurement to show the amount of air that can forcefully exhale in one second of the FVC test. FEV1 measurement can helps understand and identify the severity of disease. Usually, lower FEV1 scores show more severe stages of lung disease (Lung Institute , 2018).

xiv. Forced vital capacity (FVC)

The measurement to show the amount of air that can forcefully and quickly exhale after taking a deep breath. The result of FVC can use to diagnose a chronic lung disease, and to understand the severity of the condition. The measurement of FVC the will be compare with predicted FVC based on weight, age and height (Lung Institute , 2018).

xv. Chronic obstructive pulmonary disease (COPD)

Chronic obstructive pulmonary disease (COPD) is a disease characterized by airflow limitation but not fully reversible. The airflow limitation usually associated with an abnormal inflammatory response of the lungs to noxious particles and gases (Boschetto et al., 2006). Construction workers are exposed to these disease from the inhalable or total dust from the air pollution at construction site.

xvi. Occupational asthma

Work-related asthma can be triggered by exposure to substances found in the workplace that cause the airways of the lungs to swell and narrow. This can leads to the attacks of wheezing, shortness of breath, chest tightness, and coughing. (Medical Plus, 2018) Specific construction site which cause asthma will triggers include from grout, cement, solvents, lime, paint, diesel emissions, epoxy resins, adhesives, welding fumes, concrete, mould, and smoke. (Walton, 2017)

CHAPTER 2

LITERATURE REVIEW

1.1 INTRODUCTION

This chapter presents the review of previous researches on the study of inhalable dust exposure and lung function impairment among workers in construction industry. Every elements or topics were stated clearly in this chapter by review several previous research in order to make sure the details of the study can be understand. The topic consist of inhalable dust, construction equipment and heavy vehicles, air monitoring method (dust mate and personal air monitoring), lung function impairment, lung function test, respiratory diseases (chronic obstructive pulmonary disease (COPD) and occupational asthma), correlation inhalable dust with lung function, permissible exposure limit (PEL).

2.2 PARTICULATE MATTER

Particulate matter is a collective group of very small solid particles, aerosols, mist, smoke, dust, fibres and fumes (Kumar, 2018). It is the sum of all solid and liquid particles suspended in air many of which are hazardous. This complex mixture includes both organic and inorganic particles, such as dust, pollen, soot, smoke, and liquid droplets. These particles vary greatly in size, composition, and origin. Particulate matter can cause air pollution which will greatly cause serious health effect when inhale the air with this particles.

2.2.1 Inhalable and Respirable Dust

Table 2.1 shows the particulate emission from US Environmental Protection Agency (USEPA). Particles are classified according to aerodynamic diameter as inhalable, thoracic and respirable. Based on size, particulate matter is often divided into three main groups which are the inhalable contains the larger particles with a size smaller than 100 µm, thoracic fraction contains particles with size smaller than 25µm and respirable particles are in diameter of smaller than 10µm.

Table 2.1: Classification on size for particulate matter

Particle Type	Aerodynamic Diameter
Inhalable	<100µm
Thoracic	<25µm
Respirable	<10 µm

Sources: US Environmental Protection Agency (1996)

Inhalable particulate dust can enter any part of the human respiratory tract upon inhalation that can be breathed into the nose or mouth. Meanwhile respirable particles dust can penetrate through the breathing airways to the pulmonary region of the lung beyond the terminal bronchioles into the gas-exchange region of the lungs. Actually, the small sizes of particulate matter enough to affect the health although it is not as small as respirable particulates. From the American Lung Association (1996), it has been reported that over 60,000 people die prematurely in the USA (by up to two years) from the exposure to dust particles.

2.3 CONSTRUCTION INDUSTRY

Construction industry had become an important role in contributing to Malaysian economic development. The property construction sectors expanded rapidly in the late 1980's as a result of the high demand for building and development. From the rapid construction development, environmental issues of air pollution had become significant concern in construction industry (Teng, 2011). When comparing with other industries, construction has an important consumption. This is because many processes in the construction industry created large quantities of total inhalable and respirable dust. The uncontrolled emissions of the air pollution will give significant risks to worker health at construction industry (Pocock, 2012).

2.3.1 Stages of Construction Work

According to Teng, (2011), the stages in construction can be divided into two phases that are preconstruction stage and construction. Preconstruction stage is the preparation of the site before any construction project is start while construction stage is the process when the construction work begins.

Some of major operation in preconstruction such as site clearance, building setting out and earth works. The task during the site clearing are extent of the site clearing works, grubbing out of roots, removal of rubbish or plants from site and diversion of existing utilities. Next, building setting out include in the first stage of construction which involves outlining the ground structure (Price & Kadir, 1996). Lastly, for earthworks are works involved the soil. In earth work, the activities are preparation of construction platform, drain system and foundations.

For construction stage, there are three stages which consist of substructure, superstructure and infrastructure (Hendrickson, 1998). Some of substructure examples are retaining walls, basements, foundations and pilings. Superstructure works involved the process of building and tiling. For infrastructure the activities refers to last process when the building finish such as trenching excavation and backfilling.

2.3.2 Type of Construction

The type of construction can be categories as road construction and building construction. Both of the construction work in road or building construction had different type of working activities based on the project. As an example, road construction required to produce bonded pavement of structure (Geol, 2012). The processes of road construction will require earthwork, area scrapping and also grazing. Road construction also involved the use of construction heavy machinery to build the road pavement structure.

Meanwhile, building construction is a process that involved adding construction to a building or construction of that building (Swenson, 2017). It can be either big construction or small construction project. Small scale construction only makes small renovation such as adding a room or bathroom while big scale construction involved commercial building construction or residential construction practice. This type of construction uses several types of equipment and machinery during the building process.

2.3.3 Indoor and outdoor construction activities

There are several type of activities in construction area but in this study will only emphasize some of the construction activities for indoor and outdoor construction. Indoor constructions are activities which are done in enclosed space (Yuan et.al, 2018). Usually, indoor construction is during the stages between superstructure and infrastructure which involved mechanical activities. Indoor construction also done during modify of building. Mechanical activity of indoor construction involved task such as grinding, drilling, hammering, block breaking and the installation of plumbing and piping system (Government Quality, 2001).

Outdoor construction are the activities which done at open space. Usually, outdoor construction involved activities for transportation of building material and supplies to the construction site which use heavy vehicles such as backhoe, dump truck or semi-tractor trailers (Canadian Cente OSH, 2018). Moreover, another outdoor construction activity is housekeeping activities such as sweeping the dirt at the route of heavy vehicles, removing waste materials and also maintain the construction site place free of slip and trip hazards.

2.3.4 Inhalable Dust Emission from Construction Activities

The activities for indoor and outdoor construction can expose workers to the particulate emission of total inhalable dust. For indoor construction, some of the activities are mechanical activities such as drilling and hacking the wall, block breaking and also grinding ceramic tiles. All of these activities will release huge emission of dust particles from construction equipment use during the activities (Susan et.al, 2009). Moreover, the activities which involved crushing the block or brick can produce high dust emission. As indoor constructions are in enclosed areas, which have less ventilation system of air, this can affect the respiratory health of construction workers.

For outdoor construction activities, it involved the transportation of building materials to sites, drainage installation and also housekeeping activities. For the activities of transportation of building materials, heavy vehicles are uses that are backhoe, dump truck and semi tractor trailers. As construction equipment and heavy vehicles are used frequently in each working activities in the site, it can be harmful to the workers from the particulate emission of total inhalable dust. Actually, construction machines can release diesel exhaust fumes which discharge through the run combustion engine. The diesel exhaust fumes also contain huge amount of dust particles which can cause greater health effect to the exposed workers at the site. The use of heavy machine in operation can release huge amount of dust. The emissions from on road vehicles associated with the construction site need to be frequently monitored (CUREC, 2016). For housekeeping activities, although it did not involve the use any construction equipment, but working under dusty environment around the site can make the workers exposed more to the particulate matter emission. This is because dry sweeping of concrete dust and debris during housekeeping activities can produce high level of dust (Health and Safety Executive, 2017).

2.4 AIR MONITORING METHOD

Air monitoring is an assessment for measuring the level of air pollutant. Air monitoring is an integral part of an effective air quality management system. The data are collected to assess the level of pollution, to provide air pollution data to the public and to support the implementation of air quality standards. Moreover, air monitoring can evaluate the effectiveness control strategies for pollutant emissions; provide information and data for the evaluation of air quality models in order to support research.

Before monitoring begins, some strategy should be applied for many options. The monitoring strategy aim to determine the most appropriate methods, ensure correct data are use, know the exactly costs for investment of equipment, and the operating costs. There are several methods to measure air pollutant. One of the technique for the measurement of airborne dust by manual measurement method (Iqbal & Kim, 2016). This techniques use combination of filter sampling and gravimetric analysis by microbalance. Then, a continuous determination for the amount of particulate deposited on a filter tape during a fixed sampling interval conduct by measurement of deposited particles through the filter paper.

2.4.1 Personal Air Monitoring

Construction sites have high potential for the exposure of harmful dust and particulate matter among the workers. This air monitoring is an air sampling that performed on an individual person. Personal sampling is used to determine the actual amount of exposure that person has had to a hazardous chemical, substance, or particles. The most significant route for particulate matter to enter the body are by inhalation (Kaysen, 2016). Total inhalable dust can enters the nose and mouth during breathing and will be deposited anywhere in the respiratory tract. So, the monitoring of air while they breathe is very important. The personal air monitoring with the sampler will be mounted in the breathing zone.

According to NIOSH method 0500 (1994) for total inhalable dust, the sampling filters must be placed inside the cassette and clipped at the clothing in breathing zone.

Then, a personal sampling pump for controlled rate of air is drawn through the filter which has been pre-weighed. To get the result, filter is weighed after the sampling to determine the amount of dust collected. This method can really determines the total concentration for construction workers that exposed to inhalable dust.

2.5 LUNG FUNCTION TEST

Lung function tests are also known as pulmonary function tests. There are several tests that measure the function of lungs. Spirometry and lung volume tests was use to measure lung size and air flow (Mets et al., 2012). Moreover, another lung test measures how well oxygen get in and out from the blood. Next, fractional exhaled nitric oxide (FeNO) which is one of the lung test measures nitric oxide level in the blood that act as a marker for inflammation in the lungs.

However, this study only uses spirometry testing. Spirometry testing measures the amount of air that the lung can hold and how forcefully air from the lung can be empty. The test conduct by breathing multiple times through a tube that is connect to computer. The effect from this spirometry test is some people might feel dizziness and tired after multiple times of breathing effort. The result from values of forced expiratory volume in first second (FEV1) and forced vital (FVC) capacity can identify the severity workers respiratory disease and lung function impairment. Furthermore, Vukoja et al,. (2018) state that the measurement of forced expiratory volume in first second/forced vital capacity ratio (FEV1/FVC) can predicted the severity of lung function and lung obstruction.

2.6 CORRELATION INHALABLE DUST WITH LUNG FUNCTION

The release of dust to air can effect lung function impairment. Recent reviews of the evidence on the relative toxicity of different dust particles components and sources by the EPA and the World Health Organization (WHO) European Office (WHO, 2013) have concluded that there are associations found for both variables (Adams et al, 2015). Moreover, the study from Araújo et al, (2014) state that the health impacts of dust emissions is coarser dust which are particulate matter between 100 µm and 10µm in diameter can deposited in the lungs and therefore affect the health of people living and working in the surrounding area of the site.

As inhalable dust has smaller sizes compared to other usual dust, it will cause greater impact to human respiratory system. Particles which less than 100 micrometers in diameter can deposited in the lung, irritate and corrode the alveolar wall which can cause lung function impairment (Vukoja et al., 2018). Particulate matter have small diameters, however large surface areas which capable of carrying various toxic stuffs, passing through the filtration of nose hair, reaching the respiratory tract with airflow. The dust particles can accumulate at respiratory track by diffusion and can damage the other body parts through air exchange in the lungs (Xing et al., 2016).

2.7 LUNG FUNCTION IMPAIRMENT

Lung function is about how well person breathing. Lung function process occurs when oxygen passes through the alveoli and then goes to the capillaries and into the blood. The oxygen will be carried to the heart and then pumped throughout the body tissues and organs. When oxygen goes into the bloodstream, carbon dioxide passes from the blood into the alveoli and then makes spread throughout of the body (Lung Function Test, 2018). For lung function impairment, it is a disease when people having difficulty in breathing which can effect human respiratory system. Respiratory system is a set of organs that allows people to breathe and then exchange oxygen and carbon dioxide throughout the body (Respiratory System, 2018). In construction industry, when workers are exposed to particulate matter from construction activities or emission from heavy machine and vehicles, they might get infect to the respiratory disease.

2.7.1 Respiratory Diseases

Exposure to inhalable dust can give adverse effect to lung function or respiratory system. Xing et al., (2016) state that the previous study from Scientists in Canada and the US found that long-term exposure to particulate matter significantly increased not only the chances of cardiopulmonary problems but also the mortality of lung cancers case each year. The 7 years study which is from 2000 to 2007 in the US indicated that the average life span was extended by 0.35 years for every 10 $\mu g/m^3$ decrease of inhalable dust. This show that the exposure of workers to particulate matter can affected their life span which cause from respiratory diseases. Therefore, it can be conclude that the exposure to inhalable dust can affect the respiratory health symptoms of workers. The examples of lung function impairment which cause from exposure to particulate matter at construction industry are chronic obstructive lung diseases and occupational asthma.

2.7.2 Chronic Obstructive Lung Diseases (COPD)

Chronic obstructive pulmonary disease (COPD) is a respiratory illness which can cause limitation of airflow (Vieira et al., 2016). The symptom of this disease such as increasing breathlessness that related with persistent airflow restriction and chronic airway inflammation (Lin et al., 2018).

Workers that exposed to dust and particulate matter have high chance to get the disease. The study from Boschetto et al., (2006) state that population attributable risk for COPD associated with exposure from industrial work estimated to be at 19% overall and 31% among never smokers. Moreover, the relevant of COPD and particulate matter exposure from construction industry had been study previously. A cohort study for Swedish male construction workers from 1971 to 1999 was done and the result show that COPD fraction among worker with airborne exposure was estimated 10.7% for overall and 52.6% among never- smokers. Although smoking had been related with COPD disease, but the result show that construction workers that never smoke has high percentage of COPD fraction.

2.7.3 Occupational Asthma

Asthma is one of respiratory illness which can affect airways at the lung. When asthma attack occurs, the lining of the air passages swells and the muscles surrounding the airways become tight (Medline Plus, 2018). This condition can reduce the amount of air that pass through lung. Asthma also a form of allergic lung disease that will cause accumulation of inflammatory cells and mucus in the airways (Donaldson et al., 2000).

Occupational asthma might happen when workers are exposed to aerosol or dust at the surrounding. Construction workers which allergic to dust or emission from heavy machine and vehicle at construction area has high chance to get asthma attack. There is several previous study about occupational asthma among construction workers. A study from USA state that the occurrence of self-reported asthma among construction workers was lower compare to general working population. However, another study that conducted in Singapore reported, the risk from occupational asthma for construction and renovation workers had increased (Sauni et al., 2001). Moreover, there are also some previous studies about the occurrence of occupational asthma from total inhalable dust. Donaldson et al., (2000) describes about the average case in occupational asthma. The result show that 2% of average increases in hospitalisations and related health care visits, and 3% increase in asthma symptoms for each 10 $\mu g/m^3$ rise in dust from various of studies. Therefore, many workers get hospitalisation from occupational asthma when they are exposed to allergens particles such as small particles of dust or emission of aerosol from heavy equipment at industrial and other construction activities.

2.8 PERMISSIBLE EXPOSURE LIMIT (PEL)

The permissible exposure limit (PEL) is one of legal limit for workers from exposure a chemical substance or physical agent. Permissible exposure limits are established by the exposure of particulate matter in the construction industry can be controlled when the regulation were followed by the management of the construction company.

The PEL were made in order to control amount of dust in indoor space or outside. The PEL will be referred to Occupational Safety and Health Administration (OSHA) and American Conference of Governmental Industrial Hygienists (ACGIH) from NIOSH Manual Analytical Method (1994). The PEL of OSHA state that the exposure must be below 15 mg/m^3 while for ACGIH must be below 10mg/m^3. This standard is really important to determine the limit exposure to workers to avoid any effect on respiratory system or lung function impairment from happen later (DOE, 2013).

CHAPTER 3

METHODOLOGY

3.1 INTRODUCTION

This chapter highlighted the details of technique and procedures carry out in the study. This chapter consists of study area, sample size, sampling frame, sampling unit, sampling unit, sampling methods, sampling strategy, research instruments, sampling procedure, data analysis, quality control, and study limitation. Key findings for consideration in this study are the instrumentation and method by using personal air sampling monitoring and St George Respiratory questionnaire (SGRQ).

3.2 STUDY AREA

This study was conducted at construction site in Taman Gambang Damai that builds for semi-detached housing. Besides that, the study area also conducted in Gambang Water Park and Safari area which construct modifying of building. The construction sites were selected according to the suitable specification of surrounding site and the number of workers available to get adequate and proper sample size for this study.

3.3 STUDY DESIGN

The study design used was descriptive cross-sectional study between indoor construction workers and outdoor construction workers which exposed to the particulate emission of total inhalable dust. Inferential analysis was also used to identify relationship between inhalable dust exposure with respiratory symptoms.

3.4 STUDY SAMPLE

In this study, 26 respondents were randomly selected to participate according to the activities at construction site. The chosen participant consists of 24 male workers and 2 female workers. The group of sampling participant are based on the activities that available at construction site such as mechanical activities, transportation of building materials, housekeeping activities and construction of drainage.

Each type of activities of indoor and outdoor construction has different dust exposure depends to the construction equipment use and also surrounding environment. For example, transportation of building materials and supplies in the site require the use of heavy vehicles such as backhoe, excavators, dump truck and tractor. Meanwhile, mechanical activities for indoor construction use equipment such as drilling machine, grinding machine. All the workers which exposed to emission of dust that doing related activities for indoor and outdoor construction were selected as the participant for this study.

3.4.1 Exclusion Criteria

Some exclusion criteria for lung function test include the smoking habit and severe health issue, respondent age and work experiences. Smoking can become factors which can effect on lung function impairment. This is because smoking can affect the result for lung function test. However, since most of the workers were smoking, so these criteria cannot be followed due to unsuitable circumstances condition. Moreover, workers with age more than 60 years old were not chosen as their lung has lower capability because of aging factor. Besides that, for the working experience, the respondent must be working for two years or above to ensure the coverage of all possible duration of exposure when working in construction site. Workers must also engage with construction job within job duration.

3.4.2 Sample Size

The calculation of sample size was very important to determine an adequate sample size for estimation of population prevalence with a good precision. In order to determine the sample size, Daniel (1999) formula can be used. Some element in the formula includes statistic for level confidence (Z), expected prevalence (P) and precision (d).

In this study, the estimation of level confident was 95 percent of case sample that is within 1.96 in the standard deviation. Actually, the acceptable precision for these studies to get accurate sample size estimated to be 1 percent. However, if there is a resource limitation, larger precision may use (Naing et al., 2006). So, five percent (d=0.05) estimation of precision was used based on this reason. The expected standard deviation of 2.5 taken from Kinsey & Cowherd, (2005) for the activities at construction area which involved the use of construction equipment and heavy vehicles (P=0.025) . Therefore the equations for sample size are as below.

$$n= \frac{Z^2 \ P\ (1-P)}{d^2} \qquad (3.1)$$

Where;

n = sample size

Z = Z statistic for a level of confidence,

P = expected prevalence or proportion

d = precision

therefore, the calculation were shown below.

$$n= \frac{1.96^2 \ X\ (\ 0.025\ (1-0.025)}{0.05^2} \qquad (3.2)$$

$$n = 37$$

Based on this formula, at least 37 must be chosen for each group in order to identify the 90 percent level of confident for the lung function impairment. But, to get more precise respondent must consider the 10% drop out from the total respondents.

$$\frac{10}{100} \times 37 \qquad (3.3)$$

$$= 3.7 = 4$$

$$37 + 4 = 41$$

Therefore, the number of respondents must be at least 41 workers after 10% drop out were considered. However, because of some limitation (can refer to study limitation), the sample sizes were reduced according to a suitable amount of respondents which were 26 workers.

3.5 DATA COLLECTION

To get the participant for this study, several construction companies were contacted to obtain agreement of participation in the study for workers at construction site. Figure 3.4 shows the flowchart of data collection process. For sampling method, 26 respondents are selected. The criteria of workers that are selected must be exposed to inhalable dust from the activities in the construction site for indoor and outdoor construction. These workers must be working in construction site area within or more than 8 hours and expose to inhalable dust.

All the chosen respondents were undergoing two type of test which is air monitoring for total inhalable dust using personal air pump and questionnaire. Before the conducting the monitoring and questionnaire, walkthrough observations were done to identify workers which can be participate according to the types of activities in the construction site. The activities for indoor and outdoor construction included mechanical activities, transportation building materials using heavy vehicles and also housekeeping activities. The selections of respondent were based on the types of activities which required in the study. The age and working experience of workers were identified by interviewing the workers. Therefore, the construction workers that meet the criteria will be chosen to recruit as the participant for the study.

All chosen participant must undergo personal air sampling test to access the level of exposure to inhalable dust. Each participant must wear personal air sampling pump and the cassette with PVC filter paper were located at breathing zone. The personal air sampling test was conducted for six hours and above.

At the same time, to identify the respiratory symptoms, a set of questionnaire were given to each of the participants. The questionnaires consist of general background, working history and current respiratory problem. Next, questions about respiratory health assessment were also including in the questionnaire to identify their symptoms get from the exposure of dust. The questionnaires given to each participant that meet the requirements needed based on the suitable activities. Although the important criteria were healthy non-smokers participant, but since the amount of workers at the site were limited, the criteria are not included in this study.

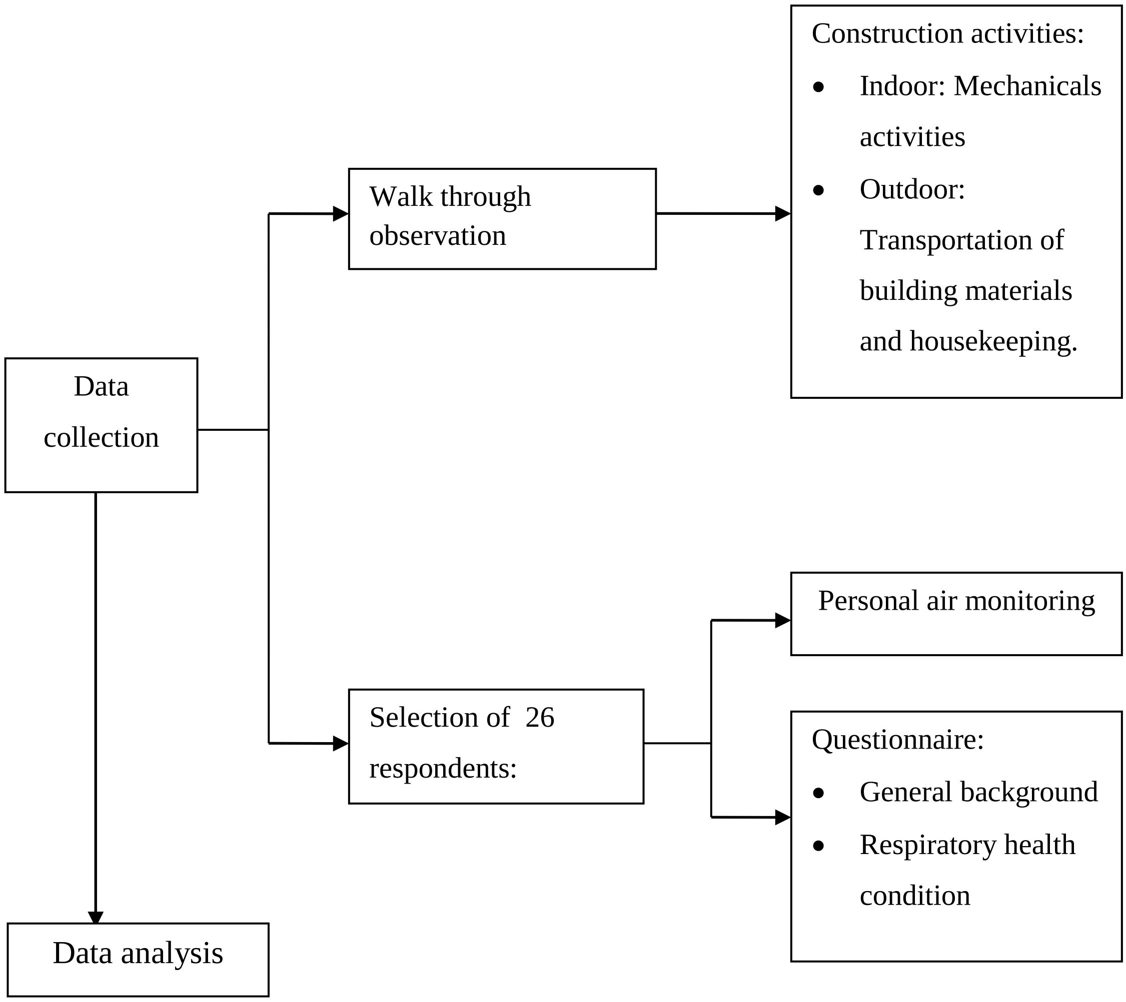

Figure 3.4 Flowchart of data collection process

3.6 INSTRUMENT AND METHOD

A set of questionnaire and three types of instrument used in this study which are dust mate, personal air sampling and spirometer. Dust mate and personal air sampling were used for air monitoring while questionnaire and spirometer are for the lung function impairment test.

3.6.2 Personal Air Monitoring

The purpose of conducting the air monitoring is to evaluate the concentration of total or inhalable dust at the construction area. The instrumentation use referred from NIOSH 0500 (1994) for measurement of total inhalable dust. According to this method, personal sampling pump were used with sampler equipment. The sampler use 37 millimetre of PVC filter with 5 micrometre pore size membrane accompanied with and supporting pad in 37 millimetre cassette filter holder.

`The sampling pump were calibrated first to ensure that the sampling accurate. Calibration of the sampling pump must be 0.1 to 2 mg per sample followed the NIOSH 0500 measurement. Before begin the personal monitoring, some step were taken to ensure accurate weight of the filter later. Firstly, filter papers were placed in desiccators for 24 hours before carry out the pre-weight. During the sampling, filter paper in the cassette filter holder must be placed at worker’s breathing zone. Each personal air monitoring sampling was taken within 8 hour time. Lastly, all the sampling filter papers were weight and calculation of samples were compared with the blanks. The calculation for inhalable or total dust as follow:

$$C = \frac{(W_2 - W_1) - (B_2 - B_1)}{V} \times 10^3 \text{ mg/m}^3 \qquad (3.4)$$

Where;

W_1= tare weight of filter before sampling (mg),

W_2 = post-sampling weight of sample-containing filter (mg),

B_1= mean tare weight of blank filters (mg),

B_2 = mean post-sampling weight of blank filters (mg),

V = volume as sampled at the nominal flow rate

3.6.2 Questionnaire

Questionnaire is a research instrument consisting of a series of questions for the purpose of gathering information from respondents. Table 3.1 show the division part in the questionnaire. The questionnaire was divided into four part which are part A, part B, part 1 and part 2. Part A consists of demographic data of respondent and part B was about their lifestyle. Part 1 and part 2 which is about the respiratory health impairment are taken from St George Respiratory Questionnaire. Part 1 (questions 1-8) are about the frequency of health related symptoms experienced by the workers while part 2 (questions 9-16) address participant current state and activities which disturb their respiratory system.

Table 3.1: The division part in the questionnaire

Part A (Demografic data	**Part B (Lifestyle)**	**Part 1 (helath related symptoms)**	**Part 2 (current state)**
• Name • Nationality • Gender • Weight • Height • Years employed • Occupational history	• Smoking habit • Alcohol • consumption	• Cough • Phlegm • Breath shortness • Wheezing • Chest discomfort • Unpleasant chest attack	• Chest condition • Breathless • Exhausted easily • Activity effect breathing • Medication

Sources: American Thoracic Society (1978)

3.6.2.1 The Scoring for ST George Respiratory Questionnaire (SGQR)

The scoring for SGRQ consists of three components that are symptoms, activity and also impact. Symptoms component is about the effect of respiratory symptoms, the frequency and also severity. The activity component concern about activities which can cause people breathless and lastly impact component is about social function and physiological disturbances which can disturb the airways. From the three components, a total score calculation summarises overall health status. The total score are in percentage form for overall impairment. Total score near 100% indicates the worst health status while scoring of 0% represents best health status (Jones, 2009). Each answer from the component had different value. The total score can identify lung impairment for asthma and COPD disease.

The principle of calculation was based on the formula below:

$$\text{Score} = 100 \text{ X } \frac{\text{Summed weights from positive items in the questionnaire}}{\text{Sum of weights for all items in the questionnaire}} \qquad (3.5)$$

The weights in formula present the different amount of score in each question. Each component was scored separately from the sum of all positive respond in each questions, deduct missed items from maximum possible weight of each component and also by divide the sum of weight for all items. Total score also used the same method for the calculation.

To make the calculation easier, the questionnaire data can be insert to the SGRQ calculator in excel form or SGRQ application. So, in this study, the SGRQ applications were used to find out the score amount because it take less time compare to excel calculators.

3.7 DATA ANALYSIS

The data analysis will be performed using computer software of Statistical Package for Social Science (SPSS) version 25. Descriptive analysis and inferential analysis were performed to present the result obtained.

3.7.1 Descriptive analysis

Descriptive statistic was used to present the result in the term of frequency, percentage which represented by the mean and standard deviation. The analysis involved demographic data, concentration of air in different type of activities and the list of lung function symptoms.

3.7.2 Inferential Analysis

Before conducting validity test, normality test must be done to make sure the pattern of data each data. Normality test was conducted to identify whether the test was parametric or non-parametric (Razali and Wah, 2011). In the normality test, Shapiro Wilk test are more suitable to use as the study only had small number of participant ($\leq$50) compared to Kolmogorov-Smirnov that is for large number of participant (1,000 samples). For the hypothesis testing, t-test was used for comparison between concentration of inhalable dust for indoor and outdoor construction while Person correlation was used to determine correlation of data for concentration inhalable dust and respiratory syptoms.. All the data were set into SPSS for analysed.

3.8 ETHICAL CONSIDERATION

The approval letter from the Universiti Malaysia Pahang (UMP) from Faculty of Engineering Technology obtained before the data were collected. A letter and short proposal were sent to the construction company asking for the consent to recruit the respondents and for the consent to done the entire sampling test and also in answering the questionnaire. The participation in this research must be a voluntary. The explanations on the purpose of this research and the description of the procedure been explained to them. They also had been informed that this study will not give any harm to them because it does not involve any invasive procedure. The description on the possible benefits from this research was also explained. They also had right and can contact the responsible person as stated in the consent form if they had any inquiry from this research. All of workers private information was explained as private and confidential.

Researcher need to respect people’s right and dignity, help the respondents rather than harm or harass them, maintain confidentially and minimize intrusion on privacy, disclose confidential information only as mandated by law and explain any constrains on confidentially to clients, and others (American Psychological Association’s (APA’s) ethic Code, 1992). As they signed for the consent form, it means that they are agreeing to participate in this study. Finally, the participation of the workers was voluntary without being forced by the researcher. Furthermore, during the session on answering the questionnaires, workers have their own freedom to answer the questions honestly without being affected by researcher or their friends.

3.9 QUALITY ASSURANCE

Quality assurance is really important in the study to ensure precise and accurate data from the sampling of spirometer and also personal air sampling. The purpose was to prevent any bias or imprecise data collection.

3.9.1 Quality Assurance for Spirometer

Before samplings were taken, the spirometer must be calibrated to ensure accurate data collection. Moreover, to take the measurement of spirometer, it used disposal mouthpieces and each worker or participant used different mouthpiece to ensure cleanliness of the spirometry test. This is very important for hygiene issue and also accuracy of the data later on.

3.9.2 Quality Assurance for Personal Air Sampling Pump

Each air sampling pump was calibrated before and after it was used. According to NIOSH analytical method 0500 (1994), the air sampling pump, the flow rate range must be fixed to 0.1 to 2 mg. Calibrations were done in order to obtain accurate data collection.

3.10 STUDY LIMITATION

The limitations for this study were about the respondents, activities and also instrument. The limitations of respondent are small number of sample size. Actually, to get more accurate result must add 10% drop out, but, as the respondent which willing to cooperate with this study were limited, the number of respondent get less than the actual sample size. For this study, only 26 workers were willing to give cooperation to become the respondent.

Actually, during the data collection, the activities at construction site are very limited. Some of the activities are also not suitable for workers to become participant such as working activities that need to go into drain or climb to high place because of the unsuitable condition to wear the personal air sampling pump. Some of workers which do the activities also refuse to be participant as it could burden them. Moreover, the actual criteria of respondents must be non-smoker for spirometer test and personal air monitoring but as nowadays it is really hard to find non-smokers at construction site, so, these criteria are excluded. Next, the criteria for respondent must be without any respiratory health for the test. These criteria become the limitation for this study because some of the construction workers already had respiratory health such as asthma.

Furthermore, this study actually required the used of spirometer to test lung function test that are (forced expiratory volume in one second (FEV1) and (forced vital capacity (FVC)) among construction workers. During the data collection process, there are problem occur with spirometer as it cannot give the accurate result of lung function status. Because of this condition, spirometer cannot be used in the study.

Therefore, although the result from this study might not be too accurate from the limitation which had been stated above, this study still contributes to identify the exposure of inhalable dust and respiratory symptoms to workers.

CHAPTER 4

RESULT AND DISCUSSION

4.1 INTRODUCTION

This chapter present the result and discussion from data collection about demographic data, personal concentration and also respiratory symptoms. All the collected data were analysed using a software namely Statistical Package for Social Science (SPSS) version 25. In this study, descriptive analysis were used to determine the frequency of demographic data gender, weight or height, age, activities in indoor or outdoor construction site, years employed, smoking habit and alcohol habit. Furthermore, comparison for indoor and outdoor construction use independent t test as the data normally distributed. The correlation between personal inhalable dust and respiratory symptoms used Pearson correlation test from normal pattern of distribution.

4.2 BACKGROUND OF THE RESPONDENTS

Table 4.1 shows demographic data for 26 respondents among the workers in the selected construction site. Most of them are male (92.3%) which consist of 24 workers while only 2 workers are female (7.7%). This is because construction industry usually dominated by male workers only. Based on Construction Industry Training Board (2003), it stated that only 9% women involved in construction work force. Female workers are facing many barriers in construction industry (Amaratunga, et al, 2006) such as lack of skills, wage discrimination, gender harassment and also problems related to construction works (Kalpana, et al, 2013).

Table 4.1: Demographic data of respondents

Characteristic		Frequency	Percent (%)
Gender	Male	24	92.3
	Female	2	7.7
Nationality	Indonesia	13	50.0
	Bangladesh	11	42.3
	Malaysia	2	7.7
Age	Young adult (18-35)	10	38.5
	Adult (36-55)	13	50.0
	Senior (>56)	3	11.5
Education Level	Secondary	3	11.5
	Primary	23	88.5
Smokers	Yes	21	80.8
	No	5	19.2
Alcoholic	No	26	100.0

N=26

Most of the workers are foreigners from Indonesia (42.3%) and Bangladesh (42.3%) while only 2 of them are the local workers from Malaysia (7.7%). Nowadays, the construction industry in Malaysia are conquered by 69% foreign workers from total employment opportunities from total work forces (Rahman. et al, 2012). Malaysian citizen demanding in choosing work and refuse to become construction labours (Jamadi, 2012). This caused foreign workers from Bangladesh, Indonesia and also Myanmar been employed in construction industry. Respondent age are categorized into three that were young adult (age between 18 to 35 years old) adult (age between 35 to 55 years old) and senior (age 56 above). They are mainly consist of adult (50%) and 10 workers are young adult (38.5%) and only 3 workers in senior group (11.5%). The suitable age for construction workers are around 35 to 55 years old because older workers has higher injury related cost compared to younger workers (Schwatka,. et al, 2012).

Construction industries are known as unattractiveness to people due to poor working environment and low wages. Rahman et al, (2012) stated that most of construction workers had low education level and skills which made them willing to work under those poor condition. In this study, the education level were asked to the workers wheather they had primary education (school education level), secondary education (certificate level) and tertiary education (collage or university graduated) The result for education level found out that only 3 workers had secondary education (11.5%) while the rest of 23 workers only had primary education (88.5%). Moreover, the lifestyle data show that among 26 workers, 21 of them are smokers (80.8%) and only 5 workers did not smoking (19.2%). Fortunately, 100% of the workers did not consume any alcohol as in the interview the workers stated that alcohols are not allowed in their faith. Smoking habit had become common problem in construction industry. For instance, Foust & Kaspar (2010) stated that construction workers has the highest prevalence for smoking with 38.8%.

The longest duration of smoking for the construction workers are 15 years while minimum duration of 0 years which is for the non-smokers. Smoking can increase the severity of respiratory health to workers because they are working under dusty environment. The average duration of smoking (mean=4.85 years) (SD=3.94 years) were low which show that not too many workers had long duration of smoking. The high SD value indicates that the ranges of data are large. This shows that only few of them have long duration smoking and the rest have short duration of smoking. Actually, smoking can affect the respiratory symptoms among workers but since the majority of construction workers are smoking, this exclusion criterion cannot be used. Contrary to this matter, low mean value might not affect much to the result for respiratory symptoms. The longest duration of working experiences are 10 years while the shortest amounts are 2 years. Tavakol et al., (2017) stated that the longer duration of working years, the higher the exposure will be.

4.3 WORKS ACTIVITIES OF THE RESPONDENT

The activities in construction site can be catogorized into indoor and outdoor construction. The same number of sample were taken for indoor and outdoor categories there were 13 samples for both indoor and outdoor. Figure 4.1 show the freqency of indoor group according to the type of activities.

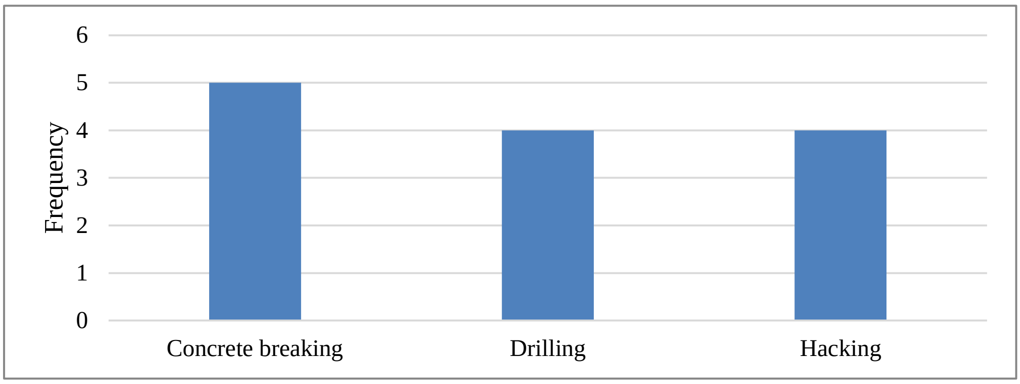

Figure 4.1: Activities for indoor construction

The activities for indoor construction are done in an enclosed space which modifying construction of building take place. As the type of working activities are limited, only three related activities which can cause the exposure of inhalable dust were choosen for personal air sampling among the workers that consist of concrete breaking, drilling and hacking. Concrete breaking is the activity which required demolishing certain part of concrete wall building using sledge hammer or jack hammer.. Drilling means creating smooth holes at the wall or concrete while hacking in construction is about roughening of concrete surface before plastering with new layer of concrete (Haq, 2017). As the indoor activity samples are taken during modifying of the building, so, all the activities was carried out before new structure was build up Appropriate amount of construction workers were selected as participant for indoor activities to get 13 samples which consist of five workers for block breaking and four workers for drilling and hacking.

Figure 4.2 shows the frequency of outdoor group according to the activities. Outdoor constructions are the activities which were done in an open space. Usually, the sources of inhalable dust come from the use of heavy vehicles around the site. During data collection, the constructions are in the stage of superstructure which is process of building of walls, drain and tiling. Therefore, there are limited activities for outdoor construction and the related activities available are operation of backhoe and dumpturck, housekeeping activities and also the construction of drainage.

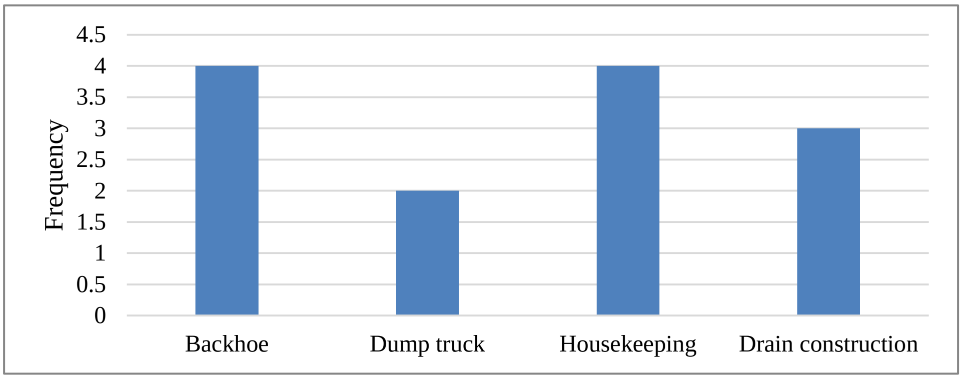

Figure 4.2: Activities for outdoor construction

Actually, backhoe and dump truck are used during the activity of transportation of construction equipment and materials. As the storage area and building place are quite distance, so the use of heavy vehicles were needed to easily transported the needed materials. Furthermore, housekeeping activity was about keeping the construction site from hazardous waste. Housekeeping activity include sweeping the dust or dirt at the site, gather and remove debris and also keeping the workplace tidy (Canadian Cente OSH, 2018). Drain construction activity about building drainage system. Therefore, 13 sample are taken for the outdoor construction that consist of four people in operation of backhoe and housekeeping activities follow by three person doing drainage construction and two person manage the operation of dump truck.

To summarize, there are quite limited amount of activities available for both indoor and outdoor. This is because usually construction activities follow by the stages and during data collection, only some activities related are available. So, among all the workers, only total of 26 workers agree to participate in the study.

4.4 PERSONAL AIR CONCENTRATION FOR INHALABLE DUST

The total concentration of inhalable dust exposure among construction workers had been measured based on the activities that are for indoor and outdoor type of work. The values are shown by mean and standard deviation. Table 4.3 shows the analysis of data for activities in indoor construction site.

Table 4.2: Personal air concentration of dust for indoor activities

Activities	N	Minimum (mg/m^3)	Maximum (mg/m^3)	Mean (SD) (mg/m^3)
Concrete Breaking	5	1.28	5.89	4.0 (1.69)
Drilling	4	0.77	5.38	3.14 (2.45)
Hacking	4	2.65	8.20	5.47(2.45)

N=13

Workers perform hacking has the highest (mean=5.47mg/m^3) (SD=2.45mg/m^3) for air concentration compare to others because the dust will directly exposed to them. When hacking, the mobile hacker machine can produce large amount of dust to roughen the concrete surface. However, the value still not exceeds limit of OSHA (15mg/m^3) and ACGIH (10mg/m^3). The lowest concentration of air was found among drilling activities (mean=3.14 mg/m^3) (SD=2.46mg/m^3) as it were not continuously done, only at certain time which did not exposed workers to high amount of dust. On the other hand, the minimum and maximum concentration of dust for indoor activity (min=0.77mg/m3, max= 8.20mg/m3) still not exceed the limit of OSHA and ACGIH. Consequently, the concentration for indoor construction site is still under control limit and will not expose hazardous condition to the workers.

Based on table 4.3 which show inhalable dust concentration for outdoor construction, the operation of backhoe (mean=8.07mg/m^3) (SD 2.53=mg/m^3) and dump truck (mean=4.44mg/m^3) (SD=1.57mg/m^3) has the highest mean. Similar result was found in the study from Kiyoung et.al (2012) which shows high concentration of particulate matter from the use of heavy vehicles in construction. This is because heavy vehicles use diesel and gasoline fuel which can contribute to the high concentration of dust to the environment air (EPA, 2006). The concentration value did not exceed the limit of OSHA (15mg/m^3) and ACGIH (10mg/m^3).

Table 4.3: Personal air concentration of dust for outdoor activities

Activities	N	Minimum (mg/m^3)	Maximum (mg/m^3)	Mean (SD) (mg/m^3)
Backhoe	4	4.77	10.56	8.07 (2.53)
DumpTruck	2	3.33	5.56	4.44 (1.57)
Housekeeping	4	1.54	4.62	3.15 (1.31)
Drain Construction	3	2.31	5.39	3.68 (1.57)

N=13

Furthermore, housekeeping activities (mean=3.15mg/m^3) (SD=1.57mg/m^3) and construction of drain (mean=3.68mg/m^3) (SD=1.57mg/m^3) show low average of dust concentration. Both of the concentration did not exceed OSHA and ACGIH limit. Drain construction need the significant use of cement in building the drainage system which can cause exposure to the inhalable dust (Musa, 2017). Study from Susan et al., (2009) stated workers in construction site can be exposed to inhalable dust concentrations from activity which related to the use of cement. Moreover, for the housekeeping activities, working under dusty environment can make them indirectly exposed to dust from work equipment, work method and working area itself (Canadian Centre OSH, 2018). However, the maximum concentration of dust for outdoor (10.56 mg/m^3) is higher than 10mg/m^3 which was the standard limit of OSHA and ACGIH. This means that the workers are exposed to high concentration level of dust for the outdoor activities and can pose dangerous health effect.

4.4.1 Comparison of Personal Concentration of Inhalable Dust from Indoor and Outdoor Activities

Table 4.4 shows the normality test of personal concentration of inhalable dust between indoor and outdoor activities. Shapiro- Wilk test show that the p-value for indoor concentration (0.956) and outdoor concentration (0.355) were higher than 0.005. The result indicated normal distribution of data.

Table 4.4: Normality test for personal concentration of inhalable dust between indoor and outdoor activities.

Variables	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	p-value	Statistic	df	p-value.
Indoor concentration	0.109	13	0.200*	0.976	13	0.956
Outdoor concentration	0.193	13	0.200*	0.931	13	0.355

N=26
*. This is a lower bound of the true significance.
a. Lilliefors Significance Correction

Table 4.5 shows the personal concentration of dust between indoor and outdoor activities. Outdoor activities (mean=4.19 mg/m^3) (SD=2.22mg/m^3) has higher average concentration of inhalable dust compared to indoor activities (mean=4.98mg/m^3) (SD=2.73mg/m^3 Therefore, it can be conclude that workers in outdoor construction are exposed more to dust concentration than indoor construction activities. However, research from Spee et al, (2007) found different result which get higher concentration for indoor construction than outdoor. This happen because during data collection, the construction was already in superstructure stages that are almost finished which cause outdoor construction to have low exposure to dust.

Table 4.5: Personal concentration of inhalable dust between indoor and outdoor activities

	N	Mean (SD) (mg/m^3)	Mean differences (95% CI)	T statistic (df)	p-value[a]
Indoor	13	4.19(2.22)	-0.80 (-2.81, 1.21)	-0.82 (24)[a]	0.42
Outdoor	13	4.98(2.72)			

[a] Independent t –test

The independent sample t- test can find out the significant differences between the two groups of indoor and outdoor construction activities. The p-value of independent t test (0.42> 0.05), so the null hypothesis can be accepted. T statistic value (-0.82< 0.05) indicate same meaning as p-value. This can show that there are no significant different between both group. This result where similar to the finding from Josef et al., (2004). Furthermore, the lower bound of 95% confident interval is 1.21 and upper bound of -2.81. The means different for both group was -0.80mg/m^3. Thus, 95% confident that dust concentration will fall between 1.21 mg/m3 and -2.81 mg/m^3.

4.5 RESPIRATORY SYMPTOMS

Table 4.6 show respiratory symptoms among workers. The number of workers which had the symptoms several days a week can show the severity attack of the disease. Among all the symptoms of respiratory impairment, highest amount of workers of 5 participants had cough (19.2%) follow by 4 workers brought up phlegm (15.4%), 3 workers had shortness of breath (11.5%) and 1 workers had attack of wheeze (3.8%). Several days a week means that they had really frequent symptoms of respiratory illness such as asthma and COPD.

Besides that, not at all means that the workers do not have any symptoms of the respiratory impairment. Most of the workers that are 26 of them did not have any attack of wheezing (61.5%), 9 workers does not had shortness of breathing (34.6%) and 7 workers did not brought up phlegm (26.9%). Only 4 workers did not have symptoms of cough during the past few months. Therefore, cough is the most common symptoms among workers follow by phlegm, shortness of breath and lastly wheezing attack. Previous study about occupational respiratory diseases had find out that chronic cough is one of the most frequent related airway diseases among the workers (David et al., 2006).

Other than that, the chest attack also had lowest symptoms among the workers with only 7 person had attack while another 19 people (73.1%) did not had any attack during the past 3 months. Thus, as many workers did not have any chest attack only 7 workers (26.9%) had worst chest trouble less than a day. 9 workers stated that they did have attack of wheezing but only 7 of them get worst wheezing during the morning. Wheezing can get worst in the morning due to nocturnal asthma which usually worst during night and morning (Orenstein, 2013). People with asthma will get the wheezing symptoms in the morning.

Table 4.6: Respiratory symptoms among workers

Characteristic		**Frequency**	**Percent (%)**
Cough	Several	5	19.2
	Few	14	53.8
	Only	3	11.5
	Not	4	15.4
Phlegm	Several	4	15.4
	Few	10	38.5
	Only	5	19.2
	Not	7	26.9
Shortness of breath	Several	3	11.5
	Few	10	38.5
	Only	4	15.4
	Not	9	34.6
Attack of wheezing	Several	1	3.8
	Few	4	15.4
	Only	5	19.2
	Not	16	61.5
Chest attack	3attack	1	3.8
	1 attack	6	23.1
	None	19	73.1
Duration of worst chest trouble	No	19	73.1
	Less than a day	7	26.9
Good days without chest trouble	Nearly every day	15	57.7
	Every day	11	42.3
Wheezing worst in morning	No	19	73.1
	Yes	7	26.9

N= 26

Indicator:
Several- several days a week
Few- a few days a month
Only- only with chest infection
Not- not at all

To conclude, workers that had the symptoms such as cough, brought up phlegm, shortness of breath, attack of wheezing and chest attack have high probability of suffering respiratory illness such as asthma and COPD.

4.5.1 The Prevalence of Respiratory Symptoms among Construction Workers.

Table 4.7 shows the prevelence of respiratory symptoms among indoor activities and outdoor activities. The result shows that the prevelence of respiratory symptoms among workers perform indoor activities is higher compare to outdoor activities. Poor ventilation for indoor air can result in high concentration of air pollution (Jiang et al., 2016). For indoor activities group, there were 92.3% stated having cough, 92.3% having phlegm problem, 84.6% suffer breathless, 42.6% had wheezing and 30.8% get chest attack. Only p-value for phlegm (0.027) and breathless (0.039) were less than significant value of 0.05.

From the result can be conclude that the prevalence of respiratory symptoms among indoor activities and outdoor activities are significantly different for phlegm (p=0.227) and breathless (p=0.039). Study from Xiping and Lihua (1993) stated both indoor and outdoor emission of particulate can effect in developing respiratory disesase. Thus, there were statistically significant association between respiratory symptoms (phlegm and also breathless) with indoor activities and outdoor activities.

On the contrast, based on the frequency, coughing (n=22), phlegm (n=19) and breathless (n=17) has highest prevalence of respiratory symptoms compared to wheezing (n=10) and chest attack (n=7). So, based on the objective, the prevelence of respiratory symptoms only in coughing, phlegm and breathless symptoms.

Table 4.7 : Prevelence of respiratory symptoms among indoor activities and outdoor activities.

Variables	Frequency %				$\chi^{2\ a}$	p-value
	Indoor activities		Outdoor activities			
	Yes	No	Yes	No		
Coughing	12 (92.3)	1 (7.7)	10 (76.9)	3 (23.1)	1.182	0.277
Phlegm	12 (92.3)	1 (7.7)	7 (53.8)	6 (46.2)	4.887	0.027
Breathless	11 (84.6)	2 (15.4)	6 (46.2)	7 (53.8)	4.248	0.039
Wheezing	6 (46.2)	7 (53.8)	4 (30.8)	9 (69.2)	.650	0.420
Chest attack	4 (30.8)	9 (69.2)	3 (23.1)	10 (76.9)	0.195	0.658

N=26
[a] Chi-square test

Furthermore, the scoring were in percentage form which indicate best health status when near 0% (low prevelence) and the score of 100% indicate the worst heatlh status (high prevelence) (Paul, 2009). Table 4.8 show the analysis component of scoring for SGRQ.

Symptoms scoring is about the frequency and severity of respiratory symptoms which cover the effect of the illness. The minimum score of symptoms was 0% can show that the best possible of health status which means that the workers did not get any symptoms of respiratory impairment at all. Meanwhile, maximum score was 69.19% can show that the worker suffer very bad symptoms of respiratory health. The mean (mean=29.62%) (SD=18.38%) was not too high indicate that the symptoms of overall workers are still in good condition. The component of activity is about activities which can cause limitation of breath and impact component concenrned the effect of airway diseases (Paul, 2009). The mean of activity (33.97%) and impact (22.55%) were not high that can indicate the workers did not suffer respiratory effect from the impact and activity in their daily life.

Table 4.8: Scoring components of SGRQ

	Minimum	Maximum	Mean (SD)
Symptoms (%)	0.00	69.19	29.62 (18.38)
Activity (%)	5.25	65.75	33.97 (16.82)
Impacts (%)	3.74	64.77	25.55 (16.72)
Total (%)	**5.07**	**63.46**	**28.82 (15.44)**

Moreover, the total scoring in SQRG questionnaire can summarize the whole respiratory health status for asthma and COPD (Thomas et al., 2012). The minimum score for total are 5.07% indicate that the worker are healthy without significant health problems while the maximum score are moderate that is 63.46% which can show that the workers had frequent respiratory problems but still can be controlled. The mean of total score is 28.82% which indicate moderate health status among all the construction workers. Therefore, the means of three components (symptoms, activity and impact) and also total score are still low which can indicated good health effect (Mariko et al., 2016). For overall, the prevalence of lung function impairment and respiratory symptoms are still low and their health status are in good condition.

4.5.2 The Correlation Between Concentration of Inhalable Dust and Respiratory Symptoms.

Table 4.9 shows normality test for personal concentration of dust and respiratory symptoms. All p-value for personal concentration of inhalable dust (0.22), respiratory symptoms (total score=0.332, symtoms score=0.596) were above significant value 0.05 indicated data normally distributed. Hence, parametric test of Pearson correlation was used to identify correlation between the variables.

Table 4.9: Normality test for concentration of inhalable dust and respiratory symptoms

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	p-value	Statistic	df	p-value
Total score	0.105	26	0.200*	0.957	26	0.332
Total concentration	0.109	26	0.200*	0.949	26	0.220
Symptoms Score	0.087	26	0.200*	0.969	26	0.596

*. This is a lower bound of the true significance.

a. Lilliefors Significance Correction

To analyse the correlation between concentration of dust and respiratory symptoms, Pearson Correlation was used to identify the validity of the data. Table 4.10 shows the correlation between concentration of dust and respiratory symptoms.

Table 4.10: Correlation between concentration of inhalable dust and respiratory symptoms

	Correlation	p-value
Concentration of Inhalable dust Respiratory sysmtoms	0.761**	0.0006

N=26

A Pearson Correlation

**Correlation at significant 0.01 level (2 tailed)

The p-value for concentration of dust and respiratory symptoms is 0.0006 which is less than 0.01. When the p-value less than 0.01 indicate that there are a strong correlation between concentration of dust and respiratory symptoms. According to Pearson Correlation, the value of 0.761 means that strong correlation between the both variables. The relation between concentration dust and respiratory symptom was significant at 0.01 level. This means that the hypothesis and objective of the study are accepted. Figure 4.3 shows the correlation between concentration of dust and respiratory symptoms.

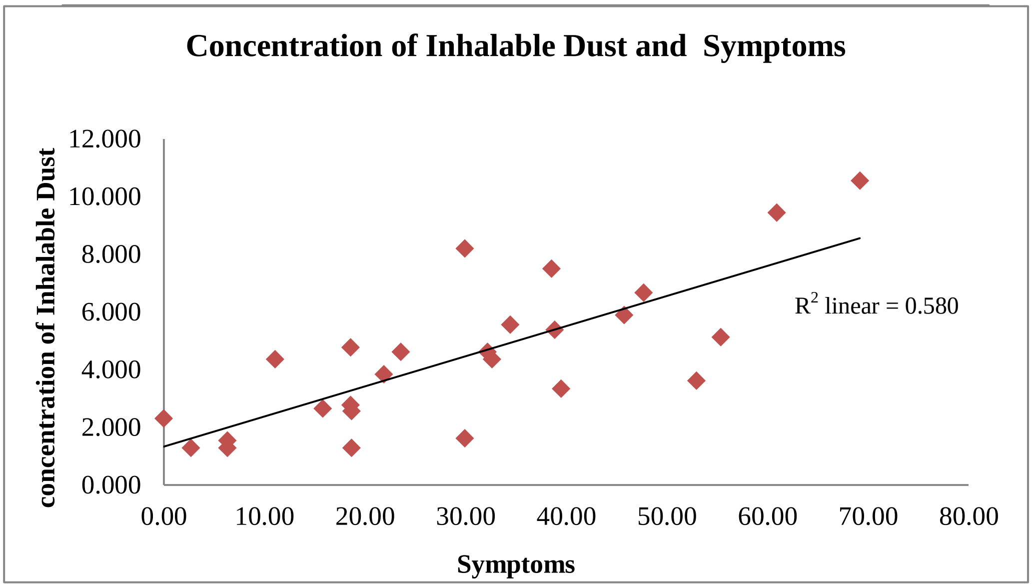

Figure 4.3: Correlation of inhalable dust and respiratory symptoms

Based on the scattered plot show strong statically significant relationship between concentration of dust and respiratory symptoms. R^2 linear (0.580) show that there are small positive linear association because only some of the point are close to the linear line while the others are far from the line. Based on study from Liu et al., (2017) stated that high concentration of particulate matter has stong associated with the reduced in respiratory function and increase in COPD prevelence. Thus, this study can prove that there were correlation between concentration of dust and respiratory symptoms.

4.5.3 The Correlation between Concentration of Inhalable Dust and Overall Respiratory Impairement Status

The relationship between concentration of inhalable dust and overall respiratory impairement status was investigated through Pearson Correlation through the total score of SGRQ questionnaire of each workers. Total respiratory status data were taken from the total score of the three components in the questionnaire. Table 4.11 show the correlation between concentration of inhalble dust and overall respiratory impairement status.

Table 4.11: Correlation between concentration of inhalable dust and overall respiratory impairment

	Correlation	p-value
Concentration of Inhalable Dust Total respiratory status	0.922**	0.00021

N=26

A Pearson Correlation

**Correlation at significant 0.01 level (2 tailed)

According to table 4.7, the p-value is 0.0021 which is less than 0.01and means that the hypothesis is accepted . The significant 2-tailed test show correlation at 0.0 level, so the result will be compared to 0.01. As 0.00021 is less than 0.01, this show the correlation between concentration and respiratory impairment status has strong relationship. Moreover, the value of correlation are 0.992 can indicated the significant relationship between the to variables. Same result can be found from study by Hamdy, (2011), Norby et al, (2011) and Carta et al., (1996). The research also found out positive relationship between dust exposure and respiratory disease among workers in various field such as cement production, mill, and miner industry. Figure 4.4 show correlation of inhalable dust concentration with total respiratory status.

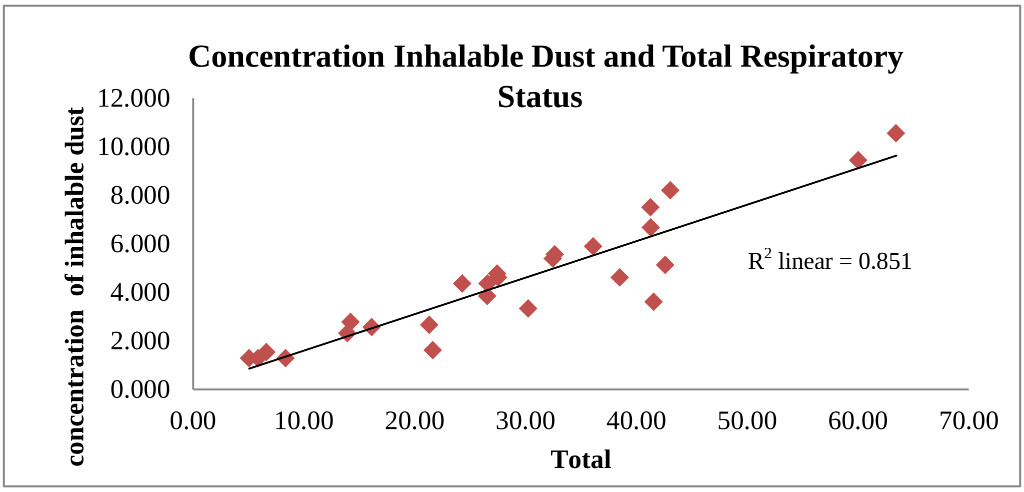

Figure 4.4: Correlation of inhalable dust and total respiratory status

Based on the scattered plot from figure 4.4, the correlation between both variables of concentration of inhalable dust and total respiratory status has significant relationship because most of the value closes the linear line. There are large positive linear association based on the r^2 linear value of 0.851. Therefore, this study can prove that there were correlation between concentration of dust and total respiratory status.

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 INTRODUCTION

This chapter discuses about the conclusion and recommendation from based on the findings from objectives and hypothesis of the study. From the conclusion, appropriate recommendation and suggestion were explained in order to ensure that the respiratory health effect from the exposure of inhalable dust can be reduced.

5.2 CONCLUSION

This study was about the effect of respiratory symptoms from exposure of inhalable dust among construction workers. The mean for concentration of inhalable dust of indoor activities and outdoor activities were within the acceptable limit. All the personal concentration of dust below the limit, however, only the maximum concentration from outdoor activity (operation of backhoe) exceeded the limit. The average concentration of dust for outdoor were higher than indoor.

Further to this, the prevalence of respiratory symptoms was in the range of 30.8% to 92.3% indoor activities while outdoor range falls between 23.1% until 76.9%. For overall, the prevalence of respiratory symptoms among the workers is not too high according to the mean of total score. Strong correlation from both variables can be seen based on the analysis of Pearson Correlation. It can be concluded that when the workers are exposed to high amount of dust concentration, so, the respiratory symptoms among them will increase.

Moreover, the significant correlation found between inhalable dust concentration and respiratory symptoms. It shows that when the workers are exposed to high concentration of dust, the probability to suffer respiratory impairment also increases. Thus, workers are at risk to get respiratory impairment such as asthma and chronic obstructive pulmonary (COPD).

Even though the concentration of dust below the exposure limit, however, workers still experience some of the respiratory symptoms such as coughing, phlegm secretion and shortness of breath. However, the small amount of participant might limit the result for the study.

5.3 RECOMMENDATION

Based on the result from the study, several recommendations can be done in order to ensure better working environment at construction site. The recommendation to reduce the concentration for outdoor activities by using use of respiratory protective equipment (RPE) and control amount of dust for outdoor site. The prevalence of respiratory symptoms can be control by rescheduling work task and exposure of dust must be control to reduce respiratory symptoms.

As the concentration for outdoor activities are high, the use of respiratory protective equipment (RPE) can control the exposure to inhalable dust. RPE can protect the workers against directly inhaling the dust from contaminated air around construction area. Actually, the uses of RPE are the last resort for choices in line of protection. The elimination of dust must be implementing first along the use of RPE. Suitable respiratory protective equipment must be use to avoid ineffective protection. For example, disposal mask only can be use for the workers that deal with exposure in short duration of working hours. Powered RPE are suitable for workers which work in a long hours and must be fit to them accordingly (HSE, 2013). The RPE must follow assign protection factor (APF) of 20 which is suitable for construction site dust exposure. Company must also provide enough RPE for construction site workers and must ensure them to comply with the rule to wear during working hours so that the exposure to inhalable dust can be reduced.

In order to control the risk at construction site, the amount of dust can be reduced and control from the use of tool and heavy vehicles. Appropriate and suitable tools must be use according to the work activities. As an example, use less powerful tool instead of cut off saw which can produce high amount of dust. To reduce dust exposure, right building material can be used such as in tiling activity so that less cutting activity are needed (HSE, 2013). Heavy vehicles can also contribute to the release of inhalable dust. So, limit the movement of heavy vehicles in construction site by only allowing the use for important activities which need the use of it. This can reduce amount of dust at construction site.

Moreover, the prevalence of respiratory symptoms can be control by rescheduling work task for workers with respiratory symptoms. After identifying workers with respiratory symptoms, the management can reschedule working period and task among the workers which was suffering from respiratory symptoms or health impairment. The duration of working time can be reduced to minimize the exposure to inhalable dust. Management can also change the working task for workers with respiratory symptoms to simpler working task that not required high level of exposure at the construction site.

Besides that, from the result found out high correlation between concentration of inhalable dust and respiratory symptom. Therefore, the company management need to control the exposure of dust to reduce the symptoms by using water system and improving the ventilation system (Rodriguez, 2018). The method can be done by using water tanker to spray the water to the construction area which effected by the dust. This method did not have high cost for implementation and can produce good result. Moreover, for indoor construction area, the use of on tool extraction can be implemented to improve the ventilation system. On tool extraction are fitted directly to the construction tool use to minimize the release of dust (Work Safe, 2017). It is one of the types in local exhaust ventilation systems which consist of several parts such as capture hood, tool, and hoses and capture unit.

Actually, this study also cover about lung function impairment by using spirometry test, but since the spirometer no longer can be used, the analysis are only done by using SGRQ questionnaire to find out the symptoms and using personal air sampling pump to identify exposure level. Spirometry test can identify the lung function status (forced expiratory volume in one second (FEV1) and (forced vital capacity (FVC)) among construction workers). As suggestion, further study can include spirometry test to ensure the result can be more reliable and accurate from lung function status data. Although this study are not too complete, because of the problem that occur, but it still can become reference to others for effect of respiratory symptoms from exposure to inhalable dust. To conclude, the recommendation that had been suggest can be implement into construction industry to ensure the risk of inhalable dust at the site can be controlled.

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APPENDIX A

GANTT CHART

Activities	Months											
	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec	Jan
The title and contents of study					FINAL EXAM & SEM BREAK							
Find out the instrument and method												
Find and create questionnaire												
Finalize proposal FYP 1 & presentation												
Identify study location												
Finalize Instrumentation & questionnaire												
Data collection												
Air monitoring & spirometry test												
Interview respondent												
Analysis of data collection												
Finalize FYP 2												
Final presentation & poster presentation												
Final hardcover thesis submission												

APPENDIX B

NIOSH Method 0500

PARTICULATES NOT OTHERWISE REGULATED, TOTAL 0500

DEFINITION: total aerosol mass CAS: NONE RTECS: NONE

METHOD: 0500, Issue 2	**EVALUATION: FULL**	**Issue 1: 15 February 1984** **Issue 2: 15 August 1994**

OSHA: 15 mg/m^3
NIOSH: no REL
ACGIH: 10 mg/m^3, total dust less than 1% quartz

PROPERTIES: contains no asbestos and quartz less than 1%

SYNONYMS: nuisance dusts; particulates not otherwise classified

SAMPLING		MEASUREMENT	
SAMPLER:	FILTER (tared 37-mm, 5-µm PVC filter)	TECHNIQUE:	GRAVIMETRIC (FILTER WEIGHT)
FLOW RATE:	1 to 2 L/min	ANALYTE:	airborne particulate material
VOL-MIN:	7 L @ 15 mg/m^3	BALANCE:	0.001 mg sensitivity; use same balance before and after sample collection
-MAX:	133 L @ 15 mg/m^3		
SHIPMENT:	routine	CALIBRATION:	National Institute of Standards and Technology Class S-1.1 weights or ASTM Class 1 weights
SAMPLE STABILITY:	indefinitely	RANGE:	0.1 to 2 mg per sample
BLANKS:	2 to 10 field blanks per set	ESTIMATED LOD:	0.03 mg per sample
BULK SAMPLE:	none required	PRECISION ($\bar{S}_r$):	0.026 [2]

ACCURACY	
RANGE STUDIED:	8 to 28 mg/m^3
BIAS:	0.01%
OVERALL PRECISION ($\hat{S}_{rT}$):	0.056 [1]
ACCURACY:	±11.04%

APPLICABILITY: The working range is 1 to 20 mg/m^3 for a 100-L air sample. This method is nonspecific and determines the total dust concentration to which a worker is exposed. It may be applied, e.g., to gravimetric determination of fibrous glass [3] in addition to the other ACGIH particulates not otherwise regulated [4].

INTERFERENCES: Organic and volatile particulate matter may be removed by dry ashing [3].

OTHER METHODS: This method is similar to the criteria document method for fibrous glass [3] and Method 5000 for carbon black. This method replaces Method S349 [5]. Impingers and direct-reading instruments may be used to collect total dust samples, but these have limitations for personal sampling.

EQUIPMENT:

1. Sampler: 37-mm PVC, 2- to 5-µm pore size membrane or equivalent hydrophobic filter and supporting pad in 37-mm cassette filter holder.
2. Personal sampling pump, 1 to 2 L/min, with flexible connecting tubing.
3. Microbalance, capable of weighing to 0.001 mg.
4. Static neutralizer: e.g., Po-210; replace nine months after the production date.
5. Forceps (preferably nylon).
6. Environmental chamber or room for balance (e.g., 20 °C ± 1 °C and 50% ± 5% RH).

SPECIAL PRECAUTIONS: None.

PREPARATION OF FILTERS BEFORE SAMPLING:

1. Equilibrate the filters in an environmentally controlled weighing area or chamber for at least 2 h. NOTE: An environmentally controlled chamber is desirable, but not required.
2. Number the backup pads with a ballpoint pen and place them, numbered side down, in filter cassette bottom sections.
3. Weigh the filters in an environmentally controlled area or chamber. Record the filter tare weight, W_1 (mg).
   a. Zero the balance before each weighing.
   b. Handle the filter with forceps. Pass the filter over an antistatic radiation source. Repeat this step if filter does not release easily from the forceps or if filter attracts balance pan. Static electricity can cause erroneous weight readings.
4. Assemble the filter in the filter cassettes and close firmly so that leakage around the filter will not occur. Place a plug in each opening of the filter cassette. Place a cellulose shrink band around the filter cassette, allow to dry and mark with the same number as the backup pad.

SAMPLING:

5. Calibrate each personal sampling pump with a representative sampler in line.
6. Sample at 1 to 2 L/min for a total sample volume of 7 to 133 L. Do not exceed a total filter loading of approximately 2 mg total dust. Take two to four replicate samples for each batch of field samples for quality assurance on the sampling procedure.

SAMPLE PREPARATION:

7. Wipe dust from the external surface of the filter cassette with a moist paper towel to minimize contamination. Discard the paper towel.
8. Remove the top and bottom plugs from the filter cassette. Equilibrate for at least 2 h in the balance room.
9. Remove the cassette band, pry open the cassette, and remove the filter gently to avoid loss of dust.
   NOTE: If the filter adheres to the underside of the cassette top, very gently lift away by using the dull side of a scalpel blade. This must be done carefully or the filter will tear.

CALIBRATION AND QUALITY CONTROL:

10. Zero the microbalance before all weighings. Use the same microbalance for weighing filters before and after sample collection. Maintain and calibrate the balance with National Institute of Standards and Technology Class S-1.1 or ASTM Class 1 weights.
11. The set of replicate samples should be exposed to the same dust environment, either in a laboratory dust chamber [7] or in the field [8]. The quality control samples must be taken with the same

equipment, procedures, and personnel used in the routine field samples. The relative standard deviation calculated from these replicates should be recorded on control charts and action taken when the precision is out of control [7].

MEASUREMENT:

12. Weigh each filter, including field blanks. Record the post-sampling weight, W_2 (mg). Record anything remarkable about a filter (e.g., overload, leakage, wet, torn, etc.)

CALCULATIONS:

13. Calculate the concentration of total particulate, C (mg/m^3), in the air volume sampled, V (L):

$$C = \frac{(W_2 - W_1) - (B_2 - B_1)}{V} \times 10^3, \text{ mg/m}^3,$$

where: W_1 = tare weight of filter before sampling (mg),
W_2 = post-sampling weight of sample-containing filter (mg),
B_1 = mean tare weight of blank filters (mg),
B_2 = mean post-sampling weight of blank filters (mg).

EVALUATION OF METHOD:

Lab testing with blank filters and generated atmospheres of carbon black was done at 8 to 28 mg/m^3 [2,6]. Precision and accuracy data are given on page 0500-1.

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APPENDIX C
QUESTIONNAIRE

Exposure of Inhalable Dust and Respiratory Symptoms among Workers in Construction Industry

PART A: DEMOGRAPHIC DATA
BAHAGIAN A: DATA DEMOGRAFIK

1. Name/Nama: ____________________________

2. Nationality/ Warganegara: ____________________________

3. Gender / Jantina
   - ☐ Male / Lelaki
   - ☐ Female / Perempuan

4. Age / Umur
   - ☐ < 21 years / < 21 tahun
   - ☐ 21-30 years / 21-30 tahun
   - ☐ 31-40 years / 31-40 tahun
   - ☐ 41- 50 years / 41- 50 tahun
   - ☐ >50 years / >50 tahun

5. Weight/ Berat: ____________________________kg

6. Height/ Tinggi: ____________________________cm

7. Type of work in construction/ Jenis kerja di tapak binaan
   ____

8. Years employed/ Tahun bekerja : _____________________

9. Education / Tahap pendidikan
   - ☐ Certificate / Sijil
   - ☐ SPM
   - ☐ Others / Lain- lain

PART B : LIFESTYLE
BAHAGIAN B : GAYA HIDUP

Please tick (√) at your answer.

Sila tandakan (√) bagi setiap jawapan anda.

1. Are you a smoker?
   Adakah anda seorang perokok?

   ☐ Yes / Ya ☐ No / Tidak

   (If YES answer question 3)
   (Jika YA jawab soalan 3)

2. Are you an alcoholic?
   Adakah anda seorang pengambil alcohol?

   ☐ Yes / Ya ☐ No / Tidak

   (If YES answer question 4)
   (Jika YA jawab soalan 4)

3. How many years had been smoking?
   Berapa lama anda telah merokok?

   ☐ < 1 years / < 1 tahun ☐ 2 years / 2 tahun ☐ 3 years / 3tahun
   ☐ 4 years / 4 tahun ☐ 5 years / 5 tahun ☐ > 5 years / > 5 tahun

4. How many times did you take alcohol in a week?
   Berapa kali anda mengambil alcohol dalam seminggu?

   ☐ Once / Sekali ☐ Twice / 2 kali ☐ 3 times / 3 kali
   ☐ 4 times / 4 kali ☐ > 4 times / > 4 kali

ST. GEORGE'S RESPIRATORY QUESTIONNAIRE
ORIGINAL ENGLISH VERSION

ST. GEORGE'S RESPIRATORY QUESTIONNAIRE (SGRQ)

This questionnaire is designed to help us learn much more about how your breathing is troubling you and how it affects your life. We are using it to find out which aspects of your illness cause you most problems, rather than what the doctors and nurses think your problems are.

Please read the instructions carefully and ask if you do not understand anything. Do not spend too long deciding about your answers.

Before completing the rest of the questionnaire:

	Very good	Good	Fair	Poor	Very poor
Please tick in one box to show how you describe your current health:	☐	☐	☐	☐	☐

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continued…

St. George's Respiratory Questionnaire
PART 1

Questions about how much chest trouble you have had over the past 3 months.

Please tick (✓) *one box for each question*:

		most days a week	several days a week	a few days a month	only with chest infections	not at all
1.	Over the past 3 months, I have coughed:	☐	☐	☐	☐	☐
2.	Over the past 3 months, I have brought up phlegm (sputum):	☐	☐	☐	☐	☐
3.	Over the past 3 months, I have had shortness of breath:	☐	☐	☐	☐	☐
4.	Over the past 3 months, I have had attacks of wheezing:	☐	☐	☐	☐	☐

5. During the past 3 months how many severe or very unpleasant attacks of chest trouble have you had?

Please tick (✓) *one*:

more than 3 attacks ☐
3 attacks ☐
2 attacks ☐
1 attack ☐
no attacks ☐

6. How long did the worst attack of chest trouble last?
(Go to question 7 if you had no severe attacks)

Please tick (✓) *one*:

a week or more ☐
3 or more days ☐
1 or 2 days ☐
less than a day ☐

7. Over the past 3 months, in an average week, how many good days (with little chest trouble) have you had?

Please tick (✓) *one*:

No good days ☐
1 or 2 good days ☐
3 or 4 good days ☐
nearly every day is good ☐
every day is good ☐

8. If you have a wheeze, is it worse in the morning?

Please tick (✓) *one:*

No ☐
Yes ☐

continued…

St. George's Respiratory Questionnaire
PART 2

Section 1

How would you describe your chest condition?

Please tick (✓) *one*:

The most important problem I have	☐
Causes me quite a lot of problems	☐
Causes me a few problems	☐
Causes no problem	☐

If you have ever had paid employment.

Please tick (✓) *one*:

My chest trouble made me stop work altogether	☐
My chest trouble interferes with my work or made me change my work	☐
My chest trouble does not affect my work	☐

Section 2

Questions about what activities usually make you feel breathless these days.

Please tick (✓) in ***each box*** that applies to you ***these days***:

	True	False
Sitting or lying still	☐	☐
Getting washed or dressed	☐	☐
Walking around the home	☐	☐
Walking outside on the level	☐	☐
Walking up a flight of stairs	☐	☐
Walking up hills	☐	☐
Playing sports or games	☐	☐

continued…

St. George's Respiratory Questionnaire
PART 2

Section 3

Some more questions about your cough and breathlessness <u>these days</u>.

Please tick (✓) in ***each box*** that applies to you ***these days***:

	True	False
My cough hurts	☐	☐
My cough makes me tired	☐	☐
I am breathless when I talk	☐	☐
I am breathless when I bend over	☐	☐
My cough or breathing disturbs my sleep	☐	☐
I get exhausted easily	☐	☐

Section 4

Questions about other effects that your chest trouble may have on you <u>these days</u>.

Please tick (✓) in ***each box*** that applies to you ***these days***:

	True	False
My cough or breathing is embarrassing in public	☐	☐
My chest trouble is a nuisance to my family, friends or neighbours	☐	☐
I get afraid or panic when I cannot get my breath	☐	☐
I feel that I am not in control of my chest problem	☐	☐
I do not expect my chest to get any better	☐	☐
I have become frail or an invalid because of my chest	☐	☐
Exercise is not safe for me	☐	☐
Everything seems too much of an effort	☐	☐

Section 5

Questions about your medication, if you are receiving no medication go straight to section 6.

Please tick (✓) in ***each box*** that applies to you ***these days***:

	True	False
My medication does not help me very much	☐	☐
I get embarrassed using my medication in public	☐	☐
I have unpleasant side effects from my medication	☐	☐
My medication interferes with my life a lot	☐	☐

continued…

St. George's Respiratory Questionnaire
PART 2

Section 6

These are questions about how your activities might be affected by your breathing.

Please tick (✓) in ***each box*** that applies to you ***because of your breathing***:

	True	False
I take a long time to get washed or dressed	☐	☐
I cannot take a bath or shower, or I take a long time	☐	☐
I walk slower than other people, or I stop for rests	☐	☐
Jobs such as housework take a long time, or I have to stop for rests	☐	☐
If I walk up one flight of stairs, I have to go slowly or stop	☐	☐
If I hurry or walk fast, I have to stop or slow down	☐	☐
My breathing makes it difficult to do things such as walk up hills, carrying things up stairs, light gardening such as weeding, dance, play bowls or play golf	☐	☐
My breathing makes it difficult to do things such as carry heavy loads, dig the garden or shovel snow, jog or walk at 5 miles per hour, play tennis or swim	☐	☐
My breathing makes it difficult to do things such as very heavy manual work, run, cycle, swim fast or play competitive sports	☐	☐

Section 7

We would like to know how your chest usually affects your daily life.

Please tick (✓) in ***each box*** that applies to you ***because of your chest trouble***:

	True	False
I cannot play sports or games	☐	☐
I cannot go out for entertainment or recreation	☐	☐
I cannot go out of the house to do the shopping	☐	☐
I cannot do housework	☐	☐
I cannot move far from my bed or chair	☐	☐

continued…

St. George's Respiratory Questionnaire

Here is a list of other activities that your chest trouble may prevent you doing. (You do not have to tick these, they are just to remind you of ways in which your breathlessness may affect you):

Going for walks or walking the dog

Doing things at home or in the garden

Sexual intercourse

Going out to church, pub, club or place of entertainment

Going out in bad weather or into smoky rooms

Visiting family or friends or playing with children

Please write in any other important activities that your chest trouble may stop you doing:

....

....

....

....

Now would you tick in the box (one only) which you think best describes how your chest affects you:

It does not stop me doing anything I would like to do ☐

It stops me doing one or two things I would like to do ☐

It stops me doing most of the things I would like to do ☐

It stops me doing everything I would like to do ☐

Thank you for filling in this questionnaire. Before you finish would you please check to see that you have answered all the questions.

APPENDIX D

PERMISSION LETTER

Universiti Malaysia PAHANG
Engineering • Technology • Creativity

Universiti Malaysia Pahang
Lebuhraya Tun Razak, 26300 Gambang
Kuantan, Pahang Darul Makmur
Tel: +609-549 2688 | Faks/Fax: +609-549 2689
Website : http://ftek.ump.edu.my

Fakulti Teknologi Kejuruteraan
Faculty of Engineering Technology

Ruj. Kami : UMP.31.02/13.16/1 Jilid 13 (73)
Tarikh : 20 September 2018

EN. MOHD AFFANDY BIN YAHYA
Sentoria Bina Sdn. Bhd.
No B3 Tingkat 1, Jalan Gambang Damai,
Taman Gambang Damai,
26300 Gambang,
Pahang Darul Makmur.

Tuan,

PERMOHONAN MENGADAKAN LAWATAN BAGI MENYIAPKAN TUGASAN KERJA KURSUS PELAJAR

Dengan segala hormatnya perkara di atas adalah dirujuk.

2. Adalah disahkan bahawa penama berikut merupakan pelajar Tahun 4 di Fakulti Teknologi Kejuruteraan Universiti Malaysia Pahang. Pelajar ini dikehendaki menyiapkan tugasan kerja kursus ***Final Year Project 2*** **(BPS4514)** di organisasi luar yang merupakan salah satu keperluan dalam aktiviti pembelajaran bagi kursus tersebut. Maklumat pelajar adalah seperti berikut:

Nama Pelajar	**: Wan Hafizah binti Wan Mohammad Roslan (PA15029)**
Program	**: Program Ijazah Sarjana Muda Keselamatan dan Kesihatan Pekerjaan Dengan Kepujian**

3. Pelajar ini diminta untuk mengadakan lawatan ke organisasi tuan pada tarikh **24 September 2018** tertakluk kepada persetujuan selanjutnya daripada pihak tuan/puan bagi tujuan di atas.

4. Sehubungan dengan itu, jasabaik pihak tuan/puan dipohon agar dapat mempertimbangkan permohonan daripada pelajar berkenaan. Sekiranya pihak tuan memerlukan maklumat lebih lanjut, sila hubungi Dr. Norazura binti Ismail (Pensyarah) di talian 09-5492289 atau emel zuraismail@ump.edu.my.

Kerjasama tuan/puan dalam perkara ini sangatlah dihargai.

Sekian, terima kasih.

"BERKHIDMAT UNTUK NEGARA"
"Memasyarakatkan Teknologi"

Saya yang menurut perintah,

ABD RAZAK BIN JA'AFAR
Eksekutif Kanan

NDFD/Akademik/AktivitiPelajar

APPENDIX E
FEEDBACK LETTER

Universiti Malaysia PAHANG

Tarikh : 24 / 9 / 18

Fakulti Teknologi Kejuruteraan
Universiti Malaysia Pahang
Lebuhraya Tun Razak
26300 Gambang, Kuantan
Pahang Darul Makmur
No. Telefon : 09-549 2385
No Fax : 09-549 2689
Emel : adminakademikftek@ump.edu.my

Tuan / Puan,

MAKLUM BALAS SETUJU TERIMA LAWATAN

Dengan hormatnya perkara di atas adalah dirujuk.

Pihak kami **SETUJU** / ~~TIDAK SETUJU~~ menerima lawatan daripada pelajar Program Ijazah Sarjana Muda Keselamatan dan Kesihatan Pekerjaan Dengan Kepujian di Fakulti Teknologi Kejuruteraan Universiti Malaysia Pahang

Sekian terima kasih.

Tandatangan
MOHD AFFANDY BIN YAHAYA
SITE SAFETY SUPERVISOR

Nama :

No Tel :

Cop Syarikat/Agensi :