A HIRARC MODEL FOR SAFETY AND RISK EVALUATION AT CONSTRUCTION SITE OF MANMADE WATER STREAMS AND WETLANDS

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RESEARCH PROJECT SUBMITTED IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF SAFETY HEALTH ANDENVIRONMENT ENGINEERING

FACULTY OF ENGINEERING
UNIVERSITY OF MALAYA
KUALA LUMPUR

2021

UNIVERSITY OF MALAYA

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Matric No: KQD190022/17149462

Name of Degree: Master of Safety, Health and Environment Engineering

Title of Project Paper/Research Report/Dissertation/Thesis ("this Work"):

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[A HIRARC MODEL FOR SAFETY AND RISK EVALUATION AT CONSTRUCTION SITE OF MANMADE WATER STREAMS AND WETLANDS]

ABSTRACT

Safety at construction sites play an important role in order to protect workers from unwanted incidents which can deteriorate the company financially and its credibility. Hazards are everywhere and one should adhere to the safety regulations all the time while at workplace. This is because workers need to deal with many risky activities before and during the construction of manmade streams and wetlands, thus safety of the workers are at high risk. However, the adherence level is less impressive since few accidents are still happening during construction activities such as site clearance and excavation. Without proper supervision and enforcement, the chances of future problems will be greatly increase and this can even cause some unwanted major injuries and even death.

In order to implement proper safety guidelines, all the hazards associated with the construction activities need to be identified. All these hazards need to be classified then according to the risk severity matrix. However, most of the employers are not giving much attention to these safety guidelines as they are lack in awareness and knowledge as their employees are in danger at the construction site. Risk severity matrix is useful to decide on the level of control measures based on hierarchy of control. Thus, HIRARC model is a compulsory part to be constructed before the construction activities to protect the employees from dangers.

Keywords : Safety, Risk, Wetland, HIRARC

[MODEL HIRARC UNTUK PENILAIAN KESELAMATAN DAN RISIKO DI LAMAN PEMBINAAN JALAN AIR DAN TANAH LEMBAP BUATAN MANUSIA]

ABSTRAK

Keselamatan di tapak pembinaan memainkan peranan penting untuk melindungi pekerja tapak pembinaan dari insiden yang tidak diingini yang boleh merosakkan syarikat dari segi kewangan dan kredibilitinya. Bahaya ada di mana-mana dan seseorang harus mematuhi peraturan keselamatan sepanjang masa semasa di tempat kerja. Ini kerana pekerja perlu menghadapi banyak aktiviti berisiko sebelum dan semasa pembinaan sungai buatan dan tanah lembap, oleh itu keselamatan pekerja berisiko tinggi. Walau bagaimanapun, tahap kepatuhan kurang memberangsangkan kerana beberapa kemalangan masih berlaku semasa aktiviti pembinaan seperti pembersihan tapak dan penggalian. Tanpa pengawasan dan penguatkuasaan yang tepat, kemungkinan masalah di masa depan akan meningkat dan ini boleh menyebabkan beberapa kecederaan besar yang tidak diingini dan bahkan kematian.

Untuk melaksanakan garis panduan keselamatan yang betul, semua bahaya yang berkaitan dengan aktiviti pembinaan perlu dikenal pasti. Semua bahaya ini perlu dikelaskan mengikut matriks keterukan risiko. Walau bagaimanapun, kebanyakan majikan tidak terlalu memperhatikan garis panduan keselamatan ini kerana mereka kurang mendapat kesedaran dan pengetahuan kerana pekerja mereka berada dalam bahaya di tapak pembinaan. Matriks keparahan risiko berguna untuk menentukan tahap langkah kawalan berdasarkan hierarki kawalan. Oleh itu, model HIRARC adalah bahagian wajib yang harus dibina sebelum aktiviti pembinaan untuk melindungi pekerja daripada bahaya.

Kata Kunci : Keselamatan, Risiko, Tanah Lembap, HIRARC

ACKNOWLEDGEMENT

All thanks to my supervisor Dr. Fathiah Binti Mohamed Zuki to assist me throughout the research project. It wouldn't be real without her encouragements and support to produce this informative project and most importantly on the explanation of in campus manmade water streams and wetland construction at University Malaya, Kuala Lumpur. I'm thankful to my family and friends for giving me endless support motivation for completing this project despite limitations such as Covid 19 pandemic restrictions and University closure during Total Lockdown. Thank you for all those 20 workers who gave me full support during interview process via teleconference and Questionnaire analysis via Google Forms.

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LIST OF SYMBOLS AND ABBREVIATIONS

PPE	Personal Protective Equipment
HIRARC	Hazard Identification, Risk Assessment & Risk Control
LCA	Life Cycle Assessment
TBM	Tool Box Meeting
BOD	Biochemical Oxygen Demand
COD	Chemical Oxygen Demand
OSHA	Occupational Safety and Health Act

CHAPTER 1
INTRODUCTION

1.1 Background of Study

A wetland is a distinct biological system that is overwhelmed by water, either for all time or occasionally, where without oxygen measures win. Wetlands give regular water quality improvement, flood security, shoreline disintegration control, openings for entertainment and tasteful appreciation and characteristic items.

Water stream is a fundamental regular element for the development of plants, creatures, and it's anything but a part in agricultural activities. All in all, agribusiness requires the safeguarding of soil water sources just as the flow of water through landscapes. Basically, wetlands are the progress between dry land and water (streams, waterways, lakes, and coastlines), wetlands take numerous structures including the recognizable bogs, marshes and lowlands. There are numerous ordinary methods for the orderly investigation of word related security and wellbeing as a rule, and danger examination specifically, for exercises did at a building site of artificial wetlands and streams. This venture was begun to make a HIRARC model for the assessment of ecological wellbeing and wellbeing at any building site of wetlands and streams.

The HIRARC model was applied to recognize the principle and optional perils which might be innate in the association which were directed as a genuine danger for the progression of exercises all through the stage. The fundamental apparatuses of the model comprised of, conventional agenda, workplace assessment plans which included assignment perception and meeting, wellbeing examination just as mishap and episode

examination. For hazard appraisal, the Liker scale was supplemented by the seriousness grid investigation to choose the likelihood and degree of security and wellbeing at the examination power age works. These were utilized to distinguish and prescribe control estimates which hold fast to Hierarchy of Control like designing and managerial perspectives just as the utilization of Personal Protective Equipment (PPE).

Hazard Identification is a stage where all the undesirable conditions have been identified which leads to life and environmental threats. The employers can easily track the hazards before the construction activities by organizing suitable skill enhancement programs to avoid the accidents. In Malaysia, the number of accidents occurred on construction sites is considered high in comparison to other industries. A comparison is made on the safety performance between construction projects which implemented HIRARC and construction projects which did not implement HIRARC. The findings show that construction project with HIRARC is actually more effective in reducing accidents on construction sites. In conclusion, the implementation of HIRARC is indeed effective in reducing accidents on construction sites. (Ahmadon Bakri et.al, 2008)

Pre Development Stage

The answers to these questions define:

- the purpose for the wetland/streams
- whether it requires a resource consent
- whether the proposed wetland/streams will be of high water quality and what measures are required during construction achieve the highest water quality
- whether it will adversely impact the downstream environment
- whether it poses a risk to the public and what level of risk.

Activities during Stream and Wetland Construction

- Site Preparation Work
- Excavation Works
- Piling Works Activities
- Structural Steel Work
- Architectural Work Activities
- Mechanical and Electrical Activities

1.2 Study Area

This study carried out at the University of Malaya , Kuala Lumpur (Figure 1.1). The location of the site is known as Tasik Varsiti Universiti Malaya. Geographically, this wetland and stream is located at 3.1209° N, 101.6538° E. The total area of the land is approximately 0.9 hectares (65m x 50m).

Figure 1.1 : The location of manmade wetland and streams

Figure 1.2 : Real image of the study area (University of Malaya, KL)

1.3 Scope of study

The study location of this research project is located at University of Malaya, Kuala Lumpur. The project is mainly about the study on the activities carried out during the construction phase and form a HIRARC model to reduce the occurrence of unwanted incidents and accidents. This study will apply Life Cycle Assessment and Ergonomic assessments to determine the potential effects in terms of individual and environmental factors. This can identify the potential sources of carbon emissions and alternatives can be suggested to reduce the emission for betterment.

The landscape design and elements should be handled carefully without destroying the existing feature and tress in the study area. The plan needs to include the pre-construction site investigation, landscape site plan drawing and the landscape element that could be included. This includes other construction activities such as bridge installation in the future once done with construction of wetland and streams. This is to ensure the view and

the properties of the wetland and streams are well maintained without any external disturbances such as erosions.

1.4 Problem Statement:

Constructed water streams and wetlands are used to treat wastewater before release it to the drain or river. Safety measurements is mandatory as hazards exist during construction works. One of the tool to identify hazards are from the past records on medium and high risk hazards imposed to both environment and workers during construction of manmade wetlands/streams. This can provide a list of incidents and lessons learned and preventive measures that could prevent a reoccurrence. For instance, one should always check the excavation before and after the work done to ensure the stability. Accidents might happen if management fail to provide information, training, instruction or supervision necessary to protect all persons from risks to their health and safety from work. Environmental impacts during the construction activities such as water, air and soil pollution is the most common phenomenon occur during construction activities. Even though the construction activities are shorter, the impact to the environment is much significant. Waste production, mud, dust, water and soil contamination occur during this construction activities. This could lead to damage to public drainage system, destruction of plants and visual damage on nature and noise pollution. Lacking in control measures available for safe work management system during construction activities including safety and health is also one of the common problem during construction activities. Safety aspects such as excavation and filtration site construction should be monitored carefully by imposing entry and exit points, safe work method system, PPE and First Aid materials. Lacking in standard operating procedures during construction activities of manmade streams and wetlands.

1.5 Objectives:

- To identify, assess and control the hazards associated with Pre- Development stage and Activities carried out during the construction of manmade wetlands/streams.
- To demonstrate the water sources which are directed to the constructed water streams and wetlands.
- To assess existing control measures and provide recommendations for improvement for both workers and environment in future construction activities by using models such as Ergonomic Assessments and Life Cycle Assessment (SimaPro).
- To develop additional enhanced standard procedures for development of manmade streams and wetlands.

1.6 Significant of Study

The ultimate goal of a business is to make the highest possible profit. This should be done with the help of smooth flow during the construction activities without any external disturbances. One accident can cause a big loss to the company due to the damage of the property, injury or even fatality and loss of business opportunities in future. (Hale et al, 2012). This project is mainly focussed on the removal of pathogens from the water source before released it into the river. The polluted water can disrupt the environment and aquatic life thus standard filtration is required. This study also aims to develop enhanced standard operational procedures during this construction period for better construction environment for both employer and employee.

CHAPTER 2
LITERATURE REVIEW

2.1 Introduction

Constructed wetland is a local area treatment office with shallow swamp frameworks planted with developing vegetation (Macrophytes) that is intended to treat stormwater overflow. The expression "wetlands" envelops an expansive scope of wet conditions, including bogs, marshes, swamps, wet knolls, flowing wetlands, floodplains, and strip (riparian) wetlands along stream channels. Developed wetlands can likewise alleviate top rates and even decrease spill over volume to a certain degree without usage of fossil fuels. They additionally can give extensive stylish and untamed life benefits. Constructed wetland region gives some volume of constriction of little tempest streams. When all is said in done, wetlands should not be utilized for outrageous flood lessening because of the expected harm to wetland plants.

Developed wetlands are man-made frameworks or designed wetlands that are planned, assembled, and worked to copy elements of common wetlands. They are made from a non-wetland biological system or a previous earthly climate, predominantly with the end goal of poison expulsion from wastewater (Cheng H.S., et.al, 2008). The framework ordinarily comprises of shallow, broadly vegetated water bodies that utilization to improve sedimentation, fine filtration and organic take-up cycles to eliminate poisons from stormwater. Water levels ascend during precipitation occasions and outlets are designed to gradually deliver streams. As well as treating stormwater, developed wetlands can likewise give living space, uninvolved amusement, improved scene convenience and brief stockpiling.

Wetland are naturally formed when water meets land. Wetlands exist in every country which play important roles in water purification, water storage, processing of carbon and

other nutrients, stabilization of shorelines, and support of plants and animals. A wetland is "an environment that emerges when immersion by water produces soils overwhelmed by anaerobic and aerobic cycles, which, thusly, powers the biota, especially established plants, to adjust to flooding. Plants (helophytes) were brought from a nearby natural locality. For example, plants such as Carex gracillis and Phragmites australis ((3-4 plants m^2) are the most common to be planted at the constructed wetlands. After planting the beds were flooded with water for 14 days. (Vlastka Kukanja et.al, 1996)

2.1.1 Wetland as Water Storage

Wetlands provide range of benefits in the storage of water. During rain storms, the amount of water running over the surface increases and flash flood occurs due to lacking in water storage areas especially at urban areas. Numerous wetlands, especially floodplain wetlands, have the ability to briefly store rising waters during high overflow events. Despite the fact that wetlands have regularly alluded as a natural sponge that absorbs water, they really work more like common tubs, putting away either rising waters that flood riverbanks or surface water. As rising waters retreat, the water is delivered gradually from the wetland soils. By keeping down a portion of the rising waters and easing back the rate that water reenters the stream channel, wetlands can lessen the seriousness of downstream flooding and erosion. Wetlands that provide protection as in terms of temporary storage of stormwater can reduce the damage to public properties, attenuates the risk to public, reduces erosion and maintain a balanced ecosystem for aquatic organisms.

2.1.2 Constructed Wetland for Wastewater Treatment

Constructed wetlands give a scope of benefits in the treatment of wastewater. Wetland usage generates economic investment funds, as it relies on common treatment routes which cost less as far as power and human work and have lower development and maintenance costs, including chemicals, fuel, administrations and plant activity. Moreover, they offer flexible site determination, simple activity and fundamental tenance, an untamed life territory just as high steadiness under changing natural conditions. Constructed wetlands are typically large passive systems with long residence times. Conversely, conventional wastewater treatment plants rely on energy-intensive operation with short residence times. Steel-and-concrete treatment systems have the disadvantage of excess sludge production, high energy demand, and high cost for operation and maintenance. Also, the purified water produced in constructed wetlands is suitable for reuse. (Chang et.al, 2009)

Activity of the CW framework built for waste water treatment from the food preparing industry exhibits that a CW can proficiently diminish high wastewater COD and BOD. Results from 1992 to 1994 demonstrate that purification improves with development. Following quite a while a continuous efficiency of over 90% can be expected concerning BODs, COD and orthophosphate and somewhere in the range of 80% and 90% as to ammonium and nitrate. Disregarding high filtration proficiency, effluent values intermittently don't come to the endorsed principles when using pressurized water over-burden, subsequently, the productivity should be improved by expanding the CW surface region.(Dani VrHovsek et.al, 1996) The advantages of constructed wetland compared with conventional water treatment plants are their appearance, relatively inexpensive construction, simple maintenance and less dissipation of energy which can bring up to high operational cost to the company.

2.1.3 Constructed Wetlands as Bioreactor

Constructed wetland is considered as a bioreactor. A number of physical, compound, and organic cycles with microbial networks, new plants, soil, and sediments accumulated in the lower layer happen in the frameworks. Nitrogen fixation is regularly of concern as a result of its potential to cause negative impacts in accepting water systems. Among different nitrogen gatherings, broken down inorganic nitrogen species like nitrate (NO_3^-), nitrite (NO_2^-), and ammonia (NH3) or ammonium (NH_4^+) – as opposed to particulate nitrogen – greatly affect aquatic systems, on the grounds that they are effectively accessible for take-up by miniature organic entities. Numerous researches have shown the effect of excessive nitrogen stacks on accepting waters. The removal of natural substances, ordinarily 80–90%, is currently palatable in constructed wetlands on account of progressive improvement over two decades. (Guangzhi Sun et.al, 2009). Since nitrogen-rich releases into accepting water frameworks are responsible for an assortment of natural issues, optimizing nitrogen evacuation is a basic goal. Up until now, activated sludge and biofilm measures have been the fundamental concentration for biological nitrogen expulsion. Be that as it may, these cycles are expensive, particularly when utilized in medium and little communities. Constructed wetlands have demonstrated potential for nitrogen removal, however nitrogen expulsion efficiency has been inconsistent, due to inadequate observation of nitrogen change and removal mechanisms. There are still many unknown parts related to developed wetlands execution, various driving operations, and nitrogen limitations.

2.1.4 Role of Plants at Constructed wetland

The community of aquatic plants can be separated into three sorts by their life type: coasting plant local area, submersed-plant local area, and stick-plant local area. In the new many years, countless examinations on constructed wetlands for treating contaminated waters have created information on toxin decreases, and the impact of sea-going plants for nitrogen and phosphorus evacuation effectiveness in built wetlands. Yet, there is as yet an absence of information concerning the system of wetland plants work. Since information on the strategies for investigating the system of wetland plants work is scarce. Summing up numerous examinations for developed wetlands, wetland plants assumes numerous significant parts in constructed wetlands. The most two significant capacities include: 1) up taking the supplements, ingest and gather heavy metal and harmful substances from wastewater, however the receptiveness and functionary method of eliminating supplements and toxic substances by wetland plants are extraordinary. 2) moving oxygen to rhizophere for the development, multiplication and deteriorations of microorganisms, and assuming significant parts in the Simultaneous nitrification and denitrification. Dissolved Oxygen (DO) is a key factor influencing the concurrent nitrification and denitrification measure and higher DO in the wetland framework can improve the synchronous nitrification and denitrification. As per some micro environmental examines in regards to plant, oxygen discharge in a wastewater climate are critical to comprehend the standards of developed wetlands for wastewater treatment. Numerous investigations insighted into root-instigated microenvironments and would be useful for the measurement of the sum of oxygen contributed by plants in built wetlands. Wetland plants planted in the built wetlands should be those with high resilience against contamination, great disinfecting productivity, created root framework, and those has monetary worth. However, it should be focus on that the wetland plants should be harvested on schedule in the event that the arrival of natural and inorganic nitrogen from

the senesced wetland plants local area. Since gathering of wetland plants and impediments of oceanic plants inclusion improved wetland nitrogen evacuation and reaping of wetland plants diminished inside stacking of N and P. (Zhang, H. G. and J. M. Hong (2006). The type of plants frequently used during wetland constructions and its functions are stated below. (Mohd Shafiq Asnawi Md. Akhir et al. 2016)

Plants	Function	Reference
Neptuniaoleracea (Water mimosa)	Helps to reduce total nitrogen & total phosphorus. Absorb organic compound and suspended solids.	Suppadit et al. (2005)
Eichorniacrassipes (Water hyacinth)	Helps to reduce suspended solid, heavy metals, BOD level, nitrogen, phosphorus and pathogen.	Jayaweera et al. (2008) Nesir (2010)
Thaliageniculata (Arrowroot)	Helps to absorb metals like ferum, copper, plumbum and zinc.	Korsah (2011)
Chrysopogonzizanioides (Vetiver)	Helps to absorb nutrients like nitrogen and phosphorus.	Zheng et al. (1997) Wagner et al. (2003)
Ipomoea aquatica (Water spinach)	Helps to absorb nutrients. Prevent algal growth.	Li & Li (2009)
	Helps to reduce BOD and COD level.	Said et al. (1997)
Nymphaeacaerulea (Water lily)	Helps to reduce pH, BOD and COD level.	Muda (2010)

Table 2.1 : Type of plants used in constructed wetland and their function

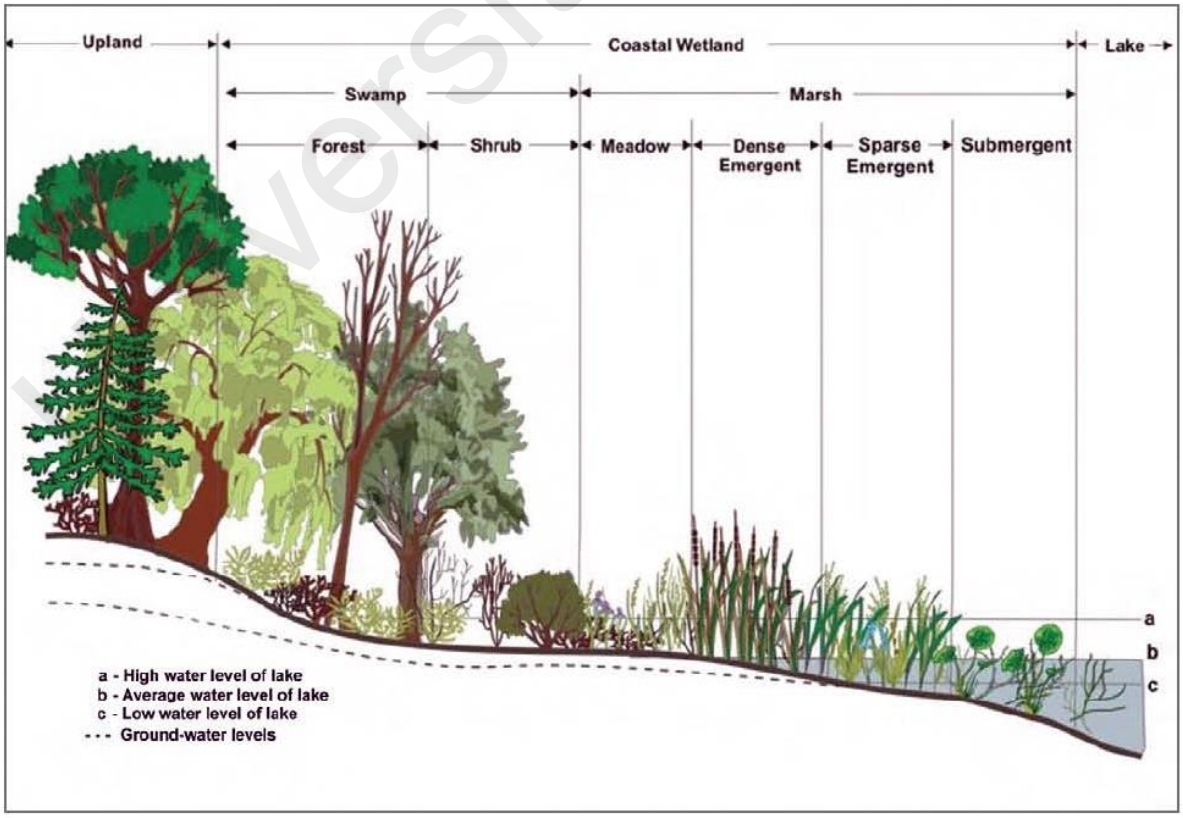


Figure 2.1: Wetland system with type of plants (based on the water level)

Figure 2.2 : Cyperus papyrus (Picture from Manmade Wetland in UM)

Figure 2.3 : Typha latifolia (Picture from Manmade Wetland in UM)

Figure 2.4 : Phragmites australi

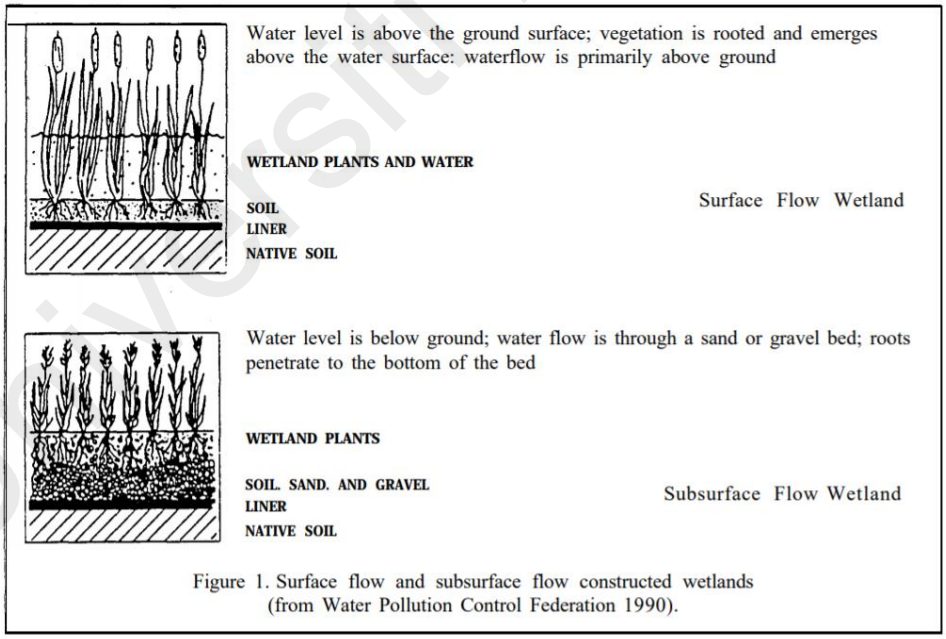
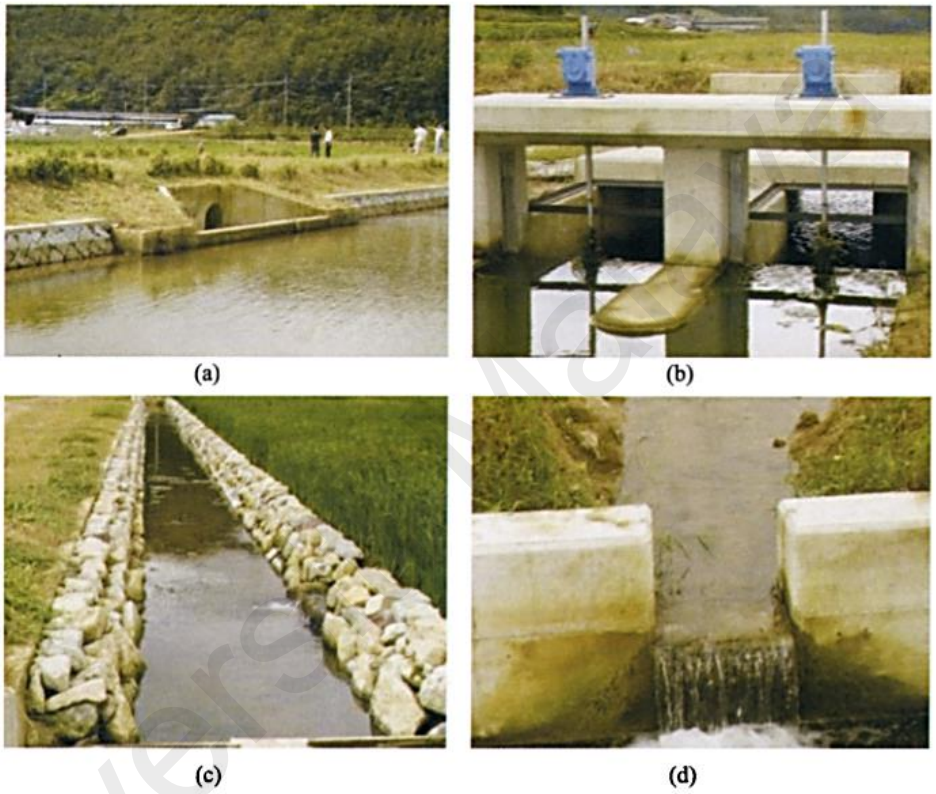


Figure 1. Surface flow and subsurface flow constructed wetlands (from Water Pollution Control Federation 1990).

Figure 2.5 : Type of Constructed Wetlands

2.2 Structure of the Constructed Wetland

Toward the start of wetland development, the building materials comprised principally of soil. The banks of wetlands, channels, bays and outlets were made of soil works. These spots are inclined to fall due to weighty precipitation. As of late, soil works are being supplanted by solid and strong materials, for example, rock gabion, stall and cement.



(Kim Youngchul et al., 2006)

Figure 2.6 : Pictures showing some practical examples (a) Side bank reinforced with stonewall; (b) Outlet structure built with concrete and steel gate; (c) Naturally looking rock channel;(d) Inlet structure with concrete weir.

2.3 HIRARC Model

HIRARC model should be implemented by every workplace regardless of small or medium industries as this will make sure of the identification and assessment of physical hazards. Department of Occupational Safety and Health has released these guidelines in

2008 and became the foundation to plan, manage and operate the activities at their workplace. (Department of Occupational Safety and Health, 2008)

Thus, construction activities during manmade streams and wetlands should be done with aid of HIRARC model to identify, analyse and control the hazards based on the severity index. This can help for betterment in work culture as they understand the need of being adhered to the regulations during activities and work conditions. (Asmalia et al.,2016) The risk is defined as the product of the likelihood and the severity of the event. The evaluation of hazard probability is frequently founded on the laborers' encounters, investigation or estimation though the seriousness appraisal depends on the level of effect on individual including both employee and employer wellbeing, climate or property.

Current practices related to hazard identification generally depend upon manual reviews performed by a security supervisor. Frequently, such reviews make restricted progress because of the unique idea of development workplaces, the irregularity of an assigned individuals' inspection method, and the restricted accessibility of the individual who should physically investigate huge regions. Under these conditions, numerous hazards stay unidentified and present high dangers to the workers in building destinations. As this is being a serious issue at construction sites, we need to come out with some innovations on creating novel approaches to hazard identification that can address the current challenges of manual inspection. (Kanghyeok Yang et al., 2019)

In the field of OSH, Malaysia is presently moving away from the conventional methodology that accepts all occupational risks can be successfully controlled through regulations. On 25th February 1994, Occupational Safety and Health Act 1994 (OSHA) came into power to give insurance on the security and well-being for work exercises in all economic fields HIRARC is necessary as Under Section 15 (1) and (2) of OSHA 1994,

managers have a duty to guarantee, the extent that practicable, that representatives are not presented to any danger at the working environment. (Salim Mkubwa Salim et al., 2017)

As third world country, upgrades to its laborers' security and wellbeing issues should go connected at the hip with Malaysia economy booming. With the expanded number of businesses, Malaysia is currently confronting more prominent difficulties to successfully screen the authorization of the OSH necessities. Among the Southeast Asian nations, Malaysia is positioned third for the least accident rate (14000 cases) and casualty rate. Construction site contributes to most number of accidents. In light of the report by Social Security Organization (SOCSO) in 2000, the casualty rate for construction industry in Malaysia is more than three times than other workplaces. Related to this, remuneration paid out by SOCSO for mechanical mishaps and illnesses represented nearly RM650 million. (Social Security Organisation, "Annual Report for 2009" (2010).

2.4 Risk Assessment

Risk assessment is the framework to identify the hazards, analyse those risk associated with the hazards and determine suitable control measures to eliminate or control the hazards. There are qualitative and quantitative value of risk related that can be determined to identify those hazards.

Qualitative analysis is focussing on the determination of the severity level. Data obtained then will be recorded in the risk severity matrix. It measures both the likelihood of a specific risk event occurring during the project life cycle and the impact it will have on the overall activities. Quantitative analysis focusses on the verifiable data such as costs, resource consumption and schedule delays. This method is more to numerical values to assess risks.

Likelihood / Severity	1 Very Unlikely	2 Unlikely	3 Likely	4 Very likely
First Aid (1)	L	L	M	M
Minor Injury (2)	L	M	M	H
Major Injury (3)	M	M	H	H
Fatality (4)	M	H	H	H

*Note: L = Low, M = Medium, H = High

Figure 2.7 : Flowchart of HIRARC Process

Assessing Likelihood	Rating
Highly Unlikely, Probably Never Will, Yearly	1
Unlikely, Rarely, 6 months	2
Likely, Occasionally, Monthly	3
Very Likely, Frequently, Daily	4

Table 4: Severity rating

Severity (Injury/Accident/Illness)	Description	Rating
First Aid Injury/Illness	Minor injury or illness requiring first aid only, no loss of work time.	1
Minor Injury/Minor Illness/No Lost Time Injury	Moderate injury or illness requiring casualty treatment	2
Major Injury/Major Illness/ Permanent Disability/Lost Time Injury	Serious bodily injury or serious work caused illness	3
Fatality	Death	4

Table 2.2 : Risk Severity Rating

		Consequence				
		Negligible 1	Minor 2	Moderate 3	Major 4	Catastrophic 5
Likelihood	5 Almost certain	Moderate 5	High 10	Extreme 15	Extreme 20	Extreme 25
	4 Likely	Moderate 4	High 8	High 12	Extreme 16	Extreme 20
	3 Possible	Low 3	Moderate 6	High 9	High 12	Extreme 15
	2 Unlikely	Low 2	Moderate 4	Moderate 6	High 8	High 10
	1 Rare	Low 1	Low 2	Low 3	Moderate 4	Moderate 5

Table 2.3 : Risk Matrix Table

RISK	DESCRIPTION	ACTION
15 - 25	HIGH	A HIGH risk requires **immediate** action to control the hazard as detailed in the hierarchy of control. Actions taken must be documented on the risk assessment form including date for completion.
5 - 12	MEDIUM	A MEDIUM risk requires a planned approach to controlling the hazard and applies temporary measure if required. Actions taken must be documented on the risk assessment form including date for completion.
1 - 4	LOW	A risk identified as LOW may be considered as acceptable and further reduction may not be necessary. However, if the risk can be resolved quickly and efficiently, control measures should be implemented and recorded.

Table 2.4 : Priority of Risk Based on Risk Value

2.5 Activities involved during Wetland Construction

2.5.1 Excavation and Trench

Excavation activities are common during construction activities and required by almost most of construction field. Workers should understand the risks associated with this activity which can help to reduce injuries and fatalities. OSHA characterizes excavation as any man-made cut, depression, channel, or on the other hand discouragement in the Earth's surface framed by earth expulsion. A trench is characterized as a restricted removal (corresponding to its length) made underneath the outside of the ground. Generally, the depth of a trench is more prominent than its width, however the width of a channel (estimated at the base) isn't more prominent than 4.6m. (OSHA, 1994).

Excavation works can bring serious hazards to the workers nearby. One cubic yard of soil weighs as much mass of a car (nearly 800 kg). Employers need to ensure workers are always follow the operational procedures during this activity. Other potential hazards related to excavation work include falling loads, hazardous atmospheres, and hazards from mobile equipment. (OSHA, 1994)

2.5.2 Steel Structural Work & Bricks Installation

Structural steelwork is generally used to form a the 'skeleton' frame of a building or other built asset, typically consisting of columns and beams which are riveted, bolted or welded together. The main cause of accidents during bricks installation are injuries due to handling, lifting, carrying and mixing. Injuries include sprains and strains due to repetitive movements particularly to the arm, back and shoulder. Slips, Trips and Falls (STF) are common accidents can occur during dealing with bricks as well. Constructed wetlands need a filtration unit which can remove solid waste and pathogens from the

water source. Bricks installations are involved during this construction activities and one should be more careful while dealing with this activity. Safety managers need to manually inspect the construction site which is very limited due to nature of sites and human perception. Wearable inertial Measurement Units is one of the tool to identify the workers' abnormal gait patterns and the existence of slip, trip and fall hazards. Automated hazard identification while dealing with bricks are still a challenging due to the lacking in knowledge on decision threshold on hazard identification under different construction scenarios. (KanghyeokYang et.al ,. 2019).

2.6 Life Cycle Assessment

Life cycle assessment (LCA) is a system for assessing the natural heap of cycles and items (labor and products) during their life cycle from cradle to grave. (Ortiz.O et al.,2007) By applying LCA during construction of manmade streams and wetlands, it is feasible to improve these viewpoints, from the extraction of crude materials to the last removal of waste development materials. LCA technique depends on the International guidelines of arrangement ISO 14040 and comprises of four particular insightful advances: characterizing the objective and degree, making the inventory, surveying the effect lastly interpret the outcomes. Arrangement of the LCI results includes allocating the outflows, squanders and assets used to the effect classes picked, for example CO2, and CH4, CO. The changed over LCI results are collected into a marker result, which is the eventual outcome of the obligatory piece of a LCIA. Standardization, gathering, weighting and extra LCIA information quality examination are discretionary advances.

2.7 Ergonomic Site Assessment

Development is a genuinely requesting and conceivably risky calling. Numerous development undertakings imply ergonomic dangers that can bring about injury, including lifting, pushing, pulling, twisting and taking care of substantial burdens. Wounds that can cause transitory or lasting incapacity can incorporate back issues, carpal passage condition, tendinitis, rotator sleeve tears, injuries, and strains. (Hajaghazadeh et al.,2017) Construction workers during development of manmade streams and wetlands are at higher risk of getting musculoskeletal disorders as they are perform repetitive movements.

Ergonomic Site Assessment includes:

- Repetitive Movements
- Tools and equipment
- Best Practises

2.8 Control Measures

Hazards should be controlled where the problems arise. Selecting a suitable control is a must based on the risk severity index. This can ensure controls are not exceed the requirement level which financially can affect the management. Hierarchy of control should be adopted based on the control measures recommended (DOSH,2008).

Hierarchy of control measures as follows :

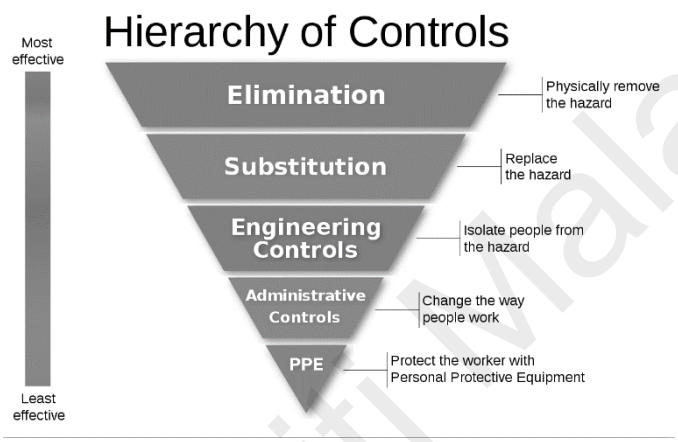


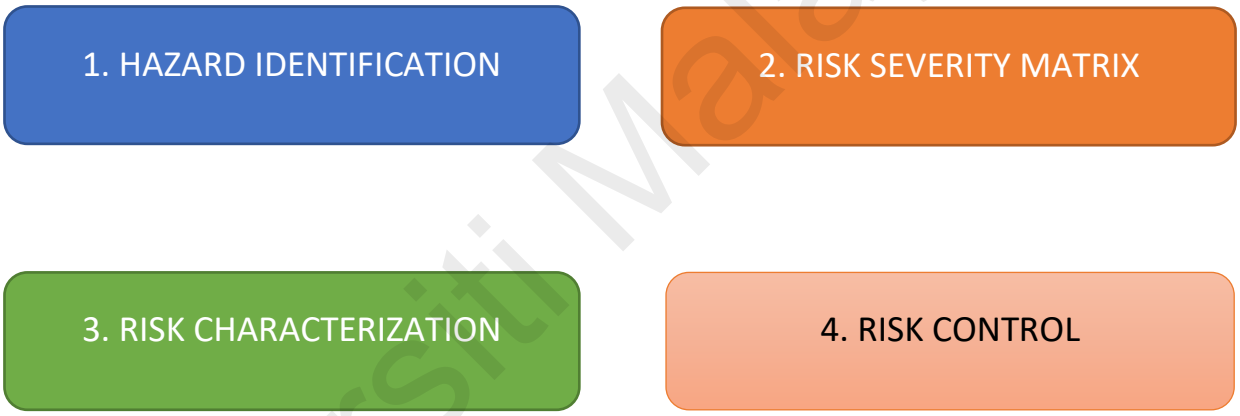
Figure 2.8 : Hierarchy of Control

CHAPTER 3
METHODOLOGY

3.1 Hazard Identification, Risk Assessment & Risk Control (HIRARC)

HIRARC form will be used to identify, assess and control the risks associated with construction activities of manmade streams and wetlands. This can provide a clear picture on the severity level of the hazards identified and right measures can be taken with minimal costing and impacts.

HIRARC Model Flowchart as follows:



Hazard Identification is a process to gather all the potential hazards by various strategies in order to ensure smooth operation during construction. Hazards are everywhere and one should comply to the rules and regulations to minimize the unwanted incidents to happen at the site.

The methods for hazard identification are as follows :

- Checklist
- Workplace Inspection
- HAZOP Study
- Accident and Incident Investigation
- Job Safety Analysis

3.2 Site Observation & Ergonomic Assessment

Site observation is one of the efficient way to identify and assess the hazards based on employees behaviors and working environment. Site observation during major activities such as site preparation, excavation, piling works and electrical activities can bring down the unwanted incidents. Important consideration should be given in ergonomic as most workers will undergo repetitive movements and improper body postures.

Ergonomic assessment tools such as RULA and REBA should be created to avoid Musculoskeletal Disorders (MSD) which is commonly happen when one failed to follow the posture guidelines. All the work conditions such as machinery tools, job steps and movement frequencies should be noted down during the observation. I able to identify some common hazards which is already existed during the site activities.

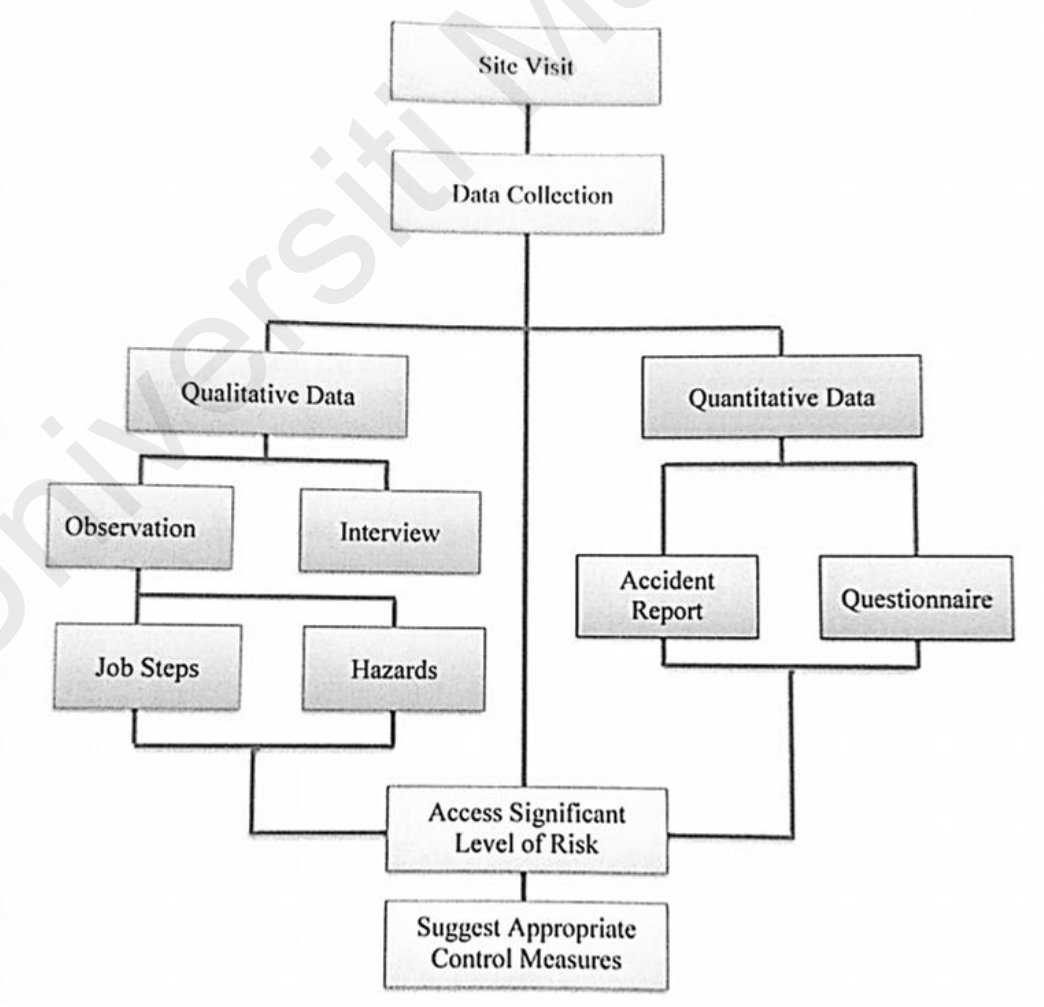


Figure 3.1 Process Flow of Study

3.3 Life Cycle Assessment (Clay Brick vs Sand Lime Bricks)

SIMAPRO is a software to assess the health, environmental, resource impact to the environment. Main construction materials such as brick will be analyzed using this software. Bricks such as clay and sand lime brick will be assessed using SIMAPRO. Greenhouse gas particularly on CO2 gas emission will be assessed to decide on the most suitable brick for constructions in future.

3.4 Soil Testing (Pre Construction Activities)

Soil Testing is the most crucial before wetland construction activities as this can determine the suitability of the soil. Soil tests for development of structures is the initial phase in development intending to comprehend the reasonableness of soil for proposed development work for manmade streams and wetlands.

Soil which plays the most important role for permitting the burdens coming from the design need to be very much tried to give superb execution. Assuming soil shouldn't tried effectively, the entire structure or construction will be harmed. Thus, soil testing is the initial step to continue any development.

3.5 Interview

Interviewing the workers is one of an efficient way to collect data as it will be more useful to perform a better risk analysis and suggest efficient control measures. This can be done through some questions which is well answerable by them based on their experience during construction activities. Questions include such as accident records, workers adherence level to SOP, complaints and suggestions for betterment in future.

3.6 Questionnaire Survey

Questionnaire survey will be conducted as well with at least 20 respondents to check on their safety awareness, health and environment at workplace. It'll be hard to meet directly in person with all of them as most of construction sites are closed during this pandemic. We'll be conducting teleconference and virtual meet with them to gather data and finally for evaluation.

CHAPTER 4
RESULTS AND DISCUSSION

4.1 Introduction

This chapter will emphasize on the result and discussion for the whole study on the construction activities at manmade wetland and streams. This chapter will mainly monitor on the objective of this study to identify, assess and formation of new Standard Operating Procedures (SOP) to minimize the incidents and accidents at construction sites. Moreover, the water sources which are directed to the constructed water streams and wetlands will be demonstrated in this study. The data obtained from site observations, interviews and Job Safety Analysis will be used as a tool to create efficient HIRARC forms, Ergonomic Assessments, Life Cycle Assessment of the materials used and enhanced SOPs to be followed at construction sites.

4.2 Description of study

The selected study areas are located at University of Malaya, Kuala Lumpur. The site was selected inside the university to construct a manmade wetland and streams to be as the source of water storage which is discharged from the Engineering faculty and Mahsa University. This constructed wetland and stream will be helpful during the rainy season as flash flood may occur. The duration of the construction was six months which started at July 2017 and end at Feb 2018. The site inspection and interview among the workers were limited due to lockdown and we were guided by the Safety Coordinator Ms. Loh Lai Ching from a construction company.

We had to attend Toolbox Meeting (TBM) together with other construction workers to ensure our safety measures before enter the construction site. Workers safety should be consistently the main need of each construction organization. Security gatherings and toolbox meetings

should be led consistently to instruct laborers on safe work practices and stay agreeable with guidelines in regard to wellbeing and preparing.

Safety meetings and TBM are imperative to create an efficient safety culture and supporting your organization's obligation to protect the workers wellbeing at workplace. Holding daily and weekly Toolbox Meetings can keep laborers from getting self-satisfied and try not to underestimate safety measures that should be followed.

Figure 4.1 : Weekly Meeting with Safety Supervisor

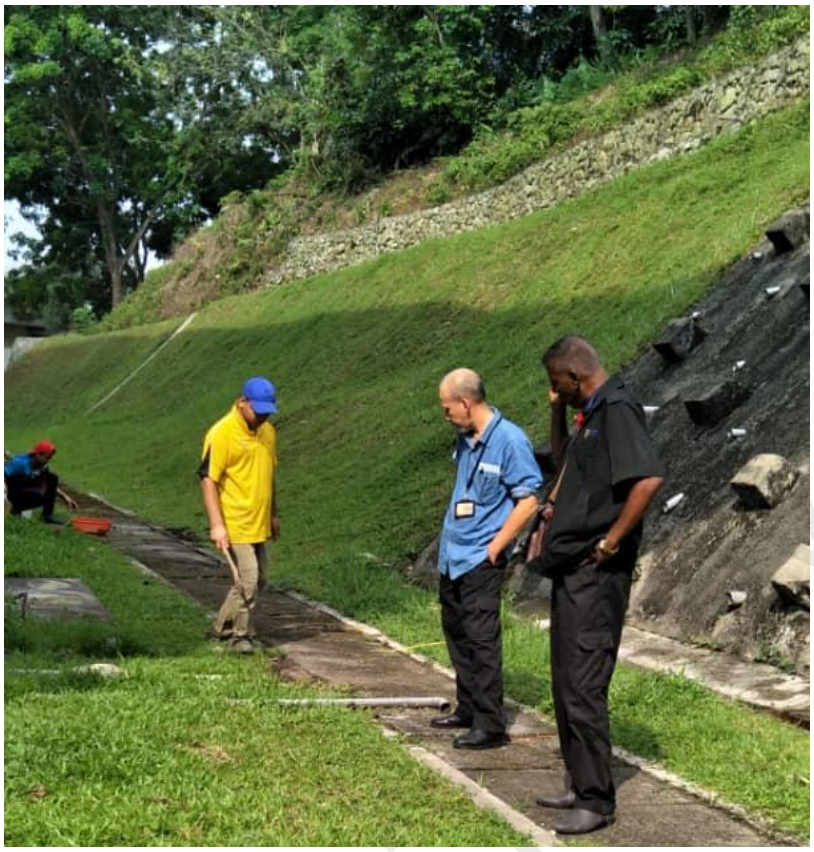


Figure 4.2 : Site observation before construction

Figure 4.3 : Site Location

4.3 Site Visit and Data Collection

Site observation is one of the mandatory part should be done by every construction company either by inspector or selected employee. Data collection can be done during this site observation and documents reviewing. Safety report should be done once complete with the site observations. The safety report serves as a proof of the observed findings during site visit such as construction activities together with detailed descriptions with supporting pictures, frequency of TBM and existing safety features around the site. Although safety features were properly implemented at the site, some hazards were still existing and the imposed risk is much higher than expected.

It was mandatory to scan MySejahtera and record our temperature reading before enter the site. Once we entered the site, Miss. Lo guided us throughout the site activities and each person's role to ensure activities are performed in an organized manner. Site activities such as excavation, loading and unloading, Bricks installations, Safety briefings and Steel structural works were performed. The site inspection form used during this visit is attached at the Appendix.

The workers were divided into groups based on the site activities where each group consisting of 8-10 persons. As we observed, mostly have been assigned for multi-tasking jobs as safety is fully ensured at the same time. Toolbox Meeting were conducted on a daily basis by certified safety officer before the commencement of activities. We observed based on many safety aspects which were stated in the checklist form as follows :

- Safe work method statement,
- Daily risk assessments,
- Works/Access permits,
- Manual handling,

- PPE,
- Tools/equipment
- Traffic/ Pedestrian Management,
- Fire hazards and procedures
- Excavation & Trenches
- Covid 19 Preventive Measures
- Emergency Preparedness

Based on the observation, workers were still lacking in safety awareness and not following the rules and regulations as per the management need to ensure safe working environment. Although SWMS is placed at the construction site, workers were not clear enough on the procedures to be followed. This can bring higher risks to their safety and serious injury or property damage may occur on a higher frequency. We can observe that some manual handling methods also need to improvised since no proper loading and unloading as this can cause back pain due to repetitive movements. Nevertheless, the adherence to PPE were impressive to see as everyone were fully obliged to the regulations. There's no much noise as only 3 heavy machineries involved in the construction site such as excavator, sky lift and concrete bucket. The break time were also sufficient enough for the workers as from 1pm till 2pm. They were also allowed to take a short 10 minute break if too exhausted with workloads.

4.3.1 Pre-Construction Procedures

As the pre-construction phase, the customer works closely with its plan group and development team to create definite drawings, timetables, budget, and labour projections before construction begins. This stage requires better communication among the core team and project consultants.

The group attempts to characterize the task, plan quotes to meet the financial plan, recognize potential development issues and arrangements, and eventually decide the most productive utilization of cash and assets. An intensive and conscious pre-development measure is critical to guarantee the task goes as arranged and all potential requirements are recognized and tended to. Based on the HIRARC report, we came across some miscommunication which leads to body injury and property damage during the construction phase where workers failed to receive proper instructions on their job tasks. The risk level is 10 which is high and additional recommendations must be proposed.

4.3.2 Site Selection

Site selection for a constructed wetland is mandatory as the location should be nearby to the wastewater source where the main source for this constructed wetland are from Faculty of Engineering, UM and Mahsa University. The selected site for this construction is gently sloping as this can make the water flow to be more faster to the exit point after treatment. The selected site also above the water table and not in a floodplain. The soil is also sufficiently compact so that no soil erosions may occur in future.

Figure 4.4 : Construction site for manmade wetland and streams

4.3.3 Excavation Procedures

Each employer in a development project that implied excavation works must ensure risks are managed in accordance with existing policies by setting up protected frameworks of work, as needed under Section 15(2)(a) of OSHA, General obligations of bosses. If more than one bosses are engaged with a construction project, every employer should engage to participate in building up safe arrangement of work to ensure their laborers and other individual that might be influenced by hazards that emerge from excavation work.

Based on HIRARC report, there are potential hazards which are high likely can happen during the construction activities. One of the main hazards is cave in which carries risk level of 20. Existing measures such as placement of New Jersey Barriers between workplace and excavation area is not sufficient to reduce the risk level. Additional recommendations are needed for this activity.

Figure 4.5 : Possible Cave in Hazards during excavation

Figure 4.6 : Excavation during manmade wetland and streams construction

4.3.4 Concrete Construction Procedure

Concrete constructions provide the foundation for the filtering chamber, inlet, and outlet of the water sources which is coming from Mahsa University and Faculty of Engineering, UM. Most common concrete constructions are chemical burns, lifting injuries, dust exposure and heat related sickness. Mixture of cement (high calcium oxide content) with water turns into calcium hydroxide with pH around 12-14. This can cause chemical burns especially while workers dealt with bare hands during mixing. The risk level is also quite high (9). This can be avoided by wearing proper PPE with pants, boots, long sleeved shirt and gloves. Wearing nitrile gloves when dealing with wet cement is the best option.

Another dangerous part is inhalation of silica dust particles when dealing with dry concrete mixtures. This can develop chronic health problems such as respiratory tract problems. The risk level is 9 which is still high even with existing measures. This exposure is unavoidable and proper PPE is necessary to avoid inhalation of dangerous levels of concrete dusts.

Figure 4.7 : Concrete Construction Activity

4.3.5 Waste Management

The waste generated at the construction site were mostly packaging materials (wooden pallet, Plastic wraps, damaged bricks, boxes, nuts and screws, and furniture. The waste were gathered and segregated based on the material type to be sent later for either landfilling or recycling factory.

Figure 4.8 : Gathered construction wastes

4.4 HIRARC FORM

HIRARC is used as a part of qualitative and semi quantitative analysis by identifying and classifying the job activities during the manmade wetland and streams construction.

The HIRARC was carried out to analyse the work activities and hazards associated to these activities by multiple methods such as survey, interview and site inspection. Construction activities are comprised of excavation, concrete construction, health measures, Material delivery and operation and maintenance. Risk level whether low, medium or high was calculated based on the likelihood and severity. We found that some hazards possessed to high risk level thus additional control measures were suggested for minimization in future.

Based on the findings from HIRARC forms above, we could identify 30 hazards associated with construction activities of manmade wetland and streams. These hazards were then assessed based on the likelihood and severity index and additional enhanced SOPs were proposed to the management. The safety hazards involved are unstable trenching activities, unstable soil composition, lacking in inspection (daily basis), lack of safety knowledge, toxic gases and and chemical contamination, lack in safety design and implementation. The risk associated with manmade wetland and stream construction activities were classified with the lowest risk level of 4 (First aid Injury, Poor communication (walkie-talkie), Weather condition and high heat absorptions by concretes. Cave in and hitting utility lines are among highest risk value of 15 - 20.

Job Title : Construction activities for manmade water streams and wetlands. **Date : 14/7/2020** **Approved By : Piradeepan**

1. HAZARD IDENTIFICATION				2. RISK ANALYSIS				3. RISK CONTROL
No.	**Activities (Routine / Non-Routine)**	**Actual and Potential Hazards**	**Which can Cause Potential Consequences / Risk Effects**	**Existing Control Measures**	**Likeli hood (A)**	**Severity (B)**	**Risk Level (A) x (B)**	**Additional / Recommended Control Measures**
1	Excavation and Trench	Cave in	Unstable Trenching activities	• Plastic NJB Shield between workplace and excavation area	5	4	20 (H)	Refer to Control Measure
		Soil Erosion	Unstable Soil Composition	• Site inspection	2	3	6 (M)	Refer to Control Measure
		Miscommunic ation	Lacking in inspection (daily basis)	• Soil Classification	1	2	2 (L)	Refer to Control Measure
		Falls and Falling Loads	Lack of Safety knowledge	- Training and tool box meeting	4	3	12 (M)	Refer to Control Measure
		Hazardous Atmosphere	Toxic gases and and chemical contamination	• Atmospheric Hazard Testing	4	3	12 (M)	Refer to Control Measure
		Hitting utility Lines	Lack in safety design and implementation	• Determine the approximate locations of utility installations	3	5	15 (H)	Refer to Control Measure
		Moving Objects	Dump Trucks and Backhoe loaders	• Head and hand protections (PPE)	2	2	4 (L)	Refer to Control Measure

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2	Pre Start Requirements and Site preparation	Miscommunication	Serious Injury or property damage	• Make sure all workers involved are briefed on the SWMS, pre task talk before any initiation on work activities.	2	5	10 (M)	Refer to Control Measure
3	Material Delivery	Heavy Machineries Movement	Serious injury or property damage	• Establish logistic plan by setting up exclusion zones for vehicles entry and exit. • Ensure all the vehicles for material delivery are in good condition. • Deploy banksman to monitor and control on the vehicle movement at the entry and exit point. • Ensure drivers are complying with all safety regulations during at the site.	2	5	10 (M)	Refer to Control Measure

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4	Material Delivery	Poor material arrangements	First aid Injury or property damage	• Allocate adequate space for proper material storage and stackings as per the requirements to ensure safety throughout the construction.	2	5	10 (M)	Refer to Control Measure
5	Loading and unloading	No proper access into lorry for loading and unloading	First aid injury or property damage	• Use podium ladder to climb onto the lorry for loading and unloading activities. • Standing supervision	2	5	10 (M)	Refer to Control Measure
		Caught in between object	First aid injury	• Ensure materials are arranged and loaded properly for safe unloading process. • Apply buddy system or work in group. • Unload materials at designated area only.	2	2	4 (L)	Refer to Control Measure

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6	Concrete	Mixture of cement with water (turns into calcium hydroxide with pH around 12-14	Chemical Burns	• Wear Proper PPE with pants, boots, long sleeved shirt and gloves. • Wear nitrile gloves when dealing with wet cement.	3	3	9 (M)	Refer to Control Measure
		Health Hazards	Inhalation of dusts from cements	• Wear Face Mask	3	3	9 (M)	Refer to Control Measure
		Heavy Concrete	Lifting Injuries	• Provide lifting equipments while dealing with heavy concretes such as forklifts or manual lifting. • Provide training for workers on proper lifting techniques.	2	3	6 (M)	Refer to Control Measure
		High heat absorptions by concretes	Heat related sickness	• Pour concrete during high humidity weather • Provide isotonic drinks during extreme heat • Take short breaks	2	2	4(L)	Refer to Control Measure

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7	Loading and Unloading	Heavy Loads	Back Injury/ Musculoskeletal Disorders	• Practise correct manual handling method. • Apply buddy system or work in group for any manual handling when loading materials weighs more than 30kg. • Always comply with RUBA/RELA assessments which can indicate the severity of the repetitive movements.	3	4	12 (M)	Refer to Control Measure
		Miscommunication	Serious Body injury	• Use of communication device (walkie talkie) • Engage trained lifting crews (Riggers and Signalman) who attended Academic Verification of Competency (VOC)	2	5	10 (M)	Refer to Control Measure

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7	Loading and Unloading	Hit by moving load during transferring from lorries/ crane	Serious bodily injury	• Ensure materials are well packed and palletized before unloading • Engage trained lifting crews (Riggers and Signalman) who attended Academic Verification of Competency (VOC) • Use of tagline to control load movement.	2	3	6 (M)	Refer to Control Measure
		Use of unfit lifting equipment	Serious bodily injury / property damage	• Make sure only certified and regularly examined lifting equipment is used. (Hand Hydraulic Hoist) • Engage trained lifting crews (Riggers and Signalman) who attended Academic Verification of Competency (VOC) • Use of tagline to control load movement.	2	5	10 (M)	Refer to Control Measure

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8	Workplace	Covid-19 Virus	Spread of the virus to others	Avoid physical contact with each other Maintain social distancing (min 1 meter) Wear face mask all the time & glove properly.	2	5	10 (M)	Refer to Control Measure
		Health Hazards	Inhalation of dusts from cements	Practise proper handling method while dealing with cements Wear Face shield and mask	2	3	6 (M)	Refer to Control Measure

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9	During Construction	Electrical hazard due to improper electricity connection of tool, equipment & wring	Short circuit	• Inspect electrical items before start work & ensure it is in safe condition • Ensure power tools send to inspection on monthly basis	2	3	6 (M)	Refer to Control Measure
		Weather condition	• Working under hot sun may led to cramp or heat stroke • Lightening, strong wind & rain may course untoward situation	• Recommended to wear light colour clothes • To standby drinking water to avoid dehydration • To stop operation by lowering skylift to ground level • No entry or exit to the excavation area during break time.	2	2	4(L)	Refer to Control Measure

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9	During Construction	Poor communication (walkie-talkie)	• Technician hard to deliver information if power supply issue • Worker in excavator hard to reach technician if there is a mechanical problem	• Supervisor or foreman in charge to ensure walkie-talkie are given • Ensure walkie-talkie battery are full or been charged before use • Worker to ensure walkie-talkie are secure from fall down	2	2	4(L)	Refer to Control Measure
		Falling objects from excavator/skylift due to some activity	• Bodily or serious injury if other workers trespasses during heavy machines operation or property damage	• Standby person to alert other workers from trespasses into trenching working area • Ensure excavator/skylift working area to barricade with signage	2	3	6(M)	Refer to Control Measure
		Noise	Body injury (deafness) and stress	• Wear Earplug based on the noise level at site • Have break in between	3	2	6 (M)	Refer to Control Measure

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10	Workers access / into and from site	Covid-19 Virus	Person contracted with the virus	• Every individual must take Covid-19 PCR Test. Result shows Negative only can enter into site. • Health temperature screening at entry point • Avoid physical contact with each other • Maintain social distancing (min 1 meter) • Frequently clean hands by using alcohol-based hand rub or soap & water. • Wear face mask & glove properly. • Continuous education on Covid-19 awareness & precautions measure.	3	4	12 (M)	• Briefing & educate to workers on daily basis during TBM on Covid-19 prevention method • Educate on 1-meter social distancing during peak hours, especially in passenger lift & during queup at thermal temperature devices

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11	Lay temporary protection to existed waterproof surface and set up exclusion zone. Install temporary protection with New Jersey Barriers.	Trip and Fall	First aid Injury	• Segregate and place materials and in an orderly manner. • All materials that unloaded from lorries should be properly placed. Regularly maintain work and storage area.	2	2	4(L)	Refer to Control Measure
		Heavy Load	Back Injury	• Transfer materials in a small quantity step by step if load exceed 30kg weight. • Use proper body postured while carrying heavy loads to avoid back injuries	3	2	6(M)	Refer to Control Measure
		Temporary storage area	Body injury / Property damage	• Set up exclusion zone using plastic New Jersey barriers • Filling up water inside NJB before setting them in position. • Position and interlock NJB.	3	2	6(M)	Refer to Control Measure

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12	Operation and Maintenance	Routine Cleaning	Physical and Chemical hazards	Wear proper PPE while dealing with chemicals	2	2	4 (L)	Refer to Control Measure
		Inspection	Miscommunication & Lack in implementation	Training and brainstorm on proper inspection. Decide as a team.	2	2	6 (M)	Refer to Control Measure
		System Monitoring	Miscommunication and Human error	Training and brainstorm on proper inspection. Decide as a team. Attend competitive courses to gain more knowledge on the system.	1	2	2 (L)	Refer to Control Measure

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13	Waste Storage & Disposal	- Water pollution - Land Pollution	- Illegal dumping - Burn and bury at the site.	- Separate waste materials into different types for storage, transport and recycling. - Located away from the drains and watercourses. - Indicate the scheduled wastes using labels.	3	2	6 (M)	Refer to Control Measure
	Soil Clearing and land levelling	- Soil Erosion - Sedimentation and Pollution - Loss of nutrients	- fauna death and loss habitat. -Existing plants and tree impacted too. -carbon footprint - soil erosion and soil saliently	-Both animal and plants living at site of soil Clearing and land levelling are safely relocated. -Work procedure implementation is closely monitored	2	3	6 (M)	Refer to Control Measure
	Excavation	- Stormwater runoff - Site flooding - Polluted soils	- Excessive digging - Soil stabilization	-The monitoring is done to make sure correct measurement is taken into action to avoid excessive of digging.	2	3	6 (M)	Refer to Control Measure

				- Soil monitoring is done to maintain quality of soil.				
	Transportation	- Climate Change - Noise Pollution - Water pollution	- GHG gases emissions - Illegal dumping of used engine oil	- Limited number of transportations is allowed at site. -The waste at site is segregated and labelled according for appropriate better waste management. The waste authorised waste handler for disposal.	3	2	6 (M)	Refer to Control Measure
	Cement Mixing	- Air Pollution -	- Dust and other toxic gases	- Place cement at the last after crushed rock and sad to reduce dust.	2	2	4 (L)	Refer to Control Measure

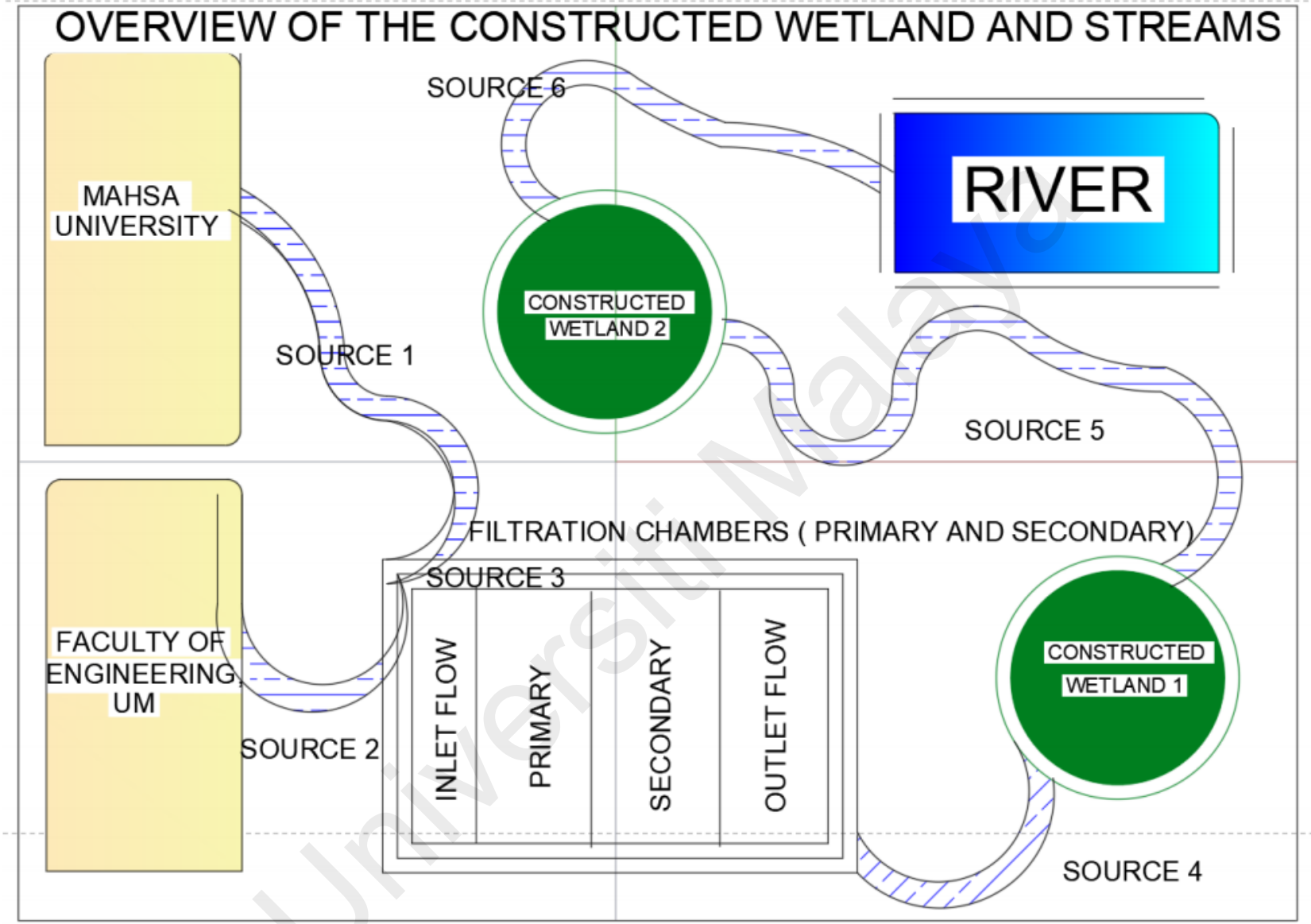


Figure 4.9 : Water sources from UM & Mahsa Uni which are channeled to manmade water str

4.5 Ergonomic (REBA) Assessment

4.5.1 : REBA Assessment for Filtrate fixing around Filtration Chamber

Figure 4.10 : Filtration Chamber Activities

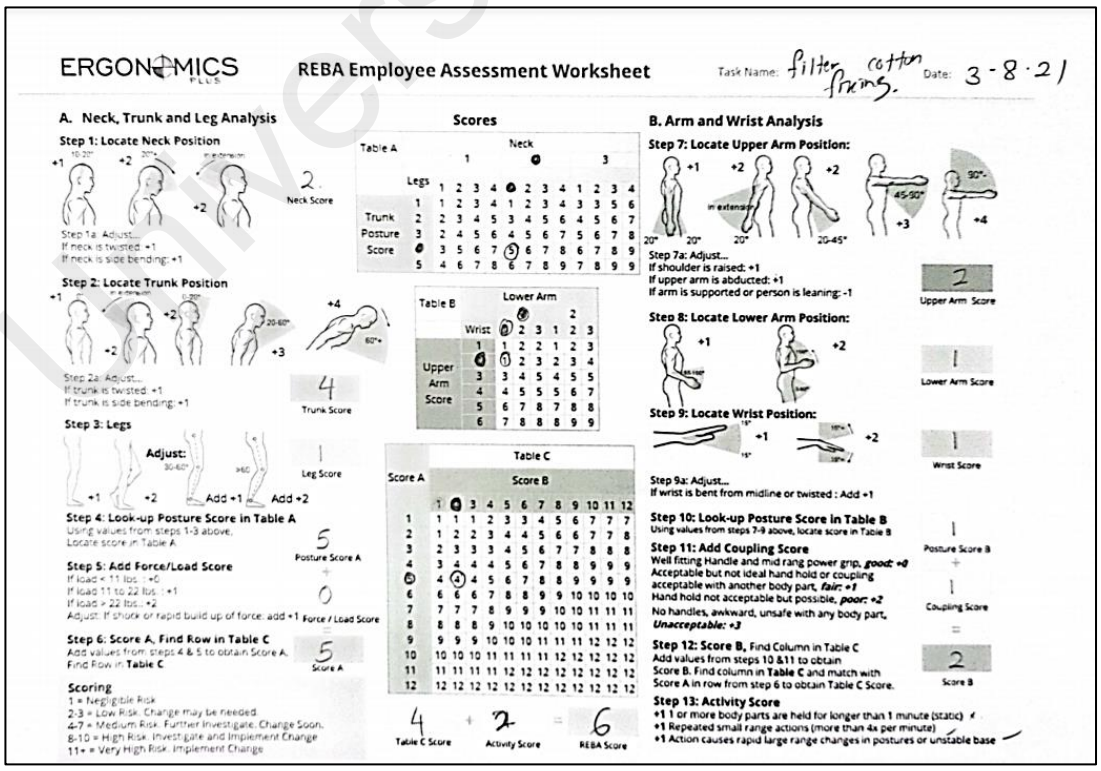


Figure 4.11 : REBA for Filtration Chamber Activities

4.5.2 : REBA Assessment for Concrete Construction

Figure 4.12 : Concrete Construction Activities

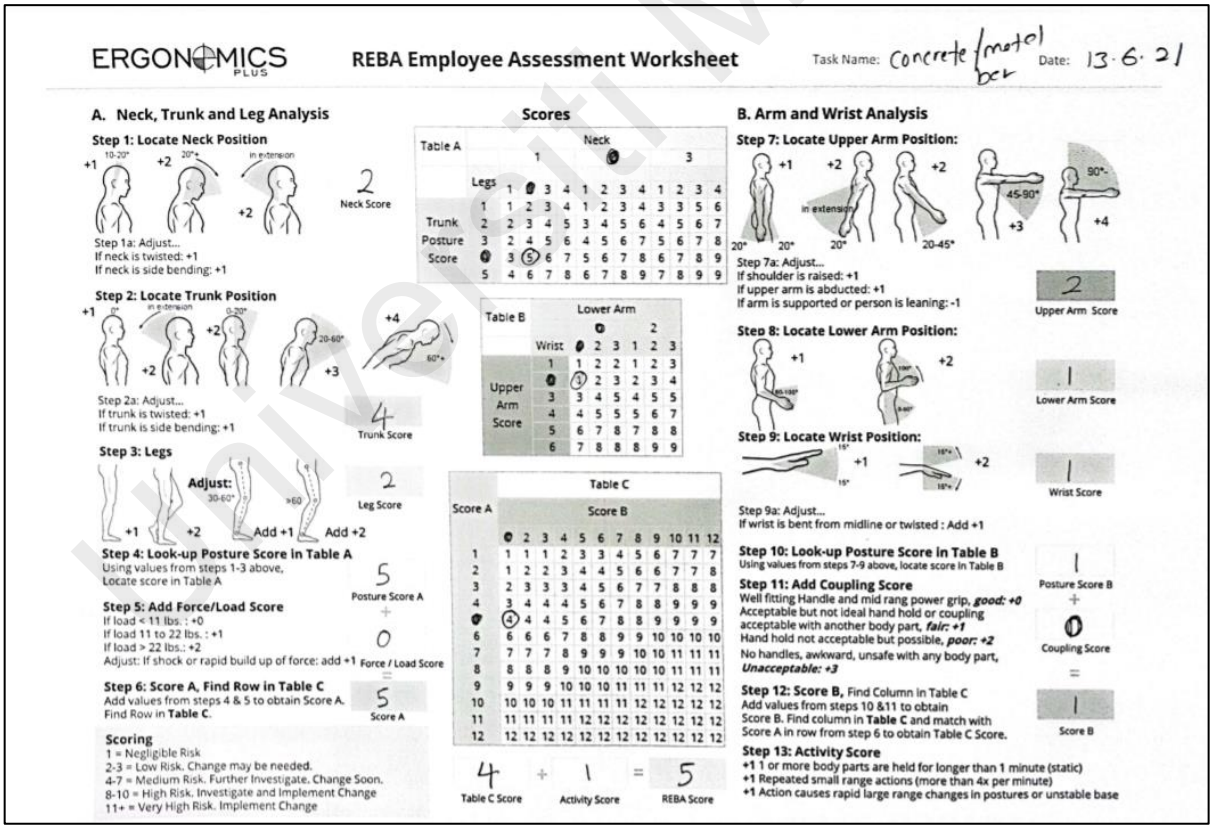


Figure 4.13 : REBA for Concrete Construction Activities

4.5.3 : REBA Assessment for Loading/Unloading

Figure 4.14 : Loading and Unloading Activities

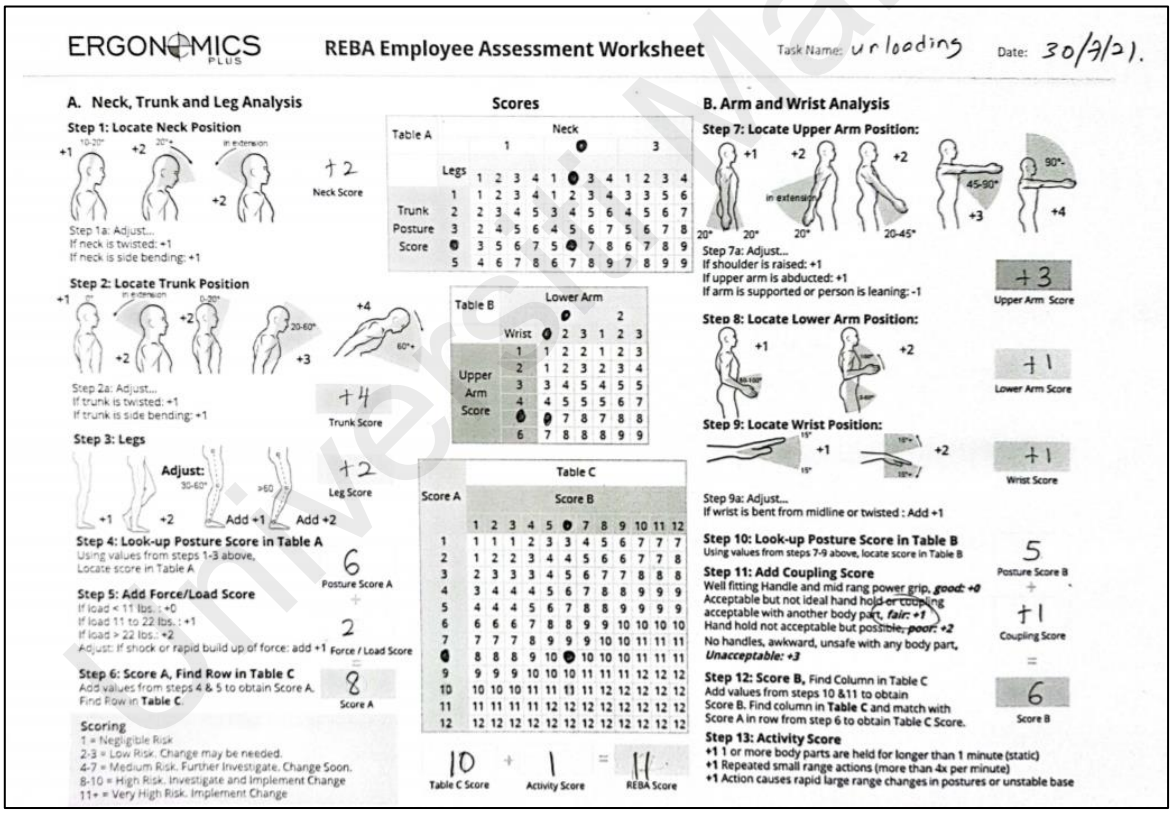


Figure 4.15 : REBA for Loading and Unloading

4.5.4 : REBA Assessment for Excavation

Figure 4.16 : Excavation and Manual Digging Activities

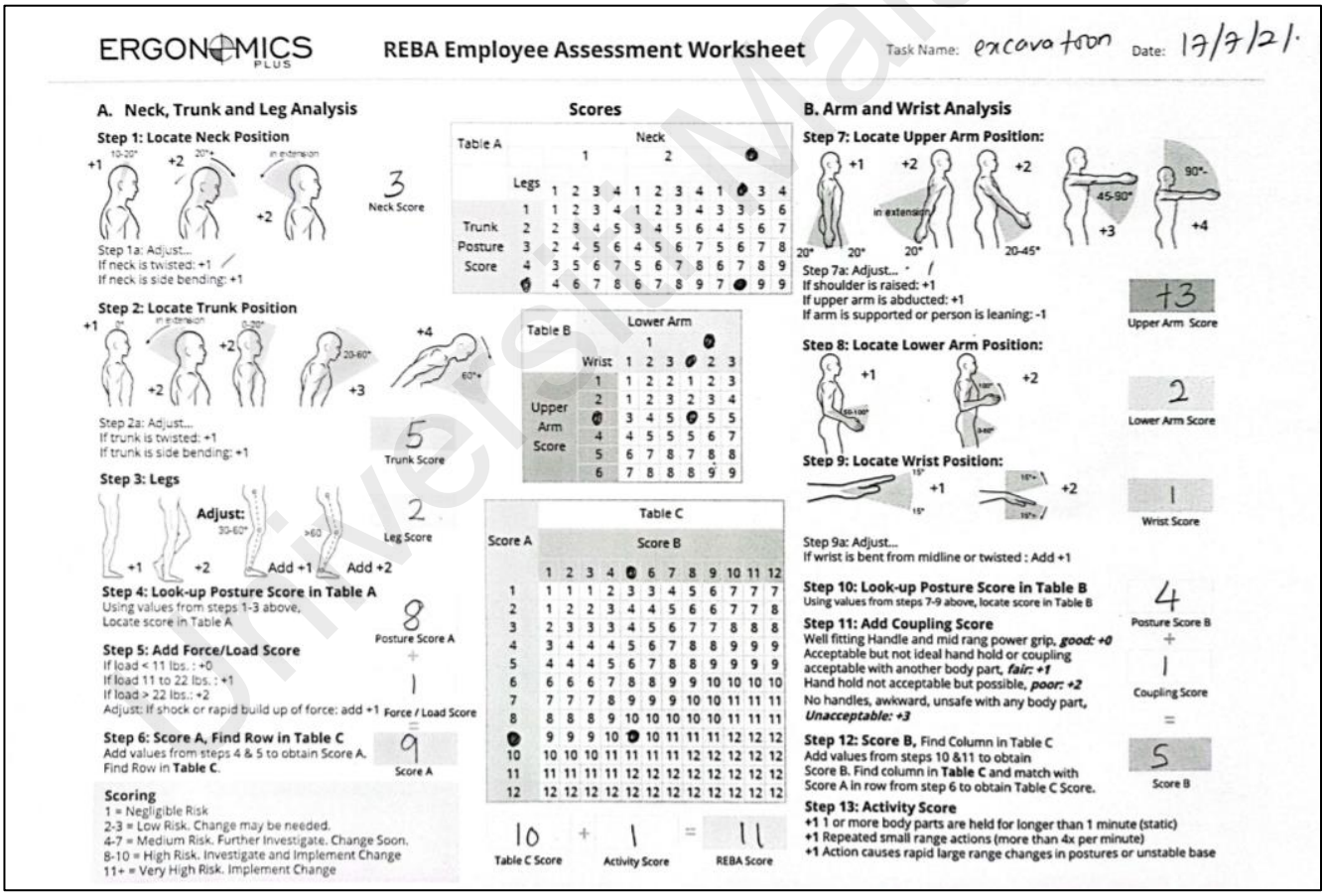


Figure 4.17 : REBA (Manual Digging)

Rapid Entire Body Assessment (REBA) is a tool to analyse the entire body (neck, trunk, leg, arm and wrist) based on the angle of movement, load and type of activities. This tool can evaluate the risk associated with Musculoskeletal disorders (MSDs) for any tasks involving repetitive body movements. First, we identified the job tasks from the site and snapped the worst movements with a photo using our smartphone. Bases on the REBA Assessment, we calculated the risk level for each task and came out with the final REBA score. The findings are as follows:

No	Activity	Table A	Table B	Table C	REBA Score
1	Filtration Chamber Activities	5	1	4	6
2	Concrete Construction Activities	5	1	4	5
3	Loading & unloading	8	6	10	11
4	Excavation (Manual Digging)	9	5	10	11

Table 4.1 : REBA Assessment

Based on the findings, we could find that two activities (Loading & Unloading and Excavation (Manual Digging) brought very high chance for MSDs with REBA score of 11. Additional control measures need to be implemented immediately and will be discussed further. The other two activities carried out with less repetitive movements and with safety measures as per the regulations at the construction site. The level of MSD risk based on the REBA score obtained are as follows:

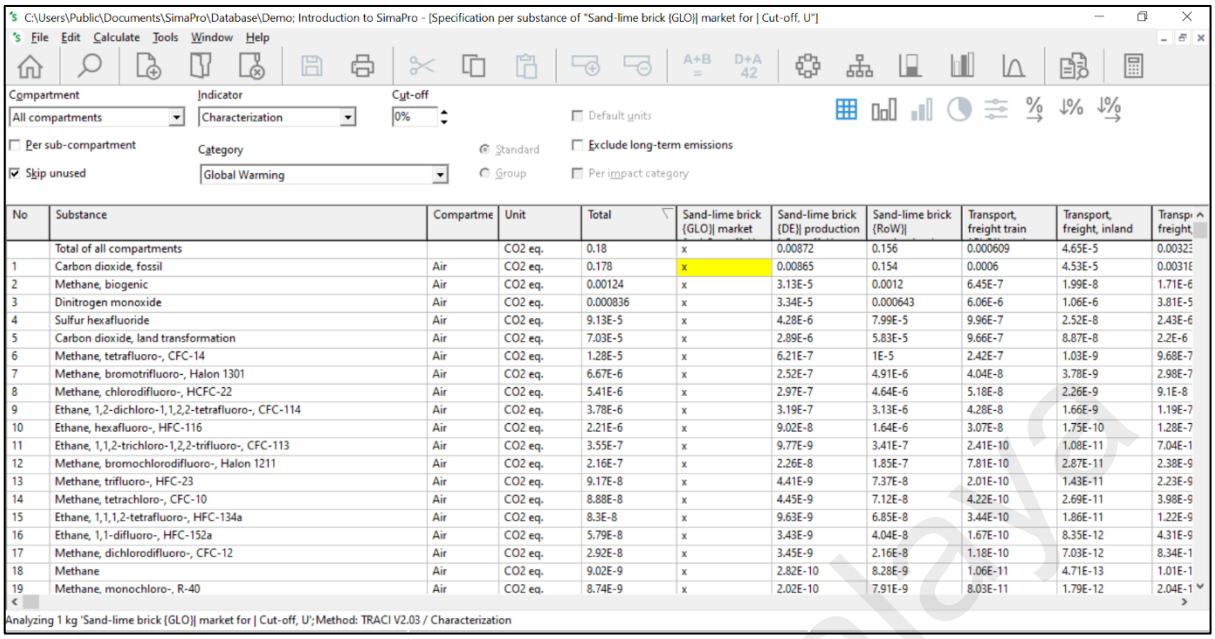
Score	Level of MSD Risk
1	negligible risk, no action required
2-3	low risk, change may be needed
4-7	medium risk, further investigation, change soon
8-10	high risk, investigate and implement change
11+	very high risk, implement change

Table 4.2 : Risk Level (REBA Score)

4.6 Life Cycle Assessment

Our environment is deteriorating for the last two centuries and almost every part of the planet has been touched by it in one way or the other. The primary cause of environmental degradation is human disturbance. The industrial revolution of 19th century mechanized the production and manufacturing of goods and introduced the use of machinery and other heavy equipment - which in turn, used fuels as source of energy, which deteriorate the environment. The modern technological progress, for which we are so proud of, is actually the root cause of the environmental deterioration. Environmental changes are based on factors like urbanization, population and economic growth, increase in energy consumption and agricultural intensification. The degradation has adverse impacts on humans, plants, animals and micro-organisms. To cope up with the critical situation, we need to make optimum use and management of resources, sustainable development, adoption of green concept and above all community participation in all developmental activities. As such that, we have done Life Cycle Assessment on the raw material such as clay brick and sand lime brick which is commonly used for construction activities using SIMAPRO.

Functional Unit : Production of 1 Kg of Sand Lime Brick



No	Substance	Compartme	Unit	Total	Sand-lime brick {GLO}| market	Sand-lime brick {DE}| production	Sand-lime brick {RoW}|	Transport, freight train	Transport, freight, inland	Transp freight
	Total of all compartments		CO2 eq.	0.18	x	0.00872	0.156	0.000609	4.65E-5	0.0032
1	Carbon dioxide, fossil	Air	CO2 eq.	0.178	x	0.00865	0.154	0.0006	4.53E-5	0.0031
2	Methane, biogenic	Air	CO2 eq.	0.00124	x	3.13E-5	0.0012	6.45E-7	1.99E-8	1.71E-6
3	Dinitrogen monoxide	Air	CO2 eq.	0.000836	x	3.34E-5	0.000643	6.06E-6	1.06E-6	3.81E-5
4	Sulfur hexafluoride	Air	CO2 eq.	9.13E-5	x	4.28E-6	7.99E-5	9.96E-7	2.52E-8	2.43E-6
5	Carbon dioxide, land transformation	Air	CO2 eq.	7.03E-5	x	2.89E-6	5.83E-5	9.66E-7	8.87E-8	2.2E-6
6	Methane, tetrafluoro-, CFC-14	Air	CO2 eq.	1.28E-5	x	6.21E-7	1E-5	2.42E-7	1.03E-9	9.68E-7
7	Methane, bromotrifluoro-, Halon 1301	Air	CO2 eq.	6.67E-6	x	2.52E-7	4.91E-6	4.04E-8	3.78E-9	2.98E-7
8	Methane, chlorodifluoro-, HCFC-22	Air	CO2 eq.	5.41E-6	x	2.97E-7	4.64E-6	5.18E-8	2.26E-9	9.1E-8
9	Ethane, 1,2-dichloro-1,1,2,2-tetrafluoro-, CFC-114	Air	CO2 eq.	3.78E-6	x	3.19E-7	3.13E-6	4.28E-8	1.66E-9	1.19E-7
10	Ethane, hexafluoro-, HFC-116	Air	CO2 eq.	2.21E-6	x	9.02E-8	1.64E-6	3.07E-8	1.75E-10	1.28E-7
11	Ethane, 1,1,2-trichloro-1,2,2-trifluoro-, CFC-113	Air	CO2 eq.	3.55E-7	x	9.77E-9	3.41E-7	2.41E-10	1.08E-11	7.04E-1
12	Methane, bromochlorodifluoro-, Halon 1211	Air	CO2 eq.	2.16E-7	x	2.26E-8	1.85E-7	7.81E-10	2.87E-11	2.38E-9
13	Methane, trifluoro-, HFC-23	Air	CO2 eq.	9.17E-8	x	4.41E-9	7.37E-8	2.01E-10	1.43E-11	2.23E-9
14	Methane, tetrachloro-, CFC-10	Air	CO2 eq.	8.88E-8	x	4.45E-9	7.12E-8	4.22E-10	2.69E-11	3.98E-9
15	Ethane, 1,1,1,2-tetrafluoro-, HFC-134a	Air	CO2 eq.	8.3E-8	x	9.63E-9	6.85E-8	3.44E-10	1.86E-11	1.22E-9
16	Ethane, 1,1-difluoro-, HFC-152a	Air	CO2 eq.	5.79E-8	x	3.43E-9	4.04E-8	1.67E-10	8.35E-12	4.31E-9
17	Methane, dichlorodifluoro-, CFC-12	Air	CO2 eq.	2.92E-8	x	3.45E-9	2.16E-8	1.18E-10	7.03E-12	8.34E-1
18	Methane	Air	CO2 eq.	9.02E-9	x	2.82E-10	8.28E-9	1.06E-11	4.71E-13	1.01E-1
19	Methane, monochloro-, R-40	Air	CO2 eq.	8.74E-9	x	2.02E-10	7.91E-9	8.03E-11	1.79E-12	2.04E-1

Figure 4.18 : Emissions from production of 1 Kg of Sand Lime Brick

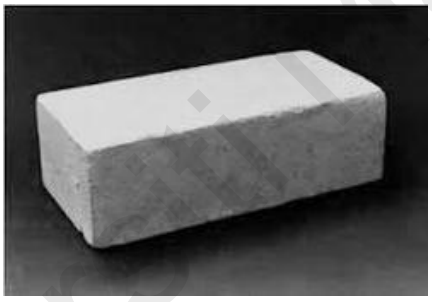


Figure 4.19 : Sand Lime Brick

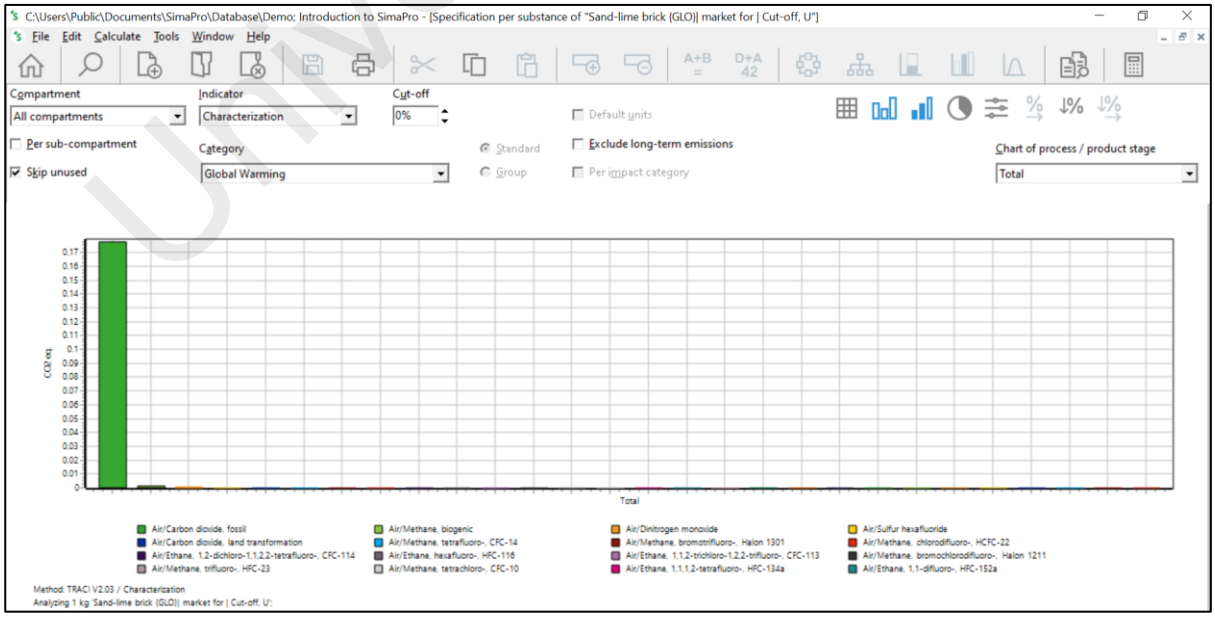


Figure 4.20 : Emissions from production of 1 Kg of Sand Lime Brick (Bar Chart)

Functional Unit : Production of 1 Kg of Clay Brick

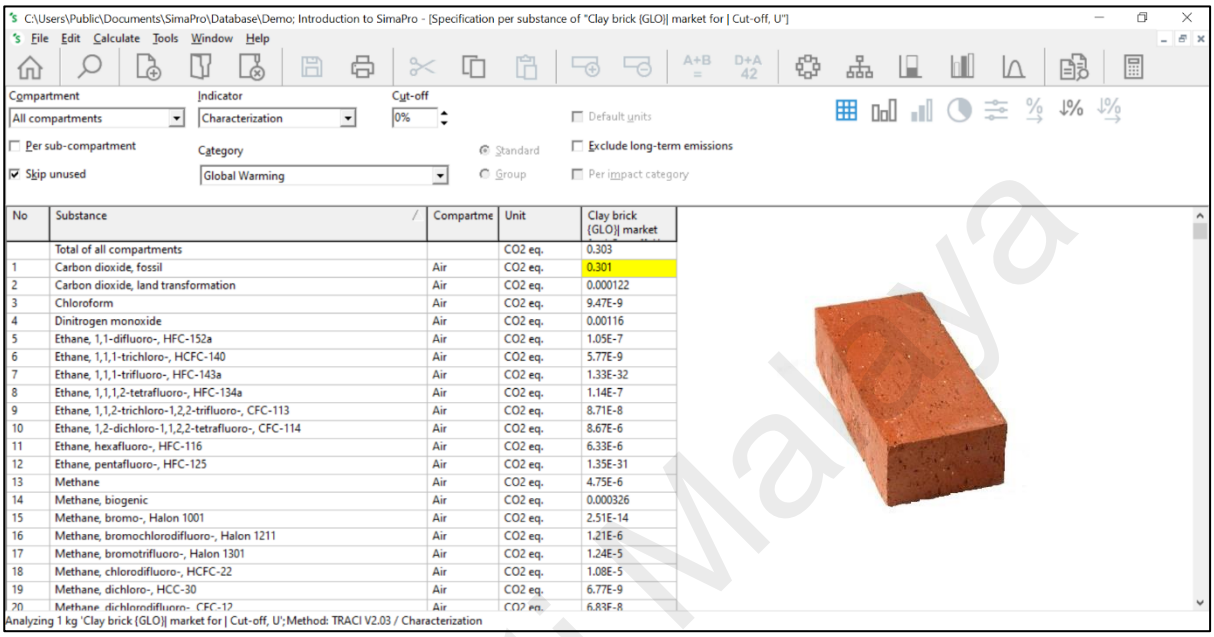


Figure 4.21 : Emissions from production of 1 Kg of Clay Brick

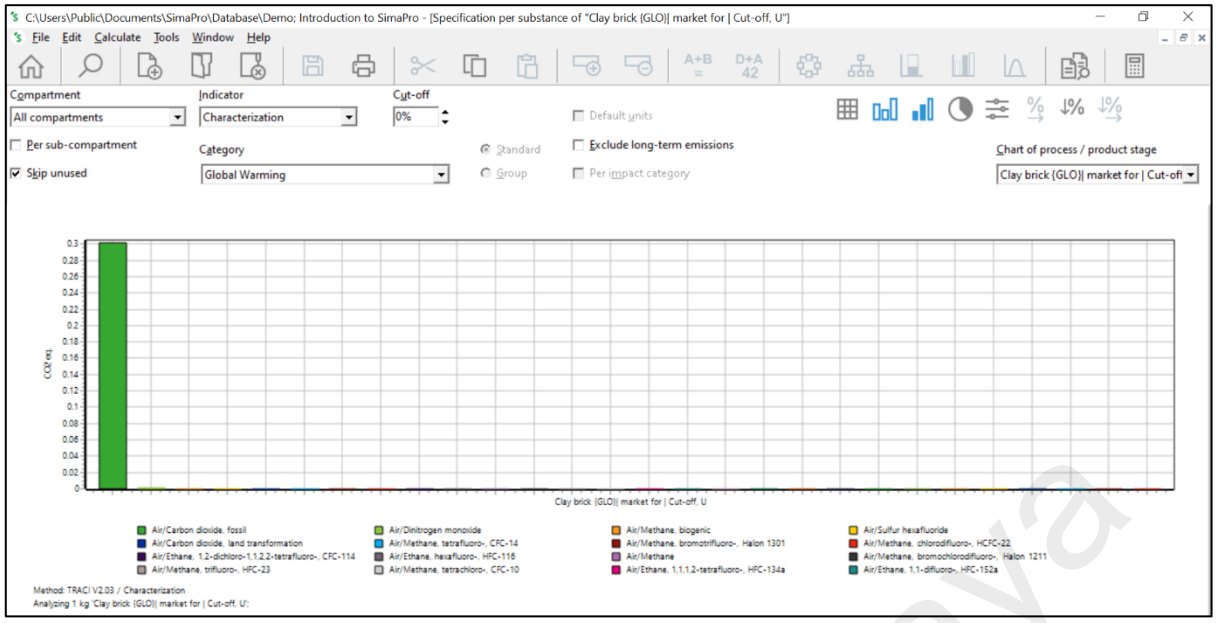


Figure 4.22 : Emissions from production of 1 Kg of Clay Brick (Bar Chart)

No	Brick	CO_2 eq Emission (kg)	Percentage
1	Clay Brick	0.301	62.58 %
2	Sand Lime Brick	0.178	36.85 %

Table 4.3 : Amount of CO2 emitted from Brick Productions

The findings for the emissions from the production of two types of bricks (Sand Lime & Clay brick) was analysed using SimaPro Software. The functional unit for this study is 1kg for material where we can easily compare the emissions especially on the global warming. Carbon dioxide is the main source of greenhouse gas emission via human activities which is 81% of all greenhouse gas emission produced. CO2 is emitted during the non- renewable sources such coal, oil and natural gas are burned during human activities such as industries, agriculture and transportations. Based on the finding, production of clay brick emitted around (0.301kg of CO_2) compared to Sand lime brick which emitted 0.178 kg of CO_2. This can clearly show that sand lime brick is the best option compared to clay brick for construction activities to save the planet from severe environmental destructions in future.

4.7 Interview

Interviewing the workers is one of an efficient tool to get the real situation happening around construction site. This can help to create a more concerned safety features and also training sessions based on their nature of work at site. There was so many challenges to interview the workers as our country is in lockdown and all construction activities are not carried out during this period. We had a virtual meeting for about thirty minutes to share the experiences at their site. The outcome from the interview were quite impressive as they're aware with most of the safety features placed at site. The past incident records were not recorded properly and transparently revealed by the management for review and future assessment purpose.

4.8 Questionnaire Analysis

A total of 20 employees were able to complete the survey questions. The remaining workers were not available due to Covid positive and couldn't contact them for this survey purpose. The result of the survey were discussed as below:

4.8.1 Demographic Information

Gender	**No of Respondents**	**Nationality & No of Respondents**
Male	20	Malaysia (2) Foreign (18)
Female	0	-

Table 4.4 : No of Respondents and Nationality

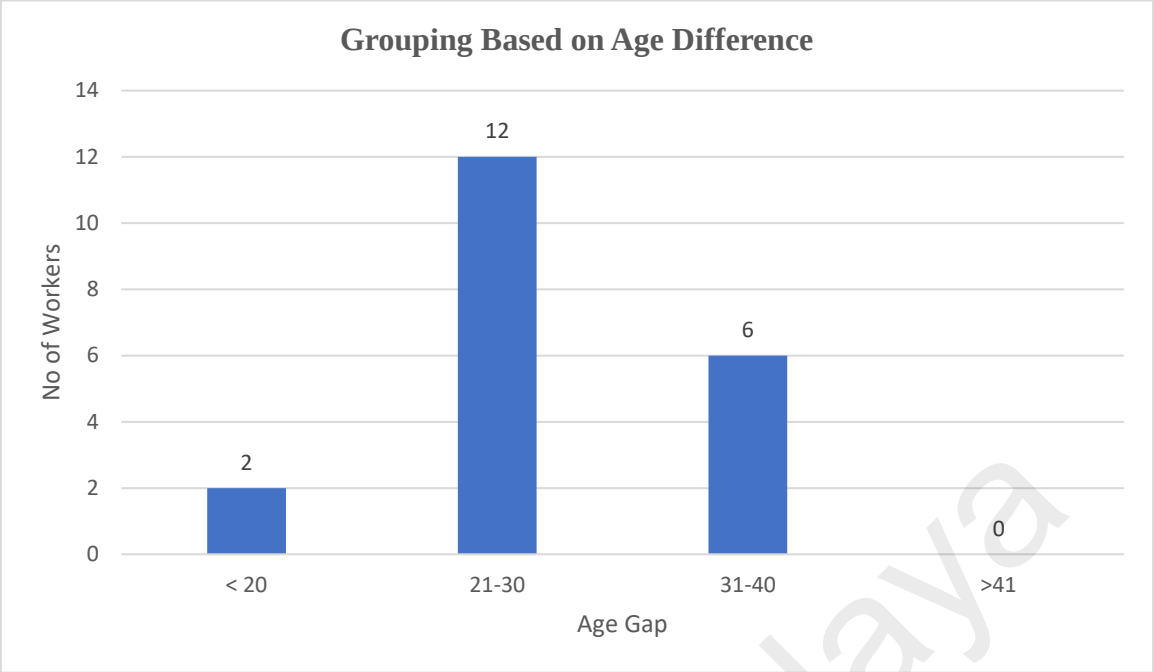


Figure 4.23 : Age Gap among 20 workers

4.8.2 General Information

All the workers had smartphone where they can be connected by a WhatsApp group where efficient communication can be done throughout the construction activities. The working time during this manmade wetland and streams construction is limited to 7 hours (8am – 4pm) with three break times since the activities are carried out at an opened area with direct sunlight towards the workers. The questionnaire also checked on the experience level of each worker to ensure smooth construction flow is maintained as more experienced workers can guide the beginners. From the 20 respondents, 5 of them were working in this construction field for 4-5 years, 10 workers for less than 4 years whereas 5 workers for less than 2 years respectively.

Technology	Yes	No
Smartphone Availability	20	0
WhatsApp Group Availability	20	0

Table 4.5 : Adaptation to current technology by workers

All the respondents worked for 7 hours on weekdays and 4 hours on Saturday. This has been standardized to all since there's no overtime for anyone to ensure there's no workers inside the campus after 6pm.

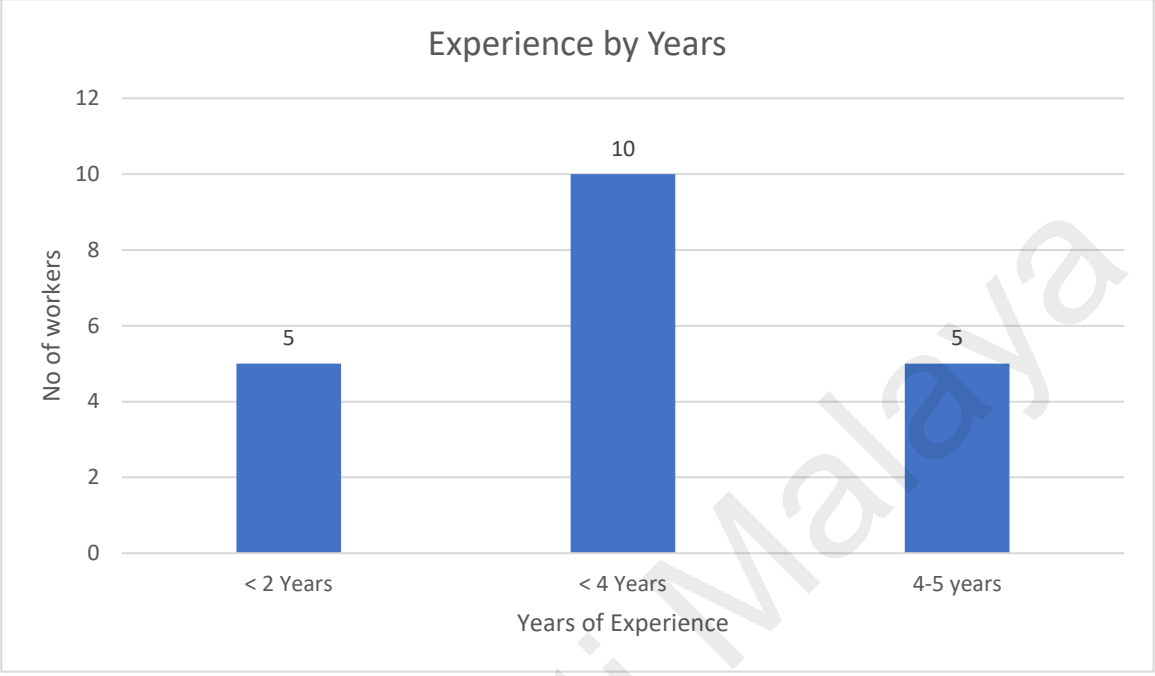


Figure 4.24 : Experience by Years

4.8.3 Work Environment & Safety Awareness

Based on the questionnaire analysis on safety health manuals and procedures, 16 of the respondents are aware on the placement of this manuals at their workplace. Safety manual is the collection of useful information, rules and regulation, policies involved and job steps for entire construction period. This ensure the safe dealing with heavy machineries, chemicals and tools that require proper techniques to deal with. The target should be on the balance 4 of the respondents who are not aware on this which could lead to possible accidents during at the site. A simple unsafe act could lead to any consequences to both property and people involved.

From the observation done, we could identify that Toolbox Meeting (TBM) was conducted every day before the construction work begin. This daily reminder on safety aspects and possible dangers lying on their works could make them more alert while carrying out their task.

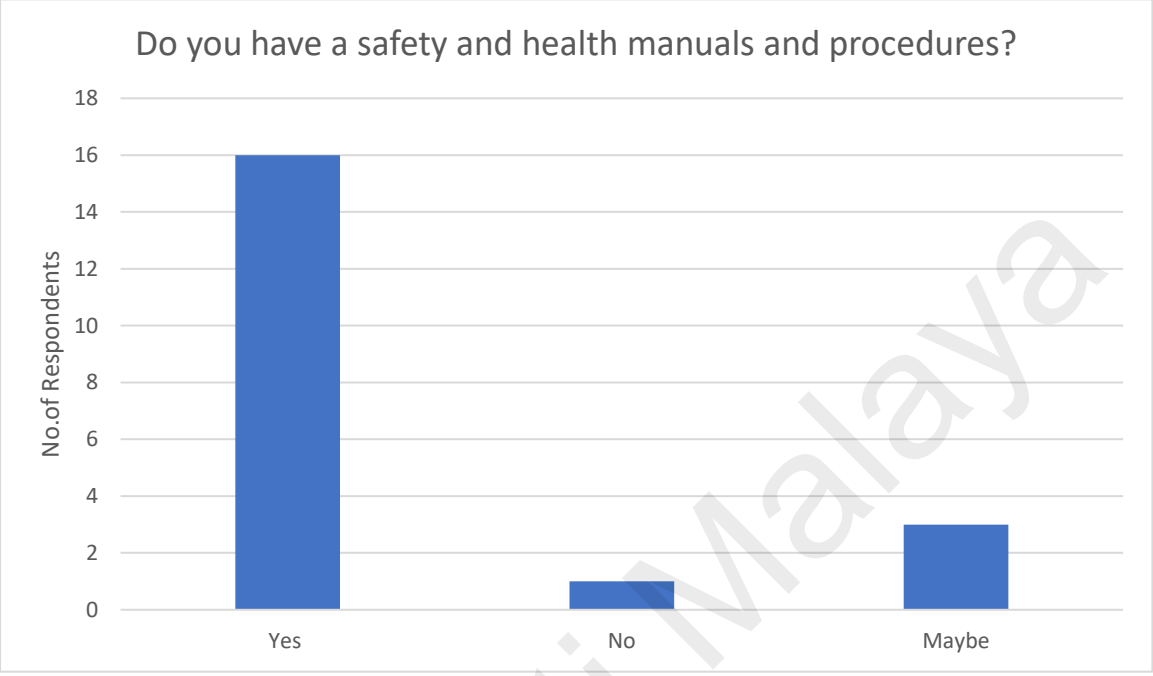


Figure 4.25 : Safety and Health Manuals at workplace

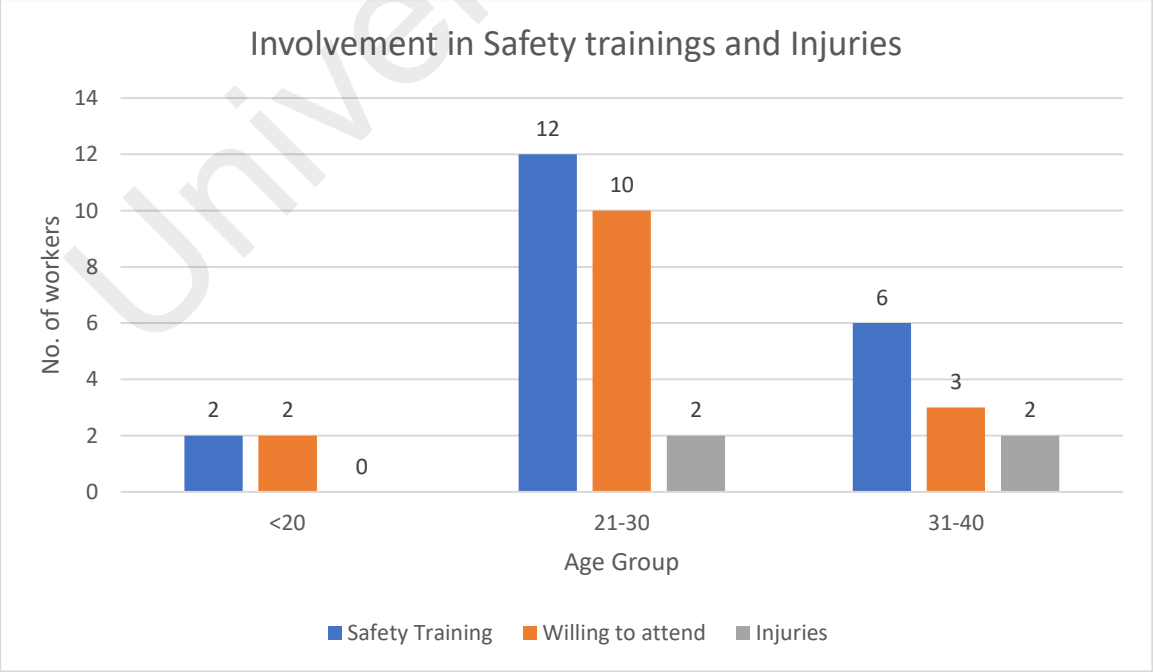


Figure 4.26 : Involvement in Safety trainings and Injuries

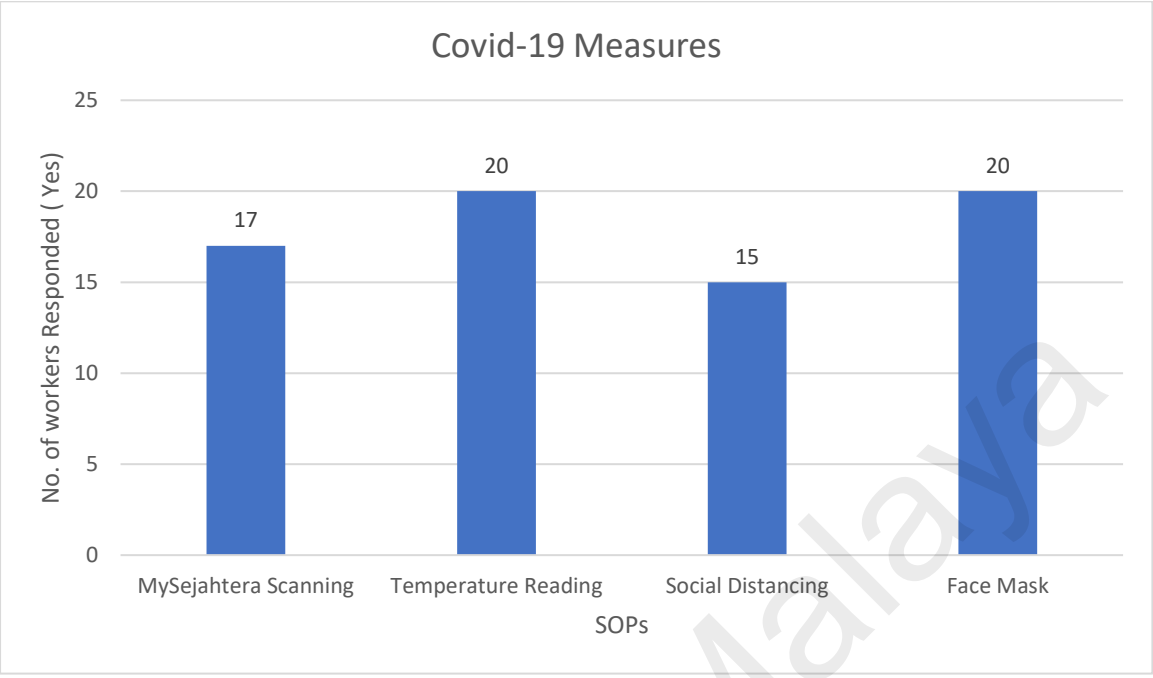


Figure 4.27 : Covid-19 Measures at construction site

Based on the findings on the Covid – 19 measures, everyone is obeyed to the mandatory face masking and temperature reading. Only 17 of them are scanning their presence using MySejahtera app and 15 of them are following the social distancing measures. This is due to the laziness to scan their MySejahtera app where temperature reading is effortless compared to other tasks. Management need to make it a mandatory part and fine those who disobey to these rules as this step can make it easier for the authority to identify those who were present in the work site when anyone got infected with Covid 19.

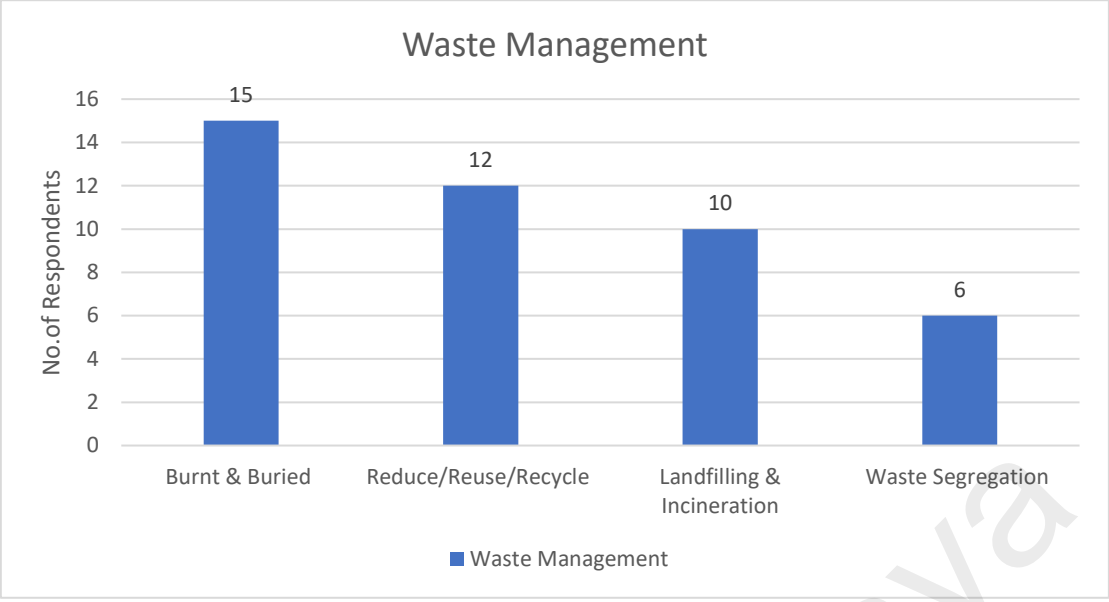


Figure 4.28 : Waste Management at construction site

As we see the chart above, we can find that constructors are urged to burn and bury the waste produced at the construction site as well. This is good but at the other it also emits most of the harmful gases to the environment which leads to health impacts to the workers and residents nearby to the site. One of the best examples is an initiative brought by University of Malaya where Zero Waste Campaign where organic wastes are converted into fertilizers for their own organic farming without disposing it neither to landfilling nor incineration. This initiative should be implemented by every university together with the construction of manmade wetland and streams to reduce the environmental impacts by composting the waste material produced as a fertilizer for the agriculture activities.

Figure 4.29 : UM Zero Waste Campaign

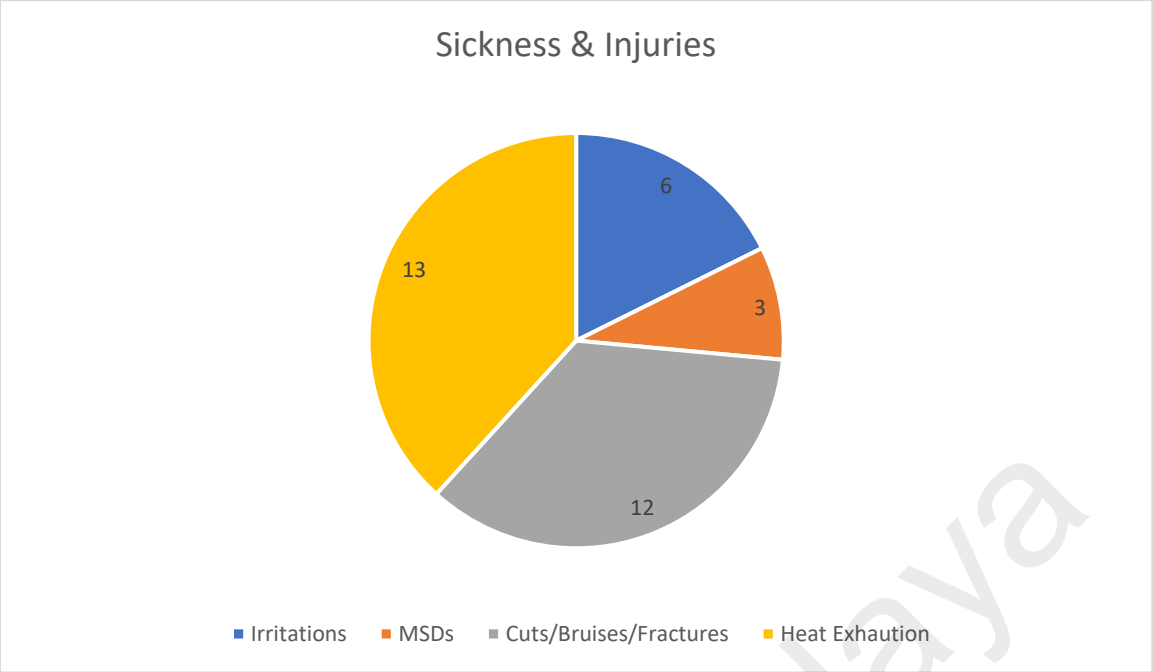


Figure 4.30: Sickness & Injuries

From the figure above, we can see that those who suffer with heat exhaustion is the highest which comprised of 13 out 20 of them. Management need to come out with an immediate action to prevent this in future. Cut, Bruises and fractures also play an important category which lies nearly the same to heat related sickness. This is due lack in awareness among employees and careless while dealing with sharp materials.

4.9 Environmental Impact Assessment (EIA)

Environmental Impact Assessment (EIA) is a process of evaluating the likely environmental impacts of a proposed project or development, taking into account inter-related socio-economic, cultural and human-health impacts, both beneficial and adverse. Although legislation and practice vary around the world, the fundamental components of an EIA would necessarily involve the following stages such as screening, scoping, assessment and evaluation of impacts and development of alternatives, reporting, review, and decision making and at last monitoring, compliance, enforcement and environmental auditing.

4.10 Control Measures

From this study, several control measures were determined based on the hierarchy of control comprising of elimination and substitution, Engineering control, administrative control and Personal Protective Equipment. We urged the management to give more focus on the hardest part which is prevention and substitution. This measure can bring the greatest impact in the long run and more promising towards a clean environment and workers health. We've suggested many enhanced control measures which is more sustainable and suit enough for current tech generation where everything can be accessed from their smartphone. More technical measures are more encouraged during this pandemic as many are scared to involve physically for any event in terms of trainings and big events.

4.10.1 Elimination & Substitution

Covid-19 is spreading at a fast pace around Malaysia and the cases are increasing rapidly over the year. As a responsible management, we need to take stern actions towards this pandemic as workplace clusters are the highest contributor for the infections. Thus, it is mandatory to restrict the entry of all visitors to the site unless they have proper approval and went through PCR test at least two days ago. If any worker has symptoms, they must be stay home till receive their RTK-Ag test for confirmation. Management should make it compulsory for all the site workers to attend the briefings on Covid 19 preventive measures and promote hygiene that focus on wearing a face mask, sanitize hand regularly and avoid close contact with employees. Management should also provide free face masks and hand sanitizers for all the workers despite top to bottom management to make sure they're replacing their face masks regularly for hygiene purpose.

Management should clean all the places with high density workers contact with disinfectants at least three times a week. As per the government rules, Dr. Khairy Jamaludin has urged the people to wear face mask even the worse situation back to epidemic as this is the primary preventive measure from infecting with contagious virus from sneezing or coughing. The loading and unloading process should only be carried out once the vehicle is sanitized properly.

As a preventive measure for heat stroke, wear loose fitting and lightweight clothes during construction activities at open area to prevent from over sweating. Management should provide plenty of fluid especially isotonic drinks for all the employees for hydration maintained throughout the 7 hours work period. Workers are also encouraged to wear white or brighter clothing as it is a good reflector of heat. They should also wear safety helmet to avoid direct exposure to excessive sunlight heat.

Based on the findings from LCA of clay and sand lime bricks productions, it is recommended that sand lime brick contributes to lower emission of CO2 to the environment (0.178 kg of CO_2 per 1kg of production). We found that the brick used in this construction site was sand lime bricks which is more strategy enough with minimal budget for raw material purchase since one sand lime brick cost RM 1.50 whereas clay brick is more expensive which is around RM 3.50.

We also found that any external constructions such as bridge construction (30 m approx.) from the existing construction site could damage the constructed wetland and streams. Soil erosion is one of a proof of damage due to heavy machineries movements and drilling activities. One should prevent this kind of heavy construction from getting approved from the management in the future to preserve the existing beauty and functionality of the wetland and streams. The pictures of the constructed bridge and soil erosion have been attached as follows :

Figure 4.31 : Constructed Bridge near to Manmade wetland & streams

Figure 4.32 : Soil erosion and clear visibility of PET bags which were initially inside the soil

4.10.2 Engineering Control

From the Questionnaire analysis, we found that there are many ergonomic related problems during the construction activities due to repetitive, excess force and irregular postures. Poor work practices and no recognition at an early stage can could lead to Musculoskeletal disorders (MSDs). Management need to identify those hazards and need to eliminate those excessive force and repetitive movements immediately to prevent future long run problems. Repetitive movements can be avoided by providing safe and effective work steps to complete the task given. They should be trained with proper techniques to avoid MSDs in the future. Job rotation is one of the efficient tool to avoid MSDs by reducing durations and avoiding concentrating on single task for a longer period. Employees must do stretching exercises to improve their blood circulation.

For excessive force, one should avoid excessive loads which can leads to fatigue and eventually MSDs in long run. They should slide the heavy loads instead of carrying or lifting it. Every worker should attend training sessions to know more on lifting techniques which can prevent MSDs problems. Irregular postures lead to many joint and muscle pains. Risk of MSDs is increasing with increased force in joints which are working outside the mid-range motion of the joint. Job rotation and stretching activities can help to minimize the sustained postures during a work task where for instance 10 minutes break for every 1-hour job task.

4.10.3 Administrative Control

Administrative control is considered when engineering control is failed to implement due to costing and other management factors. This control measure is mainly focusing on providing an alternative to the existing work procedures, policies, work schedules and trainings. Adult may not be easily motivated and the opportunity for taking education is restricted if compared with the children. The environmental education for the workers can be effectively carried out, especially for the workers together with their children by introducing related basic safety features which can enlighten both in different aspect by organizing activities which is capable for both. This can bring more awareness and keen to learn and teach more to their children as well since young. This will be the first and unique approach which never been carried out before elsewhere. Management will be more focused on the workers family as well to bring out the best safety culture in a whole as responsibility starts from their home.

Management should also encourage workers to participate in online training courses which is more popular during this pandemic. They should pay behalf of their employees to show their care for them and make them more vigilance enough while dealing with hazardous activities.

4.10.4 Personal Protective Equipment

PPE is the last level which is not encouraged to enhance and focus more as this measure is mostly follow by all the workers at the construction site. We observed that excavation, loading and unloading works brough most hazardous effects to the workers at the site. So, the usage of harness is a must while dealing with sky lift and unloading goods from height. This can reduce the consequences of a fall.

5.0 CONCLUSION AND RECOMMENDATION

The HIRARC model for safety and risk evaluation at construction site of manmade water streams and wetlands was done based on intense discussion and monitoring from the activities carried throughout the construction period. All the information received from this study was enough to create more enhanced strategies based on the final outcome of the risk level of each hazards identified. Based on HIRARC, we have identified 33 job hazards where mostly are possessed with low risk level (8 Job activities- 24%) which is less than 4. 23 Job activities (70%) were labelled as medium risk level while 2 (6%) jobs were categorized under High risk level and enhanced SOPs were suggested.

The water sources were from two main sites which is from Faculty of Engineering, UM and Mahsa University. Both the inlet sources not much polluted and this manmade water streams and wetland are capable enough to filter the water sources before discharge into the river. The water sources are comprised of organic matter such as food waste and laboratory chemicals from the engine fac which is less concentrated with strong reagents.

Based on the Life Cycle Assessment carried out on the materials used specifically on bricks, we can conclude sand lime bricks are better choice compared to clay stone which is expensive and emits more greenhouse gases (CO_2) to the environment. 0.178 kg of CO_2 were from the production of Sand Lime Brick whereas 0.301 which is almost doubled from the clay brick production.

Based on the Ergonomic Assessment, two main activities possessed dangerous repetitive, high force and postures which can lead MSDs in long term. Excavation (Digging), Loading and unloading are among two activities that need to be considered for immediate actioan whereas concrete construction and filtration chamber cotton fixing possesses lower MSDs risk.

Some recommendations that can be implement as an immediate strategy is job rotation, multiple breaks, sufficient amount of isotonic drinks and banksman placement during excavation and trenching activities. Safety harness usage and proper PPE can minimize the risk of getting involved with unwanted accidents which could lead to even death.

LCA allows you to consider these flows of energy and materials to and from the environment and so see what production stages have the most environmental impact. You can then identify ways to reduce the overall environmental impact of your product. For example, you may be able to reduce the amount of raw materials needed , use locally sourced, recyclable materials, avoid using toxic materials, use clean manufacturing technology to minimize emissions during manufacture, improve the energy efficiency of the product, use durable materials to increase product life, reduce packaging and reduce transportation.

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