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# THE CAUSES OF DELAYS AND DISRUPTION AT CONSTRUCTION PROJECT IN SERDANG SELANGOR, MALAYSIA

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**ABSTRACT**
Construction industry has become one of the greatest income provider as it has contributed to the Gross Domestic Product (GDP) for Malaysia. However, construction sector has been much affected by unexpected situation such as construction delays and disruption. This research discusses the importance of studying the construction sector through the identification of gaps between theory and practice associated with delays in the completion of construction projects. The objectives of this research are; To identify the causes and factors contributing to delay and disruption in construction projects. To investigate the effect of delays and disruption in construction projects, to determine the methods that can be used to minimize delays and disruption in construction projects. These objectives achieved through viewing different research paper, articles from previous studies, by considering all viewpoint from various parties that are involved in construction process such as contractors, client, consultant, and others, the research identified the major factors, causes and effects that contributes to delays and disruption in Serdang, Malaysia. Questionnaires were distributed among respondents that are involved in construction project in Serdang. The process of data analysis was conducted by using descriptive statistic that ranked the mean value of the factors, causes and effects that contributes to delays and disruption in construction project. By using the ranking method, financial difficulties were recognized as the most significant factor while cost, time overrun and dispute were recognized as the most significant effects that caused delays and disruption in construction projects. Based on the results and findings a framework has been developed to be an effective tool to help all parties to avoid causes of delay and disruption in construction projects. Finally, recommendations have been developed for each of the contracting parties (owner, consultant, contractor), in order to minimize and avoid the delays causes and get projects completed within the planned schedule.

**Keywords:**
*dyslexia, symptoms, visual dyslexia, dyslexic students, identification of dyslexia, level of learning*

## INTRODUCTION

There are a lot of construction project going on around the world, be it road construction or infrastructural construction, and a lot of the end users are experiencing delays at construction areas, and most of these areas contractors are now building alternative that are made to tackle congestion, moreover the construction project can as well create delay and congestion. According to Shehu et al. (2014) delay is a reoccurring incidence that can occur in almost every project carried out by any construction industry if appropriate project management knowledge is not employed. (Emeka 2016) claims that the competence of a construction industry or its project team can best be described by their ability to meet or complete the project on or before the project deadline.

Amoatey (2015) analyzed the major causes of delay and their influences on construction project. Their analysis was based on the numerous delay factors and effects on a project using two case studies Pakistan et al. (2014) delay may differ from project to project depending on the type and magnitude of the structure. Desai et al. (2013) mentioned that the view that project is generally associated with a complicated state of affairs in the course of execution. However, delay affect projects in many different ways. According to (Duodu 2016) Proper project management practice is also needed in trying to solve the causes and effect on escalation of cost in the construction project, delays in constructions is a universal problems and however a lot of countries around the world are facing this global fact.

**PROBLEM STATEMENT**

One of the biggest problems associated with most of the construction projects in the world todays is the problem of delay and disruption at both pre-contract and post-contract stages of construction in building and civil engineering works. In Malaysia the construction industry constitutes a very high percentage of the economy contract, Johor for example is among one of the developing state in Malaysia and also among the main urban centers on the peninsular Malaysia, it is also one of the main contributors to the nation GDP in the country after Kuala Lumpur and Selangor (Department of Statistics Malaysia, 2009). For example, Selangor, some of the most delayed and disrupted projects includes:

The construction of a flyover and road upgrade at the junction of the Bukit Jalil Highway and the Serdang Raya main road, the project which started in December 2006 was halted in July 2007 because of land issues and was stopped again in March the following year as the contractor had claimed that the flyover design by PWD was incomplete.

Figure 1.1: Construction of flyover and road upgrade at the junction of the Bukit Jalil Highway and the Serdang Raya main road.

The project was announced in December 2011 and expected to be completed in May 2012, However, it was delayed for more than seven months. The delay would not have happened if the project had been properly planned. The contractor did not carry out discussions early with the affected agencies, such as Tenaga Nasional Bhd (TNB) and Syarikat Bekalan Air Selangor Sdn Bhd (Syabas), to relocate their lamp posts and underground piping. Because this procedure was not properly carried out, the delay caused a lot of inconvenience to traders and residents, as well as motorists who regularly ply the route.

Figure 1.2: One-way street in Serdang in limbo.

Identifying some of the causes and factors of delays and disruption usually the first stage when addressing the problem and then a corrective measure would be taken, hence it is very essential that the researcher will diagnose some of the main causes, factors and effects of delays and disruption. This is because the principle reasons for delays and disruption may diverse at different places (Ogunlana & Prokuntong, 2008). In addition to that, this research will determine the possible way to minimize delays and disruption in construction projects from the perspective of those involved in the construction industry like the clients, the contractors, and the consultants. Based on the findings from the analysis some recommendations that would be aimed at reducing the impacts of delays and disruption caused to the construction industry has been outlined, the study would also clarify and create awareness of the extent to which delays and disruption can affect project delivery.

## RESEARCH OBJECTIVES

The research objectives allow the researcher to get an insight into a particular information of the topic in question. Research objective is also a clear and specific statements that identify what the researcher wishes to accomplish as a result of doing the research and also objective are mostly acceptable to the research community as proof of the researcher's clear sense of purpose and direction. The specific objective of this study are:

A. To **identify** the causes and factors contributing to delay and disruption in construction projects.
B. To **investigate** the effect of delays and disruption in construction projects.
C. To **determine** the methods that can be used to minimize delays and disruption in construction projects.

## RESEARCH QUESTION

The research question is one of the most critical part of research, it is important to develop some research question that the researcher is interested in, this research questions will help the researcher to focus completely on the research. The purpose of the Research question is to acquire and develop new information and knowledge from existing information on the topic of study with

the objective of formulating your findings to enable you complete your study on the topic. Choosing the proper question is important, questions that are neither too broad nor too narrow. This research work, intends to focus on the following question:

A. What are the causes and factors contributing to delays and disruption in construction projects?
B. What are the effects of delays and disruption in construction projects?
C. What are the methods used to minimize delays and disruption in construction projects?

## SCOPE OF WORK

The scope of this research will mainly be focused on location, main stakeholder, source of knowledge size and also literature review. This study is also needed to ascertain the level of understanding and knowledge whereby applying to delay and disruption, planning and field of operation while the questionnaire survey would be designed based on the effect and causes of delay and disruption in construction and also its effect on cost.

## LITERATURE REVIEW

This chapter will be focused on literature review of the topics that are related to this study, which includes the importance of construction industry, the main factors and causes of construction delays and disruption and also the methods used to minimize delays and disruption in construction projects.

Delays and disruption in the construction industry is a global problem that is faced by many construction industries all around the world, for this reason the extent of risk and uncertainty is on the high raise in the construction industries to be compared to other industries (Shujaa 2014). However, the problems of construction delays are a reoccurring issue in the engineering practice (Emeka 2016). This occurs often in the entire projects life span leading to conflict and legal proceeding Marzouk et al (2014). According to (Nihal 2015) there are many negative aspects that result from delays and disruption in construction projects for example; mistrust, dispute, arbitration, adversarial etc. the study also seeks to mitigate and reduce these problems and also the consequent negative effects.

## CONSTRUCTION DELAY AND DISRUPTION

Delays and disruption in construction is known to be the most widely hazardous and expensive problems that is being faced today in any construction project. Most projects in building are usually exposed to major threat on the time delay. Such kind of threat situations always lead to expansion of expense and time. Delays and disruption in construction projects may be caused by one or a mixed of few reasons which may begin with a basic reason and at the end lead to a great arrangement of an interrelated complex question in contract understanding.

## SUCCESS FACTORS IN CONSTRUCTION PROJECT

The success of most construction project always depends on many factors such as the experience of the project manager, the stability of the project team and the level of each of the planning, supervision, monitoring, cash flow and also control of the project etc. many researchers will agree

that the fundamental properties of a successful project is always significantly associated with good administration and also good management which includes planning, control, monitoring, specific and clear target and also providing motivation for the project employees Junxiao Liu et al. (2015).

Junxiao Liu et al. (2015) said some of the success factors for construction projects must always have successful management that will help to achieve three main goals which are time, cost and quality, these goals can be interrelated and any change in one or any of them could affect others and also success factors can be achieve through.

Finishing the project at less period of time.

Finishing the project at less cost.

Finishing the project with high quality.

## STAGES INVOLVED IN CONSTUCTION PROJECT

Every construction project passes through different stages and levels during the period of construction, it is also an idea for the owner or client to know the stages until it reaches the time of operation. Construction project stage can vary from one project to another depending on the nature and size of the project, but also begin and end with the owner and client. Furthermore, the stages of any construction project are always definite and clear because any fault made in the early stages of the construction project will affect the later stages, and it may become very difficult and also complicated to either improve or even correct, if not impossible.

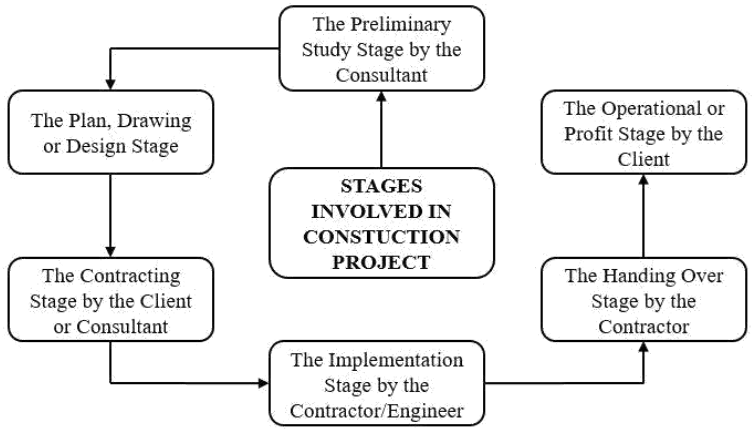


Figure 2.1 below shows the stages involves in construction project.

## TYPES OF DELAYS

(Rodriguez 2018) & (Lepage 2017). It is however important to always understand the various types in which a delay falls into before trying to analyze construction delays. To further initiate the mitigation efforts and to convert it into a merit. The various types of delays are as follows:

Excusable delays

- Excusable with compensation
- Excusable without compensation Non-Excusable delay

Concurrent delays

Non-concurrent delay

Critical or non-critical delays

There is also a need to understand the assimilation between the various types of delays before determining the impact of delays on the project. Must determine whether or not the delay is critical or non-critical. All delays are either excusable or non-excusable. Both excusable and non-excusable delays can be defined as either concurrent or non-concurrent. Delays can be further broken down into compensable or non-compensable delays.

## CAUSES AND FACTORS CONTRIBUTING TO CONSTRUCTION DELAY AND DISRUPTION

The causes of delays and disruption are factors or events that occurs during the process or before the process of construction that will affect the completion time of the project. And based on most research that has been done through journal, articles and some other reference. Project delay and disruption can be caused by many parties that involved in construction projects, which includes client, contractor, consultant, labor, material, equipment, financial, and some external causes.

Mohammad Saiful Islam et al. (2015) showed two types of factors that is caused by delay in construction project completion, these are internal and external causes. The internal causes are causes that are caused by one of the three main parties that are involved in the project (contractor, consultant and owner), and also the factors include: (administrative, technical, human and financial) factors etc. while the external factors are those factors caused by materials, government, political, weather condition. etc. there are also many reason that will lead to delays and disruption in construction project, which comes from various sources and cannot be counted, every project always has a special circumstances and environment that differentiate it from other projects such as the nature of work, total cost, contractors experience, flexibility in design, site condition and implementation.

## EFFECTS OF DELAYS AND DISRUPTION

The effects of delays and disruption is one of the main problem in the construction industry which either occurs during the process or before the process of construction that always affect the completion time of the project. And based on most research that has been done. Project delay and disruption can be caused by a lot of seen and unforeseen problems which includes:

A. Time Overrun
B. Cost Overrun
C. Dispute
D. Arbitration
E. Litigation
F. Total Abandonment

## METHODS OF MINIMIZING CONSTRUCTION DELAYS AND DISRUPTION

During construction phase of an ongoing project when delay occurs, the Owner suffers financially. However, the extent to which the Owner can recover back the losses of his or her income from the Contractor, and more importantly trying to minimize the risk of such delays occurring depends totally on how the construction contract document or agreement was written. But based on some studies carried out on the project success factors and rectification of delays in construction project.

Here are some important methods that have been identified in minimizing construction delays and disruption.

A. Frequent progress meeting
B. Use up-to-date technology utilization
C. Use proper and modern construction equipment
D. Use appropriate construction methods
E. Effective strategic planning
F. Proper material procurement
G. Accurate initial cost estimates
H. Clear information and communication channels
I. Frequent coordination between the parties involved
J. Proper emphases on past experience.
K. Proper project planning and scheduling.
L. Complete and proper design at the right time.
M. Site management and supervision.
N. Collaborative working in construction.
O. Compressing construction durations.

## RESEARCH METHODOLOGY

The methodology of this research will give a clear account of the approach used in the process of data collection and investigation in order to accomplish the objective of this research. It will also provide an explanation of the research design and approach, research strategy, study area and location, research population, techniques used, data collection processes and techniques employed for data analysis, design and development of questionnaires. This research methodology also provides a general understanding of how the research was coordinated.

## STUDY POPULATION

The study population for data collection was focused mainly on construction companies, consulting firms, clients of various large buildings. The target professionals are the engineers, architects, surveyors and project managers from this construction companies and consulting firms. Professionals where considered in each of the organization that will be visited. Many of these companies and firms are member of various registered professional bodies like the Construction Industry Development Board (CIDB), Board of Engineers Malaysia (BEM), Malaysia Institute of Architects (PAM). The data collected from these sources will be centered on large building structures owned, supervised, or managed, by the mentioned stakeholders in these study. These structures include shopping complex, schools, hotels, office buildings, skyscrapers, large residential building, and estate. And will also be collected from both the long-time abandoned project and the one that is still under construction but may have suffered delay.

## SAMPLING

Sampling technique is the relatively selection of a small number of individuals from which the researcher collects data from in order to enable him or her generalize about a larger body or group. Sampling techniques is relevant in research work most especially where it is not possible to survey the entire population due to time constraints or limited resources. According to (Saunders 2015), Population refers to the full set of elements or cases from which a sample is taken for investigation. The basic idea behind this is that the researcher selects some elements in a population by which he or she can draw conclusions about the entire population.

## METHODOLOGY OF THIS STUDY

The methodology of this study used the questionnaire survey to collect data then analyze these data to achieve goals of this study, the approach questionnaire, as major tool for data collection on subject of study. In addition, a questionnaire was developed to study the causes and effects of delays and disruptions in construction projects.

## ANALYSIS DISCUSSION

This will be focused on the data collected, analyzing the findings and presenting the results and discussion of questionnaire survey concerning the causes of delays and disruption in construction projects from architects, engineers, project managers, contractors, consultants and owner viewpoints in Serdang Selangor, Malaysia. The aim of this study is not only to assess the causes of delay and disruption in construction project but to also achieve the objects of this study in other to provide suitable solution to resolve or reduce the problems on delay in construction industry.

## STRUCTURE OF DATA ANALYSIS AND FINDINGS

This is the analysis of data collected through questionnaire survey in this research work. The analysis was done using SPSS, tables and percentage were necessary. The questions in the questionnaire survey and the data collected are all of equal and great importance and will be well analyzed, some are tabulated for retrieving necessary information in order to achieve the research objectives. All the questions in the questionnaire survey where focused on the research objectives and research questions as stated in the methodology. In analyzing these data, both the primary and secondary data gotten are linked for better understanding and determining of the research question and objectives.

The questionnaire survey distributed were designed to find out:

The factors and causes contributing to delays in construction projects.
The effect of delays and disruption in construction projects.
Methods of minimizing delays and disruption in construction projects.

**TOP CAUSES FOR CLIENT RELATED FACTOR**

Table 4.1: shows the single rankings and means and also the overall cumulative average mean of the client related causes and factors that leads to delays and disruption in construction project.

| | | Delay in progress payments | Change orders by owner during construction | Slowness in decision making process | Owner interference | Poor communication and coordination |
|---|---|---|---|---|---|---|
| **N** | **Valid** | 72 | 72 | 72 | 72 | 72 |
| | **Ranking** | 1st | 2nd | 3rd | 4th | 5th |
| | **Mean** | 3.49 | 3.46 | 3.36 | 3.25 | 3.15 |

**TOP CAUSES FOR CONTRACTOR RELATED FACTOR**

Table 4.2: Shows the single rankings and mean and also the overall cumulative average mean of the contractor related causes and factors that leads to delays and disruption in construction project.

| | | Poor site management and supervision | Poor communication and coordination | Ineffective planning and scheduling of project | Conlicts between contractor and other parties | Inaccurate time estimation by contractor |
|---|---|---|---|---|---|---|
| **N** | **Valid** | 72 | 72 | 72 | 72 | 72 |
| | **Ranking** | 1st | 2nd | 3rd | 4th | 5th |
| | **Mean** | 3.33 | 3.31 | 3.26 | 3.18 | 3.14 |

**TOP CAUSES FOR CONSULTANT RELATED FACTOR**

Table 4.3: Shows the single rankings and mean and also the overall cumulative average mean of the consultant related causes and factors that leads to delays and disruption in construction project.

| | | Delays in producingdesign documents | Mistakes and discrepancies in design documents | Poor communication and coordination | Unclear and inadequate details in drawings |
|---|---|---|---|---|---|
| **N** | **Valid** | 72 | 72 | 72 | 72 |
| | **Ranking** | 1st | 2nd | 3rd | 4th |
| | **Mean** | 3.19 | 2.99 | 2.99 | 2.97 |

**TOP CAUSES FOR MATERIAL RELATED FACTOR**

Table 4.4: Shows the single rankings and mean and also the overall cumulative average mean of the material related causes and factors that leads to delays and disruption in construction project.

| | | Changes in material types during construction | Delay in manufacturing special building materials | Delay in material delivery | Late procurement of materials |
|---|---|---|---|---|---|
| **N** | **Valid** | 72 | 72 | 72 | 72 |
| | **Ranking** | 1st | 2nd | 3rd | 4th |
| | **Mean** | 3.31 | 3.18 | 3.10 | 30.7 |

**TOP CAUSES FOR EQUIPMENT RELATED FACTOR**

Table 4.5: Shows the single rankings and mean and also the overall cumulative average mean of the equipment related causes and factors that leads to delays and disruption in construction project.

| | | Equipment breakdowns | Low productivity and efficiency of equipment | Low level of equipment operatr's skill |
|---|---|---|---|---|
| **N** | **Valid** | 72 | 72 | 72 |
| | **Ranking** | 1st | 2nd | 3rd |
| | **Mean** | 3.07 | 2.94 | 2.93 |

**TOP CAUSES FOR LABOR RELATED FACTOR**

Table 4.6: Shows the single rankings and mean and also the overall cumulative average mean of the labor related causes and factors that leads to delays and disruption in construction project

| | | Shortage of skilled labors | Working permit of labors | Shortage of labors |
|---|---|---|---|---|
| **N** | **Valid** | 72 | 72 | 72 |
| | **Ranking** | 1st | 2nd | 3rd |
| | **Mean** | 3.26 | 3.26 | 3.25 |

**TOP CAUSES FOR FINANCIAL RELATED FACTOR**

Table 4.7: Shows the single rankings and mean and also the overall cumulative average mean of the financial related causes and factors that leads to delays and disruption in construction project.

| | | Delay payment to suppliers and subcontrantractors | Owners financial difficulties | Contractiors financial difficulties |
|---|---|---|---|---|
| **N** | **Valid** | 72 | 72 | 72 |
| | **Ranking** | 1st | 2nd | 3rd |
| | **Mean** | 3.54 | 3.36 | 3.36 |

**TOP CAUSES FOR EXTERNAL RELATED FACTOR**

Table 4.8: Shows the single rankings and mean and also the overall cumulative average mean of the external related causes and factors that leads to delays and disruption in construction project.

| | | Delay in obtaining permits from authority | Weather condition on construction activities | Effects of subsurface and ground conditions | Traffic control and restriction at job site |
|---|---|---|---|---|---|
| **N** | **Valid** | 72 | 72 | 72 | 72 |
| | **Ranking** | 1st | 2nd | 3rd | 4th |
| | **Mean** | 3.44 | 3.29 | 3.11 | 3.00 |

## ANALYSIS ON THE EFFECT OF DELAYS IN CONSTRUCTION PROJECTS

Analyzing the effect of delays and disruption in construction projects. It is divided into six sections, Time overrun, Cost Overrun, Dispute, Arbitration, Litigation and Total Abandonment. in other to be able to ascertain which of these effects are the most problems faced as a result for the project being delayed.

### TOP EFFECT OF DELAYS IN CONSTRUCTION PROJECTS

Table 4.9: Shows the single rankings and mean and also the overall cumulative average mean of the effect of delays and disruption in construction projects.

| | | Time Overrun | Cost Overrun | Dispute | Arbitration |
|---|---|---|---|---|---|
| **N** | **Valid** | 72 | 72 | 72 | 72 |
| | **Ranking** | 1st | 2nd | 3rd | 4th |
| | **Mean** | 3.76 | 3.74 | 3.13 | 2.78 |

## METHODS OF MINIMIZING DELAYS AND DISRUPTION IN CONSTRUCTION PROJECTS

Analyzing the proposed methods for minimizing delays and disruption in construction projects. It is divided into fifteen sections; Frequent progress meeting, Use up-to-date technology utilization, Use proper and modern construction equipment, Use appropriate construction methods, Effective strategic planning, Proper material procurement, Accurate initial cost estimates, Clear information and communication channels, Frequent coordination between the parties involved, Proper emphases on past experience, Proper project planning and scheduling, Complete and proper design at the right time, Site management and supervision, Collaborative working in construction and Compressing construction durations. In other to be able to ascertain which of these are the most problems faced as a result for the project being delayed.

### TOP METHODS OF MINIMIZING DELAYS AND DISRUPTION IN CONSTRUCTION PROJECTS

Table 4.10a: Shows the single rankings and mean and also the overall cumulative average mean of the proposed methods for minimizing delays and disruption in construction project.

| | | Site management and supervision | Proper project planning and scheduling | Complete and proper design at the right time | Effective strategic planning |
|---|---|---|---|---|---|
| **N** | **Valid** | 72 | 72 | 72 | 72 |
| | **Ranking** | 1st | 2nd | 3rd | 4th |
| | **Mean** | 4.04 | 4.04 | 3.99 | 3.92 |

Table 4.10b: Shows the single rankings and mean and also the overall cumulative average mean of the proposed methods for minimizing delays and disruption in construction project.

| | | Use appropriate construction methods | Clear information and communication channels | Frequent coordination with the parties involved | Accurate initial cost estimates |
|---|---|---|---|---|---|
| N | Valid | 72 | 72 | 72 | 72 |
| | Ranking | 5th | 6th | 7th | 8th |
| | Mean | 3.72 | 3.72 | 3.72 | 3.69 |

Table 4.10c: Shows the single rankings and mean and also the overall cumulative average mean of the proposed methods for minimizing delays and disruption in construction project

| | | Collaborative working in construction | Use proper and modern construction equipment | Proper material procurement | Proper emphases on past experience |
|---|---|---|---|---|---|
| N | Valid | 72 | 72 | 72 | 72 |
| | Ranking | 9th | 10th | 11th | 12th |
| | Mean | 3.68 | 3.68 | 3.67 | 3.61 |

**SUMMARY**

The construction industry is one of the most important economic sectors in every country development and Malaysia is no exception, the researcher has closely outline some of the problems faced in the construction projects and also discussed the importance of studying the construction industry by identifying the gaps between theory and practice associated with delays and disruption in the completion of construction projects.

Projects pass through different stages during construction and can be summarized and categorized in the following four main stages and each stages involves three main steps.

**A. The preliminary study stage by the consultant**: Plan Development, Time and cost estimation and Resource management.

**B. The plan, drawing or design stage**: Have alternatives designs, Use of proper design systems and Monitoring and follow-up system.

**C. The contracting stage by the client or consultant**: Work by specialist, Preparing of contract documents and Available ethics and regulars.

**D. The implementation stage by the contractor or engineer**: Use of proper construction systems, Good management by using control and follow-up system and Using proper documentation system.

## FUTURE STUDIES

For future studies, causes, effects and also financial difficulty of delays and disruption should be carried out or done in other states or cities of Malaysia. Another study can be done for a specific type of construction project.

A. Another study should be carried out specifically on construction projects such as utility projects, highway construction projects, dam construction projects, water and sanitation projects, etc.
B. Another study should be carried out to help evaluate the involvement and effect of a specific party or resource to the delays and disruption in construction projects.
C. Another study should be done to investigate the effect of financial difficulty and cash flow problems from the client or contractor on delays and disruption in the construction projects.

## RECOMMENDATION

Giving proper recommendations for every research work is very vital because it helps the researcher propose some workable solutions to the research problem. From the data analyzed and the findings gotten certain factors and causes were obtained as the causes of delays and disruption failures, cost and time overrun in the execution of construction projects in Serdang. These factors and causes are bound to continue except both the public and private sectors undertake adequate action to control these causes starting from the preliminary stage. Furthermore, some practical recommendations have been stated in order to minimize delays and disruption failures in construction project. These recommendations are to be adhered to by the construction industry both public and private sectors. They are;

A. The need for project management awareness must be created in the construction industries and also made as a compulsory skill within the industry.
B. Adequate training programs and seminars should be introduced at lease quarterly, this will help equip the specialists with latest tools and its application.
C. Well-developed mitigation strategies should be adopted and practiced by the construction industry.
D. The government policies must be flexible enough to tackle crippling issues in the industry.
E. Good contingency plans should be incorporated in every construction project executed.
F. The contractors should be given close monitoring in the course of their project execution.
G. There should be frequent progress meetings with stakeholders where issues affecting the industry can be addressed
H. There should be proper site management, supervision and coordination between the clients and the contractors.
I. The contractors should always ensure proper material procurement and commitment to every project assigned to them.
J. All communication barriers between the project participants must be broken by ensuring information flows through the right channels and media.

## CONCLUSION

The outcome from this research work can be said to be of great value and importance to the construction projects and the industry. Most of the respondents are fully involved in construction projects with good experience which means they have adequate knowledge that has supplied the vital information needed. Delays and failures in delivering project on time and on budget has been established to be the major virus eating up the construction projects and the industry. This has caused damages on the nation's economy. The construction industry ought to be the bedrock of economic growth of any nation. Furthermore, the causes of construction delays and failures in Serdang has been linked to various causes as listed in the previous chapter. These factors can be brought to the minimal through increased knowledge and competency level in project management by contractors, owner and consultant, high level of stakeholders' influence, effective government policies and above all a proposed solutions and procedures for solving and avoiding these causes.

Finally, projects pass through different stages during construction, it is very essential in monitoring work progress as well as the scope, cost and time. If this is adopted and strictly adhered to, it will be a desirable end to the delays and failures experienced in the construction industry. This would help generate achievable expectations and increase control on project delays in Serdang.

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# POTENTIAL OF *MANGIFERA INDICA* SEED AS A COAGULANT FOR WATER TREATMENT

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## ABSTRACT
Water is a vital resource for human survival and it is essential for sustainable development, hence access to safe drinking water is important to human existing. The water need to go through several treatments to make sure it is not contaminated and safe to be consume. One of the water treatment procedures is coagulation and flocculation process, it is essential process in water treatment and wastewater treatment by using chemical coagulant such as Aluminium Sulphate (alum) as conventional substance. Alum is by far the most coagulant used in water and wastewater treatment, but however studies has shown that usage of Alum did give a bad impact to the health such as Alzheimer's disease and other related health problems. A natural coagulant is preferred is because of its low price, bio-gradation, and it is readily available. This study is to find a potential of a natural coagulant using mango (*Mangifera Indica*) to function like any available conventional coagulant such as Alum, including the processing of mango kernel to become a powder as a natural coagulant. This study will be carried out by using jar testing experiment to investigate coagulation and flocculation using *Mangifera Indica* seed and Alum to three different water samples from sample one from Seri Serdang Lake, sample two from Taman Metropolitan Lake and sample three from Taman Cempaka Lake. Result obtained show that, *Mangifera Indica* has potential in removing water turbidity up to 85.45% removed and according to World Health Organisation (WHO) turbidity removal above 70% with natural coagulant is accepted. As for pH, the value is recorded is between 8.05 to 7.30 after the water treatment it is still in the range of neutral according to pH scale and according to WHO, the standard pH drinking water is between 6.5 to 8.5 is acceptable. To conclude the uses of *Mangifera Indica* has potential as a coagulant in water treatment.

**Keywords***:*
*Alum, Jar Test, Mangifera Indica, Mango Kernel, pH, Turbidity*

## INTRODUCTION

Three quarter of the earth is covered with water with about 1.4 billion km³ including 97% sea water and 3% fresh water. Almost two-third of fresh water is icebergs and glaciers. The available of fresh water for daily use, industry only 0.8% from the total amount of water present on Earth (Dudeney, 2000). Moreover, water is a vital resources for human survival and it is essential for sustainable development, hence access to safe drinking water is important to human existing (Buamah & Ebeigbe, 2017). As water is so important, the water need to go through several treatments to make sure it is not contaminated and safe to be consume.

One of the water treatment procedures is coagulation and flocculation process, it is one of the most widely used techniques for removing suspended particles from water to make it safe and attractive for due to its simplicity and effectiveness (Choy et al., 2014), it is essential process in water treatment and wastewater treatment by using chemical coagulant such as Aluminum sulphate (alum) as conventional substance. When alum is reacting with water it produces positive charged ions, while the dirt particle has negative charge ions it neutralizes the charges thus, a sedimentation is happening at the bottom so it is easy to remove. Flocculation work well together with coagulation in water treatment, after the dirt has clumped together from the coagulation process, the clumps of waste is being removes by flocculation process (Dudeney, 2000).

Many coagulations widely used in conventional water treatment to make the water is safe to be consume. The coagulant consists of several class as inorganic, synthetic organic polymer and natural polymer (Noor,M.J et.al, 2004). Alum is widely used, but it has been the main concern that alum may cause several bad effect on human health such as intestinal constipation, loss of memory (Alzheimer), convulsion, abdominal colic's, loss energy and learning difficulties (Fathinatul & Nithyanandam, 2014). Due to health concern, there is increasing interest of a natural coagulant. Examples of natural coagulant is *Moringa Oleifera*, algae, *Mangifera Indica*, and *Citrus Auratifolia*. A natural coagulant is preferred is because of its low price, bio-gradation, and it is readily available (Yeoh Kar Chuan, 2007), it is cost effective, biodegradable and are presumed to be safe for human health (Sciban et al., 2009).

## LITERATURE REVIEW

The literature review involved an analysis of different types of coagulant for water treatment purpose. The studies involve of natural, plant and fruit based coagulant such as *Moringa Oleifera*, *Mangifera Indica*, and *Citrus Auratifolia*, to works as effective as conventional coagulant in water treatment plant. Next, the studies involved of measuring turbidity and pH value of the water sample. Turbidity is measured the degree of transparency in water due to presence of suspended particles. The higher the total suspended solids in water, the more darkly the colour, the higher the turbidity value. As for pH value is to determine the effect to human health causing from acidity that leave a staining effect corrosive to plumbing and metal (Adeniran & Dummoye, 2017).

Following that, coagulation and flocculation process are physical – chemical method that are widely used in treatment of waste water (Dange & Lad, 2015). Suspended solids in water have a negative charge, it will repel each other when they come in contact. Therefore, suspended solids will remain in suspension and will not clump together and settle out of the water, unless proper coagulation and flocculation is used (Prakash et al., 2014). Coagulations is a chemical process that involve mixing the coagulant with the water sample thus it will neutralized the electrical charges of particles which the particles will clumps together. While for flocculation is a process of slow mixing using Jar test apparatus with different speed and time through the whole process. This process will increase the particle size from invisible to visible suspended particles (Prakash et al., 2014). The process involve, is the collision of the invisible particles that causes to bond together and became larger and heavier thus it settle at the base by the gravity force. The flocculation process is happen after the coagulation process which only takes a very short times while flocculation takes the most time to settle down at the base.

Previous research has shown that *Mangifera Indica* seed has the potential to use as a natural coagulant that is cheap, organic and easy to get the sources. The used of *Mangifera Indica* seed in treating water has remove 92 % of the water turbidity (A. Seghosime et.al,2017). Based on the result, the objective of this journal has been obtain to analyse the effect of *Mangifera Indica* and *Citrus Aurathiifolia* seeds as locally available fruit waste on treatment of water turbidity by using Jar test.Next, *Mangifera Indica* seeds is effective over alum in purification of domestic waste water, based on the result obtain from the Jar testing, has shown that the initial turbidity level is 13 NTU and has decrease to 2 NTU with optimum dosage of 200 mg/L (Adeniran, K. A., & Dunmoye, I.D.,2017). Thus, *Mangifera Indica* seed can be use as an alternative in treating the water since it is environmental friendly and cheaper without any side effects.

Jar testing is method used to study the effect of coagulation, flocculation and sedimentation on treated water. This method is simple and effective way that simulate the process of existing water treatment plant.

## METHODOLOGY

Methodology is a systematic, theoretical analysis of methods applied to the field of study. In this studies, the methodology used was laboratory experiment on determined the effectiveness of natural coagulant and conventional coagulant in removing turbidity from three water sources around Selangor and Kuala Lumpur.

### *Collecting Water Sample*

The water sample was collected from the three different sources from sample one from Seri Serdang Lake, sample two from Taman Metropolitan Lake and sample three from Taman Cempaka Lake by using a steriled jug, then the water was bring immediately to IUKL Environment laboratory for treatment process. In addition, the amount of water sample collected from each sources is three point six (3.6) litres each for the use of water treatment process.

### *Sample Analysis before Treatment*

The water sample from three lake sources undergoes laboratory test at IUKL Environment laboratory. The turbidity and pH values is to be recorded before the water treatment started to be able to compare before and after the treatment.

### *Preparation of Coagulant*

*Mangifera Indica* was washed with tap water and sliced manually using stainless steel knife to obtain the seed. The seed is kept opened to atmosphere about 24 hours for drying as shown in Figure 1 and further dried for 24 hours in hot oven at 105°C as shown in Figure 2 and Figure 3. The dried seed is cut opened to obtain the dried kernel as shown in Figure 4 and Figure 5 shows the kernel has been extracted after 24 hours oven dried at 105°C. The dried kernel was mechanically to fine powder using grinder available in the lab and sieved to make it fine powder appropriate size of about 300 µm as shown in Figure 6. Preparation of Alum was started with measuring 1 grams of alum powder and mixed with 1000 ml distilled water. Then the solution is stir for 10 minutes to be completely dissolved into the distilled water.

Figure 1: The seed is left for air dried for 24 hours

Figure 2: Placing the *Mangifera Indica* Seed to the oven for 24 hours

Figure 3: Mangifera Indica seed after 24 hour Oven dried

Figure 4: The dried Mangifera Indica is cut to obtained the kernel

Figure 5: The kernel has been extracted after 24 hours oven dried at 105°C

Figure 6: The kernel after grinded and sieved

***Treatment Using Coagulant***

Coagulation and Flocculation process started with record the initial reading of turbidity level and pH level for each water sample. Water sample was poured into six label glass beakers with each measurement of 300 ml. The experimental work using the jar tester had been set up as shown in Figure 7. Then, different dosage of Alum stock is pour simultaneously into the beaker and mix immediately with 100 rpm for one minutes. After that, the speed is reduced to 40 rpm for 10 minutes to be able the water sample well mix with the coagulant, following with 10 minutes with zero rpm to allowed the sample to settled down and formed a sedimentation at the base of the beaker.

Following that, the process of using Mangifera Indica stock as a coagulant was by pouring simultaneously into the six label glass beakers with 150 rpm for one minutes, then the speed was reduced to 45 rpm for 10 minutes to allow the coagulant and the water sample well mixed and following with 60 minutes of settlement with zero rpm. Figure 8 shows the settlement process after water treatment process. As a result of the settlement process, the water sample is collected by using a glass pipet to extract the water sample without disrupting the formation of sediment at the base to obtain pH and turbidity samples as shown in Figure 9. Finally, the pH and turbidity results of treated water were determined and recorded by using pH meter and turbidimeter as shown in Figure 10 and Figure 11.

Figure 7: Jar Tester set up

Figure 8: Settlement process after water treatment

Figure 9: Extract the water sample to obtain pH and turbidity sample

Figure 10: PH results were recorded by using pH meter

Figure 11: Turbidity results were recorded by using Turbidimeter

## RESULTS AND DISCUSSION

Table 1 shows the result obtained of initial and residual reading of turbidity and pH value of water sample 1, 2 and 3 with different dosage of Alum stock solution added. According to Table 1, the initial turbidity for water sample 1, 2 and 3 is 62.13 NTU, 46.43 NTU and 39.53 NTU it is less than 50 NTU and 100 NTU it is moderate, low and low turbidity (Noor M.J et.al, 2004). After the treatment using Alum, the turbidity value is decreased as stated the Malaysia guideline for Drinking Water Supplies is less than 5 NTU (Noor M.J et.al, 2004). In short, the lower the turbidity value obtained, the clearer the water is. As result shows that, the coagulant added effectively neutralized the negative charges in colloid in the water sample, thus a sediment is

formed at the bottom of the beaker after 10 minutes of settlement using Alum. The turbidity percentage removal after the treatment is in between 65.34 % to 99.12 % removed. Optimum dosage is achieved by the lowest turbidity value recorded after the treatment, the lowest turbidity value recorded for sample 1, 2 and 3 is 2.23 NTU, 0.41 NTU and 1.44 NTU. Figure 12 shows, the pattern of the experiment according to turbidity (NTU) versus the Alum stock solution added to the three water samples after the treatment.

The initial pH values for sample 1, 2 and 3 is recorded at 7.79, 7.90 and 6.88 which were consider as neutral in pH scale. pH of water treated of Malaysia standard is between 6.5 and 9 (Noor M. J et.al, 2004). The pH value obtained after the treatment is between 6.51 to 8.04, it is still in the range of neutral according to pH scale and Malaysian standard. In addition, according to National Water Quality Standard for Malaysia (NWQS) the pH is in the range in Class IIA and IIB. Figure 13 shows the pattern of the experiment according to pH versus the Alum stock solution added to the three water samples after the treatment.

The initial and residual reading of turbidity and pH readings using *Mangifera Indica* as a coagulant for sample 1, 2 and 3. The initial turbidity and pH readings for all water sample is same as stated above, it is moderate and low turbidity type. After the treatment using *Mangifera Indica* seed, the turbidity value is decreased between 20.3 NTU to 6.76 NTU, the turbidity reading after the treatment decreased almost half compare to initial turbidity reading. According to World Health Organisation (WHO) stated that turbidity removal above 70% with natural coagulant is accepted (A. Seghosime et.al, 2017). Based on the result obtained the turbidity percentage removal after the treatment is between 48.65 % to 85.45 % removed. As shown in Table 1 below, the higher dosage of *Mangifera Indica* added to the water sample, the higher the turbidity value compared to the lower dosage of coagulant added. The reason the more dosage added, the higher the turbidity value is because of the amount of colloid particle in the *Mangifera Indica* coagulant is larger it is causing the *Mangifera Indica* powder does not well mixed with distilled water, and has more colloid compare to the small dosage coagulant added. Figure 14 shows the pattern of the experiment according to turbidity (NTU) versus the *Mangifera Indica* stock solution added to the three water samples after the treatment.

Stated in Table 1 below, the initial pH values is recorded for water sample 1, 2 and 3 is 7.79, 7.90 and 6.88, which is consider as neutral in pH scale. Figure 15 shows the pattern of the experiment according to pH versus the *Mangifera Indica* stock solution added to the three water samples after the treatment. The pH value is recorded between 6.51 to 8.05 after the treatment using *Mangifera Indica* seed it is still in the range of neutral according to pH scale. According to NWQS the allowable pH is between six to nine for Class IIB the uses for recreational use body contact and according to World Health Organisation (WHO), the standard pH drinking water is between 6.5 to 8.5 is acceptable (Addo,2011).

Table 1: Initial and Residual Experiment Result Using Alum and *Mangifera Indica* for 3 water samples

| | | Water Sample | | | | | |
|---|---|---|---|---|---|---|---|
| | | Sample 1: Seri Serdang Lake | | Sample 2: Taman Metropolitan Lake | | Sample 3: Taman Cempaka Lake | |
| Initial Reading | | | | | | | |
| | | Turbidity (NTU) | pH | Turbidity (NTU) | pH | Turbidity (NTU) | pH |
| | | 62.13 | 7.79 | 46.43 | 7.90 | 39.53 | 6.88 |
| Residual Reading | | | | | | | |
| Coagulant | Stock Solution Dosage (ml) | Turbidity (NTU) | pH | Turbidity (NTU) | pH | Turbidity (NTU) | pH |
| Alum | 3 | 13.77 | 7.74 | 4.02 | 8.04 | 13.70 | 7.06 |
| | 6 | 8.54 | 7.49 | 1.26 | 7.76 | 6.12 | 6.87 |
| | 9 | 6.62 | 7.44 | 0.45 | 7.60 | 2.66 | 6.76 |
| | 12 | 3.39 | 7.26 | 0.76 | 7.60 | 1.96 | 6.93 |
| | 15 | 3.45 | 7.40 | 0.66 | 7.56 | 1.44 | 6.59 |
| | 18 | 2.23 | 7.34 | 0.41 | 7.52 | 2.01 | 6.51 |
| *Mangifera Indica* | 9 | 11.63 | 7.18 | 6.76 | 8.05 | 14.90 | 7.07 |
| | 18 | 12.90 | 7.20 | 8.34 | 7.80 | 16.37 | 6.85 |
| | 27 | 13.93 | 6.91 | 9.64 | 7.72 | 17.60 | 6.70 |
| | 36 | 15.93 | 7.30 | 11.63 | 7.56 | 20.30 | 6.57 |
| | 45 | 15.40 | 6.68 | 12.07 | 7.44 | 18.57 | 6.51 |
| | 54 | 17.30 | 6.66 | 13.33 | 7.30 | 19.27 | 6.36 |

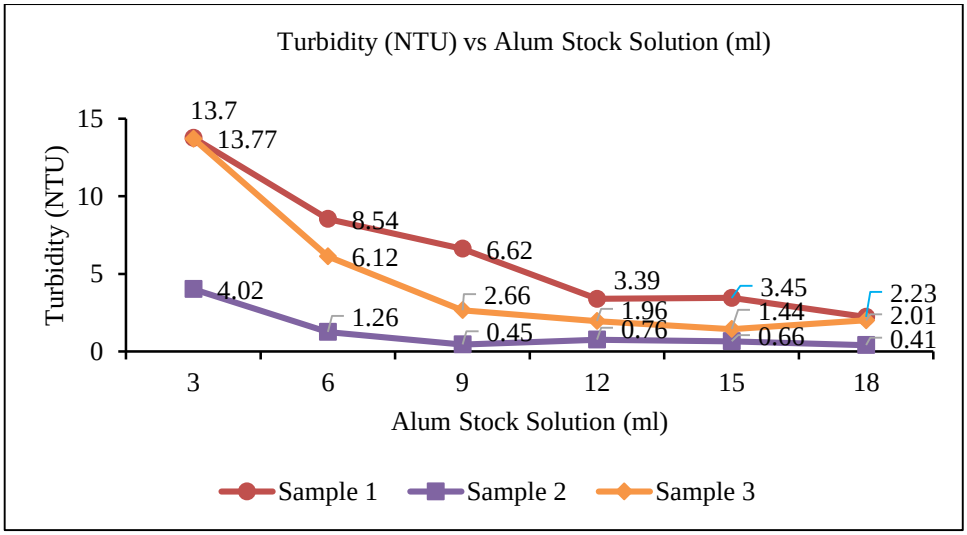


Figure 12: Turbidity (NTU) versus Alum stock solution (ml) for water sample 1, 2 and 3

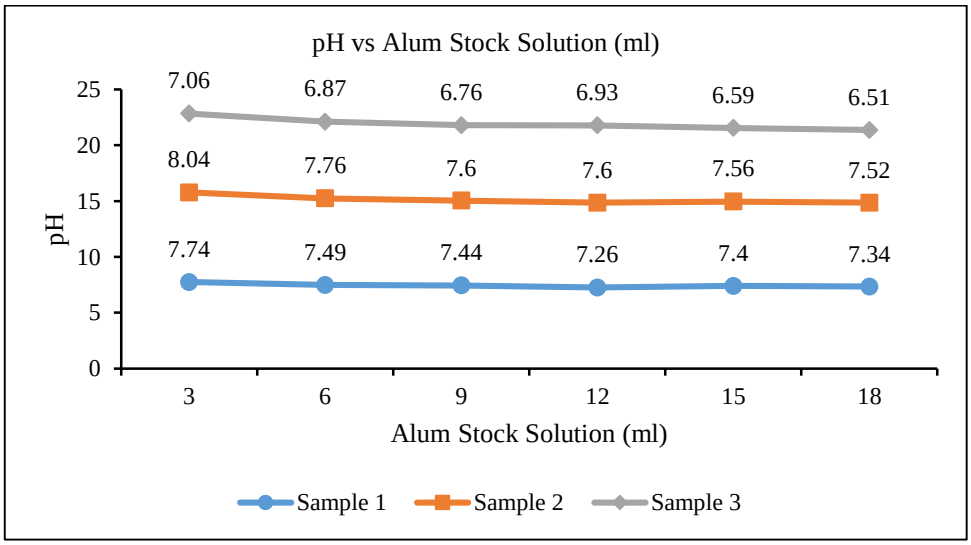


Figure 13: pH versus Alum stock solution (ml) for water sample 1, 2 and 3

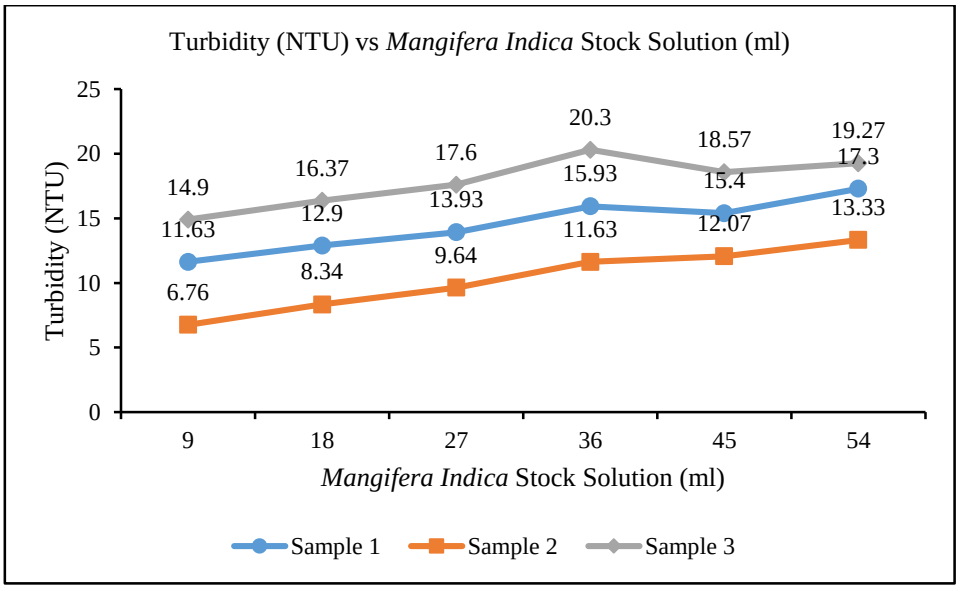


Figure 14: Turbidity (NTU) versus *Mangifera Indica* stock solution (ml) for water sample 1, 2 and 3

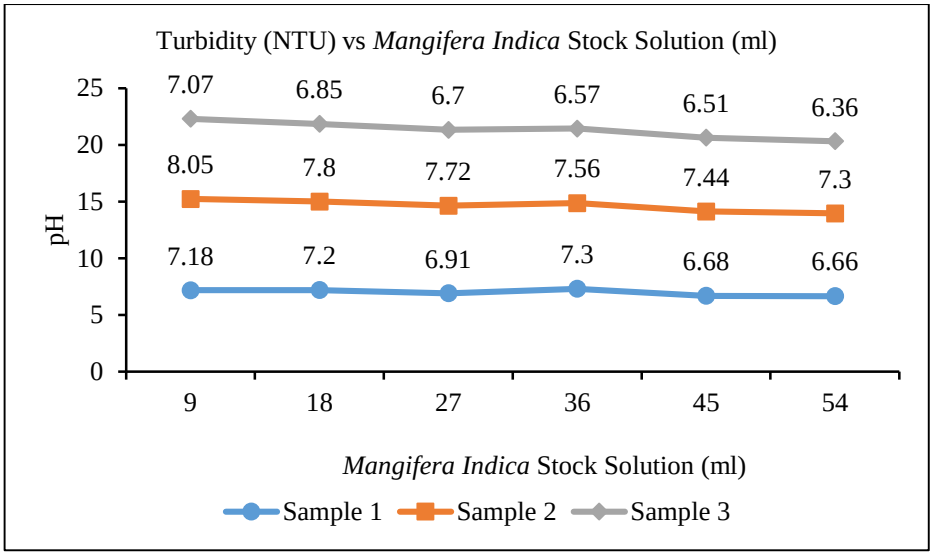


Figure 15: pH versus Mangifera *Indica* stock solution (ml) for water sample 1, 2 and 3

## CONCLUSION

The conclusion of this researched studies are outline as follows:

1. Objective 1: To determine turbidity and pH using *Mangifera Indica* seed and alum comparing the results of 3 different sources by using Jar test.
   The studies are successful as researched involved in determine turbidity and pH using different types of coagulant pouring into 3 water samples with using Jar test method, are able to make a comparison between the usage of Alum and Mangifera Indica as a coagulant in all water sample. As a result, the used of Alum and Mangifera Indica as a coagulant able to reduce the turbidity in water, as for pH does not effected by the coagulant added as it remain neutral before and after the treatment.
2. Objective 2: To determine the optimum dosage of the *Mangifera Indica* seed by Jar test method.
   To determine the optimum dosage of a coagulant is by the most turbidity reduction compare to few different dosage of a coagulant added. For Mangifera Indica the stock solution added is from 9, 18, 27,36,45,54 ml. Based on the result obtain through Jar test from week 18 to week 23 in Environment Laboratory Block 9, the optimum dosage of *Mangifera Indica* is at 9 ml of coagulant added to the three water sample with turbidity removal 62.31% to 85.45%.
3. Objective 3: Compare the effectiveness of alum and *Mangifera Indica* seed as coagulant.
   According to the result obtained from the laboratory experiment, the effectiveness of using Alum as coagulant cannot be denied as it is effective in removing water turbidity almost 99.12%. Following that, the percentage removal by using *Mangifera Indica* as coagulant is able to remove up to 85.45%. In conclusion, the usage of Alum is more effective compare to *Mangifera Indica.*

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# CONSTRUCTION AND DEMOLITION WASTE MANAGEMENT IN MALAYSIAN CONSTRUCTION INDUSTRY – CONCRETE WASTE MANAGEMENT

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**ABSTRACT**
Construction industry is continuing to be one of the principle drivers of development in Malaysia. Malaysian construction sector plays an importance role in increasing income for the country and providing job opportunities. The rapid development in Malaysia has increased the demand of concrete for construction purposes and on the other hand the concrete waste is also increasing every year and it has been pointed out as the most generated waste from construction industry. Concrete wastes are having the huge component size and harm to the environment. Meanwhile, the increasing of concrete wastes has created the landfilling issue. Malaysia is having limited landfill areas and those concrete wastes are rapidly fill up the landfill and caused the saturation of landfills. Besides, Malaysia is a developing country and there is less of knowledge and skill of waste management. The lack of efficient and proper waste management technologies has caused the increasing of construction cost and waste of resources. In fact, conduct a proper and efficiency concrete waste management technology is the long-term solution to saving the construction costs, prevent the depletion of natural aggregates resources, solve the landfills problem and protect the natural environment. Therefore, the aim of this research paper is to investigate and conclude out a proper concrete waste management which could improve the current concrete waste management in Malaysia. A literature review from related books, conferences papers and journal articles was carried out. The findings show that the awareness of Malaysian construction industry regarding waste management is still generally low and there is very little information on the study of current concrete waste management in Malaysia. Hence, an investigation is needed to find out the current situation of concrete waste management in Malaysia and along with find out an efficient waste management practices. Questionnaire approach has been adapted to achieve out the research aim and objectives. From the data obtained, current circumstances of construction and demolition waste management in Malaysia, level of awareness of construction practitioner and the best alternative concrete waste management practice have been found. It found that concrete caused most construction problem in Malaysia. Other than that, it found that Malaysian construction practitioner has high awareness level on C&D waste management, and they are having high expectation and willingness on improve the current C&D waste management situation in Malaysia.

**Keywords:**
c*oncrete waste, construction and demolition waste issues, construction waste management practices, 3R concept strategies, law and enforcement.*

## INTRODUCTION

As a developing country, the construction industry is continuing to be one of the major principles to Malaysia economy. According to Raze et al. (2013), Malaysia has executed many projects such as high rise commercial, highways, expressways, tunnels, bridges, industrial buildings, schools, hospitals, power plants, mass rapid transit rail system and housing schemes. Besides, Malaysia has also executed many construction projects for the tourism and manufacturing sectors. Some of the projects that have been completed by the Malaysian construction industry are Petronas Twin Towers (1992-1998); Kuala Lumpur International Airport (1993-1998); North South Expressway (1994); Maju Express Way; Stormwater Management and road tunnels (2003-2007) and several

other projects (Raze et al. 2013). The Malaysia government has spent a lot on the Malaysian construction industries. According to the Department of Statistics Malaysia (2019), there was a dramatical growth of construction output in 2017 with 7.2 percent compared to 2015.

As the speed of most countries' development far exceeds what we expect, the usage of concrete also increases dramatically. In Malaysia, the production and consumption of cement has grown significantly at 2% - 6% annual cement production growth, and an average of 13.8% annual growth for concrete production from 2011 until 2016 (MyCC. 2017). The huge consumption of concrete and rapid development has directly influenced and increased the amount of concrete waste. Thus, efficient solutions should be explored to overcome the problem before it becomes a crisis.

The rapid construction development is causing a serious problem of depleting natural aggregates and creating a huge amount of concrete waste in Malaysia and in other developing countries. The consumption of natural aggregate is huge for concrete as a natural aggregate is one of the key ingredients of concrete which comprise ¾ of this ingredient. The excessive consumption of natural aggregates will accelerate the depletion of natural aggregate resources and Malaysia will face the decline in the aggregate supply if there are no proper control measures for the aggregate consumption (Abdul Rahman, 2009). Therefore, natural aggregate consumption issues must be addressed with the concrete waste issues before the crisis. The concrete and construction industries need to explore the possibilities of using recycled concrete in the production of new concrete. Recycled concrete is considered as one of the best alternatives to replace the use of natural aggregate and overcome concrete wastage (Sallehan, 2013)

## LITERATURE REVIEW

### Current Concrete Waste Issues in Construction Industries

The rapid growth of development in Malaysia has led to a huge depletion of cement, a natural aggregate; and this has consequently led to the production of a huge volume of concrete waste. The growth of concrete consumption and the amount of concrete waste correlate to the growth of the country's development. The Malaysian construction industry's waste constitute a large portion of solid waste every year in Malaysia (Begum. R.A. 2007). The excessively generated construction waste is affecting the environment and causing social problems in the surrounding communities. According to Begum.R. A (2006), construction waste generated from a construction project site of a new building is estimated around 27068.4 tonnes. The construction waste is divided into 8 types and the concrete and aggregate waste is the highest generated waste among these wastes with 17820 tonnes or 65.8% of the total generated construction wastes. From another study in Sarawak, construction waste and debris disposed after the completion of a project can be sorted into three categories which are masonry rubble, concrete waste, and timber and metal with 40-45%, 30-35% and 6%, respectively (Wong, 2012).

### Ready-mixed Concrete Waste

In ready-mixed concrete batch plants, the production of concrete is accurately weighed for the required quantity of the main ingredients and well mixed in the mixer truck drums or in a static pan mixer (Sealey B.J., 2001). In Malaysia, the ready-mixed concrete is commonly used to construct structures of building. a result has reported that a medium-sized plant may generate about 20 to 80 tonnes of concrete waste per month and that would have around 0.75 million tonnes of concrete waste generated every year in UK by ready-mixed concrete batch plants.

Over-order of concrete is also a major contributor to concrete waste. An estimation states that the extra ordered concrete created about 8-10 tonnes fresh concrete waste every day from a batch plat with daily output of 1000$m^3$ of concrete. From a global perspective, it is estimated that over 125 million tonnes of returned concrete waste (0.5% of total concrete production) are generated every year and it has become a serious construction waste issue and is a heavy burden to ready-mixed batch plants (Kazaz A., 2016).

Most of the ready-mixed concrete plant waste appear from washing out truck mixer drums or washing down yard and plants after the working hours to prevent residue concrete getting harden in the drum overnight. Fresh concrete waste is generated during the different phases in production of ready-mixed concrete. About 165 to 350 million tonnes fresh concrete waste is generated every day in the world (Iizuka A. et al., 2017). There are about 250-350 kg residue fresh concrete waste in each truck mixer drum (Paolini M. et al. 1998). The reasons for generating unwanted fresh concrete waste is listed below:

- Wide margin orders of ready-mixed concrete – The estimated amount by a quantity surveyor is usually 10% more than what the project actually needs because insufficient ready-mixed concrete need is a concern when there is additional construction or construction mistakes have been made. The additional ready-mixed concrete may not be delivered in time in the busy period of a concrete batch plant. Thus, over-order is found as the best solution rather than calculate the exact quantities of concrete accurately (Kazaz A. 2016).
- Wrong calculation of ready-mixed concrete quantity – This often happens when the orders are made by workers who do not have the requisite technical knowledge like civil engineers and this causes extra ready mixed concrete to be ordered (Ulubeyli S. et al. 2004).
- Poor workmanship during the mixing of concrete – lack of relevant technical knowledge during the pouring activity.
- The adhesive concrete that is stuck in truck-mixer drums, yard and plants.

**Precast Concrete Waste**

Precast concrete is a construction concrete product which is casted in a reusable steel mold in a precast concrete factory or plant. In Malaysia, the concept of precast concrete system started after the Ministry of Housing and Local Government of Malaysia visited several European countries and this became the starting point for using the precast concrete system in Malaysia, although the idea was not popular in the early 1960's (Ng B.K. 2012). Thus, the precast concrete system is not a new technology to the Malaysian construction industry and the local precast concrete manufacturers are currently growing in Malaysia.

The precast concrete system has effectively reduced construction cost and improved the quality by reducing the labour intensity and construction standardization. Besides, this method has better quality control and has provided a cleaner environment. Other than that, it also minimizes wastage, usage of site material and also reduces the total construction costs (Ng B.K., 2012). According to *Waste reduction potential of precast concrete manufactured offsite (CIRIA, 2018)*, the amount of waste that could be reduced by using precast concrete system is around 20-50% compared to traditional construction approaches. However, there is still some concrete waste generated during the manufacturing process of precast concrete, after the process and during the transportation phase. Angel S. et al. (2017) claimed that there are many rejected precast concrete in precast concrete industry due to stringent quality control.

There are a lot of rejected precast concrete waste generated every day. The reason for the generation of unwanted harden precast concrete waste are listed:

- Lack of design or incorrect design caused due to manufacture error – Improper design may cause connection problems during installation. According to Ng B.K. (2012), the lack of precast concrete design for toilets and bathrooms has led to leakage problems. Thus, those unaccepted precast concrete parts may be rejected and disposed.
- Lack of knowledge and skills to produce high-quality precast concrete – Most of the local contractors still lack knowledge of the precast concrete system (Ng B.K. 2012). When low quality or broken precast concrete are produced, they are rejected and eliminated.
- Precast concrete components break during handling or transportation phase – these are rejected and disposed.

**Demolition Concrete Waste**

In the recent past, Malaysia has been considered a rapidly developing country. The speed of the country's development is extremely fast compared to what we thought. Thus, many demolition projects have to be carried out to tear down old building structures to provide space for new building developments.

The amount of demolition wastes generated is two times more than the amount of construction waste (Gunalaan V. 2015). Therefore, excessive demolition projects in a developing country will cause excessive demolition waste and the impact of demolition waste will definitely be more serious than the impact from construction waste.

From past studies, it is found that concrete waste contributes a huge amount to the total amount of demolition waste which is 24%. This has led to serious concrete waste issues and recycling of demolition concrete waste is still neglected. In European countries and United States, there are about 50-60 million tonnes of demolition concrete generated every year. The demolition concrete is mostly dumped and only a little demolition concrete is currently recycled in the country (Asif H., 2013).

**Current Common Practice of Concrete Waste Management in Malaysia**

In Malaysia, there are several concrete waste management practices that have been implemented. With those waste management practices, there are 3 concrete waste management that are currently most common used by the Malaysian construction industry (Huang et al., 2018) (Sasitharan N. et al., 2012) (The Ingenieur, 2009).

I. Landfill Disposal Method
II. 3R concept – Recycle, Reduce, Reuse
III. Illegal Construction Waste Dumping

***Landfill Disposal Method***

In Malaysia, landfilling and incineration are currently used as the major waste management methods to reduce construction wastes. According to *The Ingenieur* (2009), disposing of construction waste to landfill is one of the common methods in Malaysia.

Most of the contractors do not like to implement this good waste management practice because they argue that the waste materials have only less value and they choose to

dispose waste to landfills (Sasitharan N. et al., 2012). According to the Malaysia Solid Waste and Public Cleansing Management Act 2007 (Act 672), 'disposal' means the disposal of any solid waste including destruction, incineration and deposit or decomposing. In Malaysia, there are 289 landfill sites distributed in all states and 113 of these landfill sites have stopped operation due to protests from surrounding residents as the landfills are a nuisance to their surrounding or the landfills sites have hit their maximum disposal capacity (Sasitharan N. et al., 2012).

***3R concept - Recycle, Reduce, Reuse***

The 3R concepts programme (reduce, recycle and reuse) has been promoted by Malaysia government to construction industry and the 3R concept is based on the idea of fully utilizing the resources before it goes to disposal stage. The 3R concept – reduce, recycle and reuse has been generally agreed to be a guidance for construction and demolition waste management (Huang et al., 2018).

The recycling and reuse rate in some developed countries such as United States, Denmark, South Korea, Singapore, Japan and Germany can reach about 70% - 95%. Most of the construction industries have still not implemented the 3R concept into their sites and some of them are still unaware of the 3R concept (Tey J.S., 2012). However, the 3R concept is still at its infant stage in Malaysia, and recycling and reuse methods are still very limited in use which is only around 5%.

***Illegal Construction and Demolition Waste Disposal***

Illegal dumping means intentional and not legal dumping of waste in unauthorized areas. Illegal dumping activities are usually carried out to avoid paying landfill fees and save on transportation cost and time to dispose waste. Illegal dumping has become a critical problem in many countries such as Italy, Australia, Spain, Israel, China, Hong Kong and other countries with rapid gross domestic product (GDP) growth (Lu W., 2019).

Illegal waste dumping issues have increased rapidly in Malaysia. A previous study by Sasitharan N. et al. (2012) claims that 42% of total 46 illegal dumping sites are filled with construction waste in Johor. In Sebrang Perai, Pulau Pinang, it has been found there are many illegal dumping sites along roads.

There are almost 30 tonnes of construction waste illegally dumped in tropical mangrove swamps near Bandar Hilir, Malacca (Sasitharan N. et al., 2012). Other than the mentioned cities, illegal construction waste dumping issues are also a very serious problem in other cities in Malaysia.

These illegal dumping activities are causing the harmful risk sto human health and damaging living environment in many ways. These construction wastes contain toxic substances especially in concrete waste. Illegal construction waste dumping has also caused wildlife deaths, destroyed habitats, and damaged the natural landscape (Paolini M., 1998). Besides, illegal dumping also causes soil and underground water pollution.

**Policies, Law and Enforcement in Malaysia**

In Malaysia, construction waste management is still not implemented effectively to deal with waste issues. There are approximately 25,600 tonnes of construction and demolition wastes produced every day due to the rapid development in Malaysia (Saadi N., 2016).

The Malaysian government has introduced and implemented several policies and legislation related to waste management (Figure 1). The policies and legislation that have been introduced by the Malaysia government are National Strategic Plan on Solid Waste Management (2005), National Policy Waste Management Policy (2006), and Solid Waste and Public Cleansing Management Act 2011 (Act 672) Solid Waste Management and Public Cleansing Corporation, (2015). Besides, the 3R concept – Reduction, Reuse and Recycling has been introduced by the Malaysia government in the 8th Malaysia Plan (2001 - 2005). Meanwhile, local authorities have been given full responsibilities to make sure proper waste management policy can be introduced and implemented to reduce the use of material, energy, pollution and minimize waste. In 2005, the Malaysia government introduced the National Strategic Plan for Solid Waste Management as one of the solid waste management policies that provides the basic guideline for solid waste management and this strategic policy plan is to be carried out in Peninsular Malaysia until 2020 (CIDB, 2003; CIDB, 2008; Saadi N., 2016).

In 2015, the Construction Industry Transformation Programme 2016-2020 (CITP) was introduced by the Construction Industry Development Board (CIDB) to continue the roles of Construction Industry Master Plan 2006-2015 (CIMP) and achieve the 8th Malaysian Plan thrusts (CIDB, 2003; CIDB, 2015; Saadi N., 2016). In the Construction Industry Transformation Programme 2016-2020 (CITP), Quality, Safety and Professionalism, Environmental Sustainability and Productivity and Internationalisation are four strategic thrusts introduced in CITP (CIDB, 2015). CITP's strategic thrust No. 2 was introduced to achieve sustainable construction and the five strategic initiatives that have been discreetly designed and implemented to solve the construction waste management issues are apply innovation in construction, apply compliance to environmental sustainability ratings and requirement, minimize the irresponsible waste during construction, encourage and adopt the sustainable practices, focus on public project to increase the sustainable practices (CIDB, 2015). However, Malaysian contractors are unaware of these initiatives and still apply their own methods to manage their construction wastes which do not reflect existing programmes, policies, law or enforcement implemented by the Malaysia government.

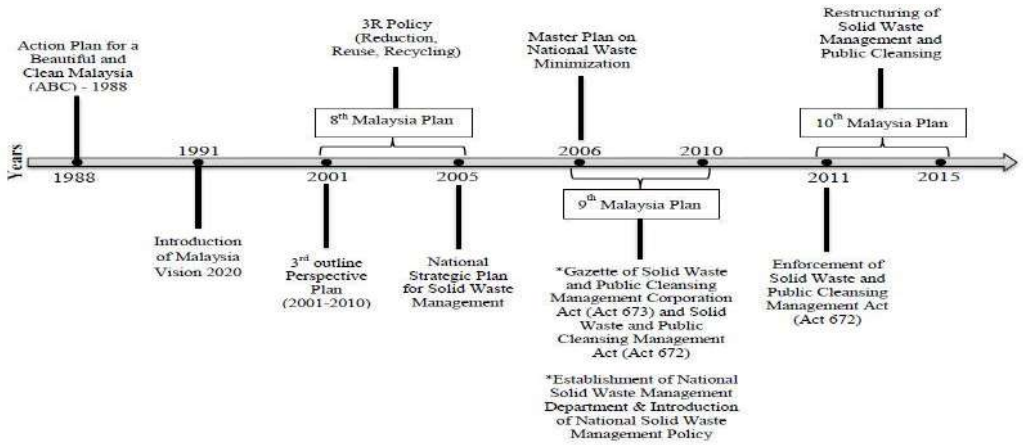


Figure 1: Timeline of Solid Waste Transition in Malaysia (CIDB 2015) (Saadi N. 2016).

## METHODOLOGY

For this study, a quantitative (questionnaire survey) approach was adapted to achieve research objectives and answer the research questions. The quantitative research approach is chosen due to its benefits and to enhance the accuracy and reliability of the research findings, it is more suitable to gather information from a large population in construction sites. Sets of questionnaire were distributed to the related population from various construction backgrounds – site engineers, supervisors, architects, main contractors, sub-contractor and consultancy agencies to gather the information and opinions regarding concrete waste management. Several questions asked related to the aims, objectives and problem statement of this research. A 100 set of questionnaires were distributed to collect the data. About 60% of the respondents gave their responses by returning the completed questionnaire.

The questionnaire items were classified in to five sections:

- Section 1 – Background of the Participants
- Section 2 – Awareness Level of Construction and Demolition Waste and its Management
- Section 3 – Generation of Construction and Demolition Waste & Contribution of Concrete Waste in Construction Site
- Section 4 – Practices on Concrete Waste Management
- Section 5 – Opinions of Participants Regarding Construction Waste Management.

## DATA ANALYSIS AND FINDINGS

In this section, data collected is analyzed and explained. The research data was collected from two construction sites in West Malaysia. The research questions and problems were explained and answered based on the collected questionnaire data. The main research questions and problems explained are:

- What is the current situation of the construction and demolition wastes management in Malaysia & causes of the current situation in the Malaysian construction industry?
- Level of awareness and knowledge of construction practitioners regardingconcrete waste and concrete waste management.
- What is the best alternative concrete waste management practice that can be proposed to the Malaysian Construction Industry to overcome the current concrete waste issues in Malaysia?

***Data analysis for Section 1 – Participants' Demographic Analysis***

Table 1: Participants Demographic Summary

| Gender | Frequency | Percentage | Working Position/ Profession | Frequency | Percentage |
|---|---|---|---|---|---|
| Male | 43 | 70% | Engineer | 24 | 39% |
| Female | 18 | 30% | Site Supervisor | 8 | 13% |
| | | | Architect | 3 | 5% |
| | | | Contractor | 8 | 13% |
| | | | Consultancy | 6 | 10% |
| | | | Others | 12 | 20% |
| **Total** | 61 | 100% | **Total** | 61 | 100% |

In this study, 103 sets of questionnaire were distributed and 61 sets of completed questionnaires were returned and analysed. Table 1 provides demographic details of the 61 participants. In this survey, 70% of participants are male and 30% are female. Furthermore, the majority of participants are working as engineers, which is 24 out of 61 participants (39% of participants).

***Data analysis for Section 2 – Level of Awareness and Knowledge of Construction and Demolition Waste and Waste Management.***

Table 2: Awareness on Construction and Demolition Waste and Waste Management

| Awareness area | Frequency | | | | | Mean |
|---|---|---|---|---|---|---|
| | Not Aware (1) | Less Aware (2) | Moderately Aware (3) | Generally Aware (4) | Highly Aware (5) | |
| C&D waste generation | 0 | 3 | 13 | 35 | 10 | 3.852 |
| C&D waste management in Malaysia | 0 | 6 | 12 | 35 | 8 | 3.738 |

**The numbers show the number of participants who chose the answer. The same mode has been adopted in subsequent tables in this research. It is noted that the sample size is 61.*

The awareness level of construction and demolition wastes and waste management was analysed. Table 2 presents the participants' level of awareness of construction and demolition wastes and its management. The last column shows the mean value of the level of awareness. Between these two awareness areas, the participants possess above average awareness level with a mean value result of 3.852 for "C&D waste generation" and 3.738 for "C&D waste management in Malaysia". From the frequency of chosen answers for "C&D waste generation" and "C&D waste management in Malaysia", it is found that "Generally Aware" is the most chosen answer, which has 35 participants (57.38%).

Table 3: Familiarity on Various Construction and Demolition Waste Aspects

| Aspects | Level of Familiarity | | | | | Mean |
|---|---|---|---|---|---|---|
| | **Not Familiar (1)** | **Less Familiar (2)** | **Moderately Familiar (3)** | **Generally Familiar (4)** | **Highly Familiar (5)** | |
| Definition of C&D waste | 0 | 4 | 23 | 21 | 13 | 3.705 |
| Waste management Hierarchy | 3 | 10 | 15 | 26 | 7 | 3.393 |
| Malaysian policies and legislation in C&D management | 7 | 18 | 21 | 13 | 2 | 2.754 |
| Role of construction players in C&D waste management | 2 | 17 | 19 | 18 | 5 | 3.115 |
| Benefits of C&D waste management | 1 | 12 | 25 | 16 | 7 | 3.262 |

The participants' familiarity and knowledge level of the 5 aspects regarding construction and demolition wastes were collected and analysed. Table 3 presents the result of the participants' level of knowledge and familiarity of the 5 different aspects of construction and demolition wastes. From the collected results, "Definition of C&D waste" resulted the highest mean value with 3.705, followed by "Waste management hierarchy" and "Benefit of C&D waste management" with 3.393 and 3.262 mean value respectively. Apart from the three aspects above, participants possess moderate and below average knowledge and familiarity on "Role of construction players in C&D waste management" and "Malaysian policies and legislation in C&D management" with mean value of 3.115 and 2.754 respectively.

From the overall results, participants are most familiar to the meaning of C&D waste and least familiar to Malaysian policies and legislation in C&D management and the role of construction players in C&D waste management. From this result, it can be concluded that there are several reasons, which cause the least familiarity aspects. The reasons are listed below:

- Low government initiative and less dissemination of information on the policies and legislation on construction and demolition waste.
- Less guidelines for construction industry players to refer to on their role and responsibility in construction and demolition waste management.

***Data analysis for Section 3 – Generation of Construction and Demolition Waste & The extent of Waste Contribution in Construction Site.***

Table 4: Contribution of Various Materials Components to Construction Waste Generation

| Materials Component | Level of Contribution | | | | | Mean |
|---|---|---|---|---|---|---|
| | Lowest Contribution (1) | Less Contribution (2) | Moderately Contribution (3) | High Contribution (4) | Highly Contribution (5) | |
| Wood | 1 | 7 | 16 | 30 | 7 | 3.574 |
| Concrete and Aggregates | 2 | 0 | 9 | 28 | 22 | 4.115 |
| Metal products/ Reinforced steel | 1 | 7 | 14 | 32 | 7 | 3.607 |
| Plastic materials/ Rubber | 13 | 17 | 15 | 9 | 7 | 2.672 |
| Sand and Soil | 4 | 11 | 25 | 18 | 3 | 3.082 |
| Bricks and Blocks | 2 | 20 | 22 | 12 | 5 | 2.967 |
| Cardboards/ Paper | 9 | 19 | 17 | 9 | 7 | 2.770 |
| Packaging Products | 19 | 12 | 12 | 13 | 5 | 2.557 |

One of the research objectives was to identify the components of construction materials that contribute to construction and demolition wastes generation in the Malaysian construction sites. The participants were asked to rank the various construction materials from 'Lowest Contributor' (1) to 'Highest Contributor' (5). Table 4 shows the results.

From the results table, it is clearly shown that "Concrete and Aggregate" constitute the most amount of construction and demolition waste materials among the listed material components with the highest mean value of 4.115. From this results, more than 50% of the participant ranked above average contributor – 'high contributor' and 'highest contributor' to concrete aggregate with 28 participants and 22 participants respectively. Furthermore, Metal products/ Reinforced steel, Wood and Sand & Soil have above moderate contributor of waste in the construction sites. Besides, we observed that most of the participants said "Sand and Soil" component is moderately contributing to construction and demolition wastes (28 participants selected 'moderately contributor) with a mean value of 3.082. Besides, it is also found that "plastic materials/ Rubber", "Brick& Blocks", "Cardboards/ Paper", and "Packaging products" have below moderate mean value which means that these materials are the least contributors to construction and demolition waste materials.

Table 5: Types of Projects Contributed to Concrete Waste Generation

| Type of Projects | Level of Contribution | | | | | Mean |
|---|---|---|---|---|---|---|
| | Lowest Contribution (1) | Less Contribution (2) | Moderately Contribution (3) | Generally Contribution (4) | Highly Contribution (5) | |
| Structure Construction Project | 1 | 3 | 9 | 23 | 25 | 4.115 |
| Renovation & Refurbishment Project | 0 | 7 | 22 | 23 | 9 | 3.557 |
| Remodelling Project | 1 | 12 | 16 | 28 | 4 | 3.361 |
| Repairing Project | 2 | 17 | 16 | 19 | 7 | 3.197 |
| Demolition Project | 0 | 3 | 13 | 17 | 28 | 4.148 |

In this questionnaire, the participants' opinions towards the types of projects that contribute the most to concrete waste generation were also collected and analysed. Table 5 presents the respondents' opinions regarding the relationship between various types of projects and concrete waste generation. The data shows that participants are of the view that "Structure Construction Project" and "Demolition Project" contribute the most to concrete waste generation among the various project types and these two types result in an above average mean value. "Demolition Project" resulted the highest overall mean value of 4.148 and "Structure Construction Project" resulted overall mean value of 4.115. On the other hand, it is found that "Demolition Project" had the most participants with 28 participants (45.90%) selecting 'highly contributor' as their response. Apart from the two types of projects above, the participants selected above moderate contribution in all other types of projects which are "Renovation & Refurbishment Project", "Remodelling Project", and "Repairing Project" with moderate mean value of 3.557, 3.361, and 3.197 respectively. In fact, "Renovation & Refurbishment Project", "Remodelling Project", and "Repairing Project" are all moderately contributing to concrete waste generation in the Malaysian construction sites.

Table 6: Agreement on Various Factors

| Factors | Degree of Agreement | | | | | Mean |
|---|---|---|---|---|---|---|
| | Strongly Disagree (1) | Disagree (2) | Neutral (3) | Agree (4) | Strongly Agree (5) | |
| Waste generation due to building demolitions or renovation works | 1 | 7 | 16 | 30 | 7 | 3.574 |
| Faulty storage of cement materials or pre-casted concrete | 2 | 0 | 9 | 28 | 22 | 4.115 |
| Poor handling / Carelessness of workers in material handling | 1 | 7 | 14 | 32 | 7 | 3.607 |
| Lack of proper on-site | 13 | 17 | 15 | 9 | 7 | 2.672 |

| | | | | | | |
|---|---|---|---|---|---|---|
| management | | | | | | |
| Wrong cement and aggregate quantity measurements | 4 | 11 | 25 | 18 | 3 | 3.082 |
| Waste generation due to poor design specifications (Design Error) | 2 | 20 | 22 | 12 | 5 | 2.967 |
| Pre-fabrication error of concrete | 9 | 19 | 17 | 9 | 7 | 2.770 |

In Section 3 Item 3, participants were asked to provide their view and opinion on the extent of their agreement and disagreement on various factors that lead to concrete waste generation. There are 7 main factors provided for participants to rate. Table 6 presents the summary results of their extent of agreement and disagreement.

Most of the participants identified "Faulty storage of cement materials or pre-casted concrete" as the factor that lead to the most concrete waste generation in construction sites. The option of "Faulty storage of cement materials or pre-casted concrete" got the highest mean value of 4.115. Other than that, participants also concurred that the major factors that lead to concrete waste generation are "Waste generation due to building demolitions or renovation works" and "Poor handling / Carelessness of workers in material handling" with mean value of 3.574 and 3.607 respectively. Besides, it is found that "Wrong cement and aggregate quantity measurement" resulted in a moderate degree of agreement with 25 participants (40.98% of participants) selecting neutral for this option.

However, apart from the above four options, the following three options resulted in below average mean value and were not found significant in term of concrete waste generation. The factors are "Lack of proper on-site management" (mean value = 2.672), "Waste generation due to poor design specifications (Design Error)" (mean value = 2.967) and "Pre-fabrication error of concrete" (mean value = 2.770).

***Data analysis for Section 4 – Concrete Waste Management Practices***

Table 7: Satisfaction on Various Construction and Demolition Management Practices

| **Type of C&D waste management practices** | **Level of Satisfaction** | | | | | **Mean** |
|---|---|---|---|---|---|---|
| | **Least Satisfied (1)** | **Less Satisfied (2)** | **Moderately Satisfied (3)** | **Satisfied (4)** | **Most Satisfied (5)** | |
| Landfill Disposal | 3 | 8 | 26 | 21 | 3 | 3.213 |
| Illegal Dumping | 12 | 24 | 16 | 7 | 2 | 2.393 |
| Waste Composition | 9 | 23 | 14 | 11 | 4 | 2.639 |
| 3R Concept – Reduce, reuse & Recycle | 5 | 11 | 19 | 19 | 7 | 3.197 |

In section 4, participants were asked to rate their satisfaction level on various types of construction and demolition waste management practices that are currently used in the Malaysian construction industry. Table 7 presents 4 common types of waste management practices and the participants' satisfaction levels.

Based on the data obtained, all of the 4 common types of management practices are rated as moderately satisfaction or below average satisfaction. The participants rated their satisfaction as moderate on two management practices, which are "Landfill Disposal" and "3R Concept – Reduce, reuse & Recycle" with mean value of 3.213 and 3.197 respectively. Meanwhile, participants rated "Illegal Dumping" and "Waste Composition" as below average satisfaction with mean value of 2.393 and 2.639 respectively.

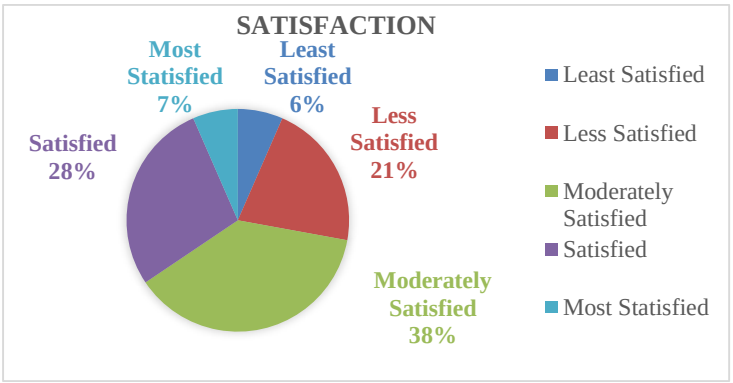


Figure 2: Satisfaction on Current Concrete Waste Management

Figure 2 presents the percentage of participants' satisfaction level with current concrete waste management practices. From the chart, it can conclude that most of the participants (38%) are moderately satisfied with current concrete waste management practices in their construction sites. Besides, 28% of participants rated less satisfied and below with their current concrete waste management practice. 35% participants are satisfied or very satisfied with their current concrete waste management practice. Form the result, it can be concluded that most of the participants are satisfied with their current concrete waste management practice.

***Data analysis for Section 5 – Opinion of Construction and Demolition (Concrete) Waste Management***

Table 8: Summary result of recommendations

| **Type of Concrete Waste Management Practices** | **Level of Recommendation** | | | | | **Mean** |
|---|---|---|---|---|---|---|
| | **Definitely Not Recommended (1)** | **Not Recommended (2)** | **Neutral (3)** | **Recommended (4)** | **Strongly Recommended (5)** | |
| 3R practices– Recycle, Reuse and Reduce | 0 | 0 | 4 | 32 | 25 | 4.344 |
| Industrialized Building System (IBS) practice (Pre-casted Concrete) | 0 | 3 | 15 | 30 | 13 | 3.869 |
| Landfill Disposal | 11 | 11 | 12 | 19 | 8 | 3.033 |
| Proper site management practices – Enforce rules and regulations on proper site management and control with strict monitoring and supervision | 0 | 1 | 11 | 25 | 24 | 4.180 |

Next, in last section, the participants are asked to rate their recommendations on 4 types of concrete waste management practices. Table 8 presents the summary of their recommendations. According to the participants recommendations, the "3R practice– Recycle, Reuse and Reduce" is the most recommend practice option among the 4 practices (with highest mean value of 4.344), followed by "Proper site management practices – Enforce rules and regulations on proper site management and control with strict monitoring and supervision" (2nd highest mean value of 4.180). "Industrialized Building System (IBS) practice (Pre-casted Concrete)" known as an advance waste management strategy has been rated as 3rd recommended practices to be implement for the Malaysian construction industry to overcome concrete waste issues. Apart from the practices above, the option of "Landfill Disposal" was not found as significant in terms of high potential concrete waste management practice for the Malaysian construction industry, and it had the lowest mean value of 3.033 among all the practices.

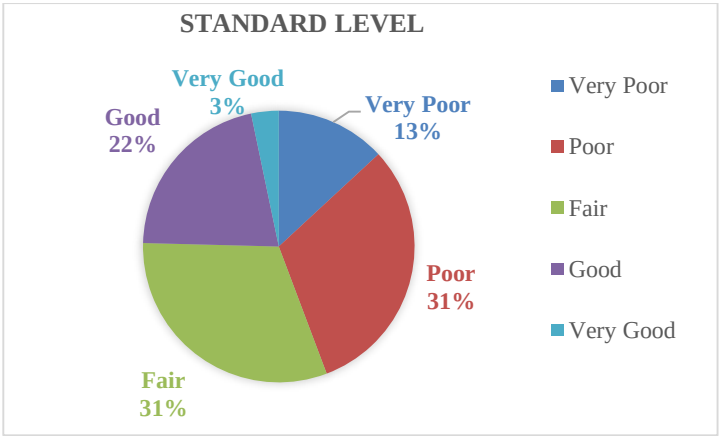


Figure 3: Standard of Current Malaysian Construction and Demolition Waste Legislation and Policies.

Figure 3 shows the rating of standard level of current Malaysian construction and demolition waste legislation and policies. From the summary results, both 'Fair' and 'Poor' options have the highest percentage with 31% each. However, from the overall rating result, we concluded that the majority participants' ratings are more inclined to below average standard level (Poor). There are only 21% of participants who rated 'Good' and 3% 'Very Good' for the standard level of current Malaysian construction and demolition waste legislation and policies.

From the data analysis, we can conclude that the Malaysian construction players are mostly dissatisfied with the current Malaysian construction and demolition waste legislation and policies.

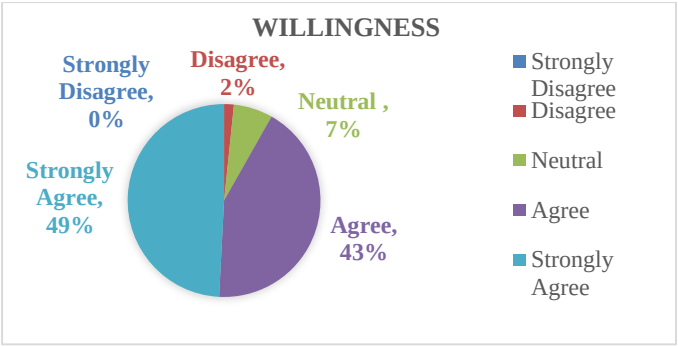


Figure 4: Result of Participants's Willingness

Lastly, the participants rated their willingness to apply and implement proper and sustainable concrete waste management in their current construction sites. Figure 4 provides the summary result of participants' willingness. We clearly observed and concluded that the majority of participants (92% of participants – 43% of "agree' and 49% of 'strongly agree') are willing and agreed to apply and implement a new proper and sustainable concrete waste management practice to replace or improve their current management practice. Furthermore, none of the participants rated 'strongly disagree', only 2% rated 'disagree' and 7% rated neutral for their willingness to implement new concrete waste management practice.

## CONCLUSION AND RECOMMENDATION

In general, construction and demolition waste is generated in the construction industry included Malaysian construction industry. From this research, it is found that concrete waste problem is the most serious construction waste problem in the Malaysian construction industries as it is the most constituted waste component in these industries and causes serious waste issues. The main reason is the high amount of concrete waste leading to landfilling issues. Besides, we also observed and concluded that the Malaysian construction industry players are mostly aware of construction and demolition waste issues and management. Furthermore, they are familiar and have knowledge of the current construction and demolition waste management practices except for the Malaysian construction and demolition waste policies and legislation. Moreover, based on the research, the willingness to improve the current concrete waste management is high in the construction industry now.

The following recommendations are made for improving concrete waste management in Malaysia:

- Implement and well utilised the 3R concept strategies to minimise and reduce concrete waste as suggested by most of the respondents.
- In order to improve awareness, the Malaysian government must show and reinforce their initiatives on improvement of construction and demolition waste policies and legislation.
- Hire personnel with advance professional skills and knowledge on construction and demolition o waste management to enforce the site rules and provide strict waste management supervision to overcome the current concrete waste issues in construction sites.
- Improve and implement proper site management on concrete materials, aggregate, and precast concrete storage to minimise concrete waste caused by faulty storage.

## FUTURE WORK

Due to several limitations of this study, future research can to be carry out in this field. This study only investigated the construction industries in West Malaysia. Thus, the findings are limited and relied only on the opinions of the construction industry players and construction and demolition management practices in West Malaysia. The opinions of the construction industry players and construction and demolition management practices in East Malaysia are missed. Thus, the investigation on East Malaysia's construction industry can be carried out in future to get an overall detail opinion on Malaysian construction and demolition waste management. Besides, the investigation in this study is limited to a few construction sites and concrete factories. Further investigations on other sites or fields could be carried out to consolidate the findings and recommendations.

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# APPLICATION OF THE BUBBLE DECK SLAB TECHNOLOGY IN MALAYSIA

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## ABSTRACT

The bubble deck slab is one of the successful attempts in biaxial technology where the amount of concrete in the slab is reduced due to the presence of grids made of recycled plastic hallow 'bubble' void formers. Generally, this newly invented slab is lightweight but still able to maintain similar load carrying capacity like the reinforced concrete slab. In Malaysia, most contractors prefer to use the conventional reinforced concrete slab compared to the bubble deck slab. This is because most contractors are not familiar with this new technology. The objectives of this research are to have a broader understanding of this technology applicability and the barriers of implementation in Malaysia. In addition, this study is able to determine the level of interest of the Malaysian construction personnel to apply this technology. This research was conducted in Selangor, Putrajaya and Kuala Lumpur only. The data collections intruments used to achieve the objectives of this research are a set of questionnaire and an interview protocol. A few barriers of implementation were identified and the majority of the respondents were interested to adopt this technology.

**Keywords:**

*bubble deck slab technology, reinforced concrete slab, biaxial technology, plastic hallow*

## INTRODUCTION

The conventional concrete slab or reinforcement concrete slab is the most common concrete slab used in the construction industry. However, this conventional method is raising controversy regarding its negative impacts towards the environment and its inefficiency in some of the building structures. Not all reinforcement concrete slab in the structure has to perform carrying effect, which means the concrete usage in that building structure is a waste. The manufacturing process and transporting of cement are contributing to carbon dioxide emission, which is a bad impact toward the environment. Hence, many engineers and technologist attempt to create effective biaxial slab with hallow cavities for decades now.

The bubble deck slab is one of the successful attempts in biaxial technology where the amount of concrete in the slab is reduced due to the presence of grid of recycled plastic hallow 'bubble' void formers. Generally, this newly invented slab is lightweight but still able to maintain similar load carrying capacity like reinforced concrete slab. The first bubble deck slab technology was introduced in 1990s by German professor, Jorgen Bruening. The first structure that used this technology is Millennium Tower in Holland. Recycled plastic balls are locked side by side between layers of reinforcing welded steel wire and an internal lattice girder eliminates concrete that has no contribution to the structural performance of the slab. This new system also reduces the usage of formwork. The overall slabs are delivered partly pre-cast with a bottom layer of 70mm concrete providing permanent formwork into which is bedded the bottom layer of mesh reinforcement. Light reinforcement girders hold top mesh in place and trap into the sandwich the plastic ball void formers (Harding, 2004).

In Malaysia, most contractors prefer to use conventional reinforced concrete slab than bubble deck slab. This is because most contractors are not familiar with this new technology. According to

the Bubble Deck Construction Sdn Bhd (2017), this technology was introduced in Malaysia since 2011, however only 8 projects in Malaysia are using this technology for the past 6 years, such as WP Hotel, Maju-LinQ in Bandar Tasik Selatan, Rasa Factory in Ulu Selangor, Kawan Food Factory in Klang, The new PAM centre in Bangsar, Bunglow Car Porch in Bukit Jalil and one Bungalow in Bukit Gambir, Penang. Mostly the projects are located in Selangor and one in Penang.

In addition, this conventional construction method has been raising controversy relating to the manufacturing and transporting its materials. It also can be considered as wasting of materials such as usage of concrete in building structures that do not have any structural functions. All of these problems can be solved by using bubble deck slab technology as it helps to eliminate concrete usage in structures that do not have any structural functions and substitute it with recycled plastic balls. Thus, decreasing the dead weight of the structures which make it more desirable in seismic active regions. In order to solve this controversy, contractors and labour must be aware of its benefits and have a high level of understanding to conduct this technology to gain familiarity in the Malaysian construction industry. Furthermore, the application of this technology in Malaysia is one of the innovation technologies that can be implemented for the construction industry. This research gives the researchers a better understanding of the bubble deck slab system and how it can be an applicable system in Malaysia.

The bubble deck slab systems pledge a high level of experience through the industry from contractors, engineers, and architects. Efficacious and prosperity implementation of bubble deck slab technology in the Malaysia construction industry will present diverse advantages and interests compared to the conventional method. As 1 kg of plastic is capable of replacing 100 kg of concrete, the company can reduce significant carbon emissions which is used in manufacturing and transporting concrete. Further, the recycled plastic hollow balls used for the bubble deck slab is reusable and recyclable which shows its sustainability potential (Ali & Kumar, M. 2017). Finally, this research is part of an on-going study which will enhance the practicing and implementation of the bubble deck slab technology in Malaysia.

The aim of this research is to achieve these objectives:

1. To examine the applicability of the bubble deck slab technology in Malaysia.
2. To identify the barriers of implementing bubble deck slab technology in Malaysia.
3. To determine the interest of construction personnel towards application of the bubble deck slab technology in Malaysia.

## LITERATURE REVIEW

### *Background Study*

In 1848, the first reinforced concrete was introduced by Jean-Louis Lambot. Lambot used iron in 1995, German professor, Mr. Jorgen Bruening introduced bubble deck slab system in the construction industry. The bubble deck slab technology is a system where the concrete usage in the area that has no structural effect is substituted with 100% recycled plastic balls. This system comprises bubble void formers, concrete and two form of steel which are reinforcement mesh for lateral support and diagonal girders for vertical support of the bubbles. The bubble voids are positioned in between top and bottom reinforcement mesh and joined together with vertical lattice girders. The reinforcement mesh and diagonal girders lock and distribute the plastic balls in exact positions. The bubble deck slab system is based on the patented integration technique - the direct way of linking air and steel (Shetkar & Hanche, 2015; Tiwari & Zafar, 2016).

The main disadvantage of concrete construction is the construction of the horizontal slab where a section of the concrete has no structural function, adds unnecessary self-weight to the

concrete structure which contributes to significant stress applied to the structure, and limits the span of the concrete. It also contributes to material wastage and energy consumption (Teja, 2016).

The bubble deck slab comprises of 3 main materials, which are concrete, steel reinforcement and the most important material, plastic balls. The main material in the bubble deck slab is the hollow sphere that is made from recycled high density polyethylene (HDPE). This material does not react chemically with concrete and reinforcement steel, has no porosity and has enough rigidity and strength to carry the maximum load, for example, the load from pouring concrete. The plastic balls can be recycled and reused to ensure its sustainability in the construction industry. This system uses the common type of cement, which is standard Portland cement, where no plasticizer is needed in this technology and the minimum grade is M30. The aggregate used should not be more than 20mm. For the precast layer, common concrete or self-compacting concrete can be used (Ali & Kumar, 2017).

The steel reinforcement in this system needs two types of reinforcement steel. First is reinforcement mesh layers for lateral supports and diagonal girders for vertical support for the bubbles. Only steel reinforcement with grade Fe60 strength or higher is used in this system. The function of this reinforcement is to lock the plastic balls into its positions. Technically the plastic balls are 'sandwiched' between bottom and top reinforcement mesh layers. These reinforcement meshes are then welded with diagonal short length bars (Joseph, 2016).

There are 3 versions or types of bubble deck slab reinforcement modules, filigree elements and finished plank. Reinforcement Modules of bubble deck slab consists of a pre-fabricated bubble deck slab where the plastic balls are well-positioned between reinforcement steels, as shown in Figure 1. These components are then transported to the site, placed on traditional formwork linked with additional reinforcement before pouring concrete mix using conventional method. The advantage of this type is that, it is suitable for small construction areas as the components can be stacked in the sites before installing these components. Filigree Elements is a combination of pre-cast and in-situ constructions, where 60mm thick of bottom concrete layer is pre-casted and transported on to the site with the plastic balls and reinforcement steels unattached. Then these elements are casted on site, as shown in Figure 2. For casting the plastic balls on the top of the concrete layer, temporary stands are used to hold the plastic balls. This type might need additional steel depending on the design of the building. This type is suitable for new constructions, where the designer has the freedom to position the plastic balls and the reinforcement steels. This type is the best to apply for slab that has opening, such as opening for stairs. Finished plank is where the whole material is pre-fabricated to its finish form by the manufacturer. Then the final product is transported to the site, as shown in Figure 3. However, this type has disadvantages compared to other types because it requires support beams or load bearing wall. This type of bubble deck slab is suitable for short spans and fast construction (Mahalakshmi et al., 2017).

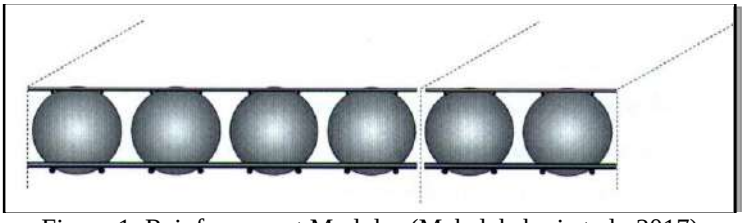

Figure 1: Reinforcement Modules (Mahalakshmi et al., 2017)

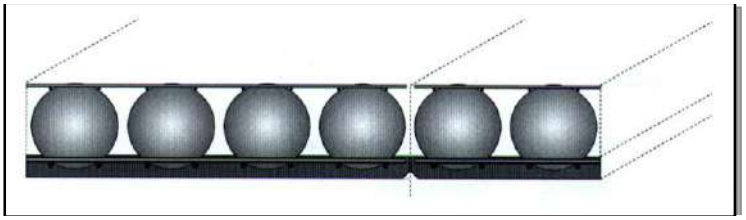

Figure 2: Filigree Elements (Mahalakshmi et al., 2017)

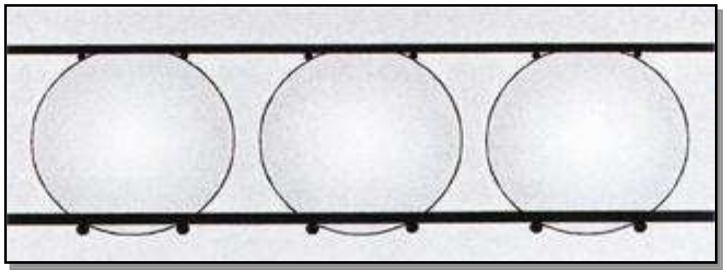

Figure 3: Finished plank (Mahalakshmi et al., 2017)

***Advantages of the Bubble Deck Slab***

Based on several studies and researches, there are many advantages for the construction industry to gain from bubble deck slab technology which are:

i. Superior Static

The bubble deck slab technology can be considered as a standard concrete flab slab due to its properties of lightweight. This technology can help to construct longer spans of slab, which have fewer columns, no beams or ribs under the ceiling is needed, and pillars have no capital.

ii. Production and Carrying Out

The slab has higher quality because of the automated and well-controlled production, the components produced are easy to erect, and requires less space for storage.

iii. Economical Approach

This technology saves up to 50% of materials; not just materials form the bubble deck slab itself, it also saves materials in constructing extra columns, beams, pillars and etc. In addition, decrease in weight and materials mean lower transportation costs, where it is easier to lift the components and does not require heavy lifting machineries.

iv. Eco-friendly Approach

The bubble deck slab is a suitable solution in construction when it comes to green approach. According to bubble deck UK, approximately 50% of concrete usage in construction is reduced. For every 5000m² of bubble deck slabs, the following can be saved: 1000m³ of site concrete, 166 trips of lorry to transport concrete ready mix, 1,798 tonnes of foundation load or less 19 piles, 1,745 GJ energy used in concrete production and haulage, and it can also save 278 tonnes of carbon dioxide emissions. In addition, the plastic balls can be recycled and reused to ensure the sustainability of the building. Accordingly, 1 kg of recycled plastic balls can replace 100kg of concrete (Shetkar & Hanche, 2015; Tiwari & Zafar, 2016; Ali & Kumar, 2017).

## METHODOLOGY

### *Introduction*

Application of the bubble deck slab in Malaysia is selected as the topic of this study because it is the best solution for problems related to the use of concrete in the construction industry, such as wastage of concrete in conventional reinforced concrete slabs. This research presents the advantages of using bubble deck slab in Malaysia and to create a broader understanding about this innovative technology through collecting information that can provide an investigative perspective to a research problem. All primary quantitative data in this research were collected through a questionnaire and qualitative data through interviews. The qualitative data from interviews of respondents give an in-depth understanding of their opinions and experiences and quantitative data from the questionnaire give information based on facts and numbers. The qualitative and quantitative data enabled the researchers to investigate and achieve the research objectives. This research paper is divided into 5 main sections including introduction, literature review, methodology, data collection, and conclusion and recommendation.

### *Instrument*

Two approaches were used to obtain data in this research. The researchers used questionnaire and interview to achieve the objectives. For objective number 1, the researchers conducted in-depth interviews with the four respondents. The questionnaire was divided into 4 sections: section A was general questions about respondent's background, Section B the respondents were equired to answer questions related to objective 2 using a Likert scale, and for section C the respondents were required to answer questions related to objective 3 using Yes/No responses. While in section D, respondents gave their recommendations and suggestions relating to the application of bubble deck slab technology in Malaysia. Figure 4 shows the chart of instruments used in this research.

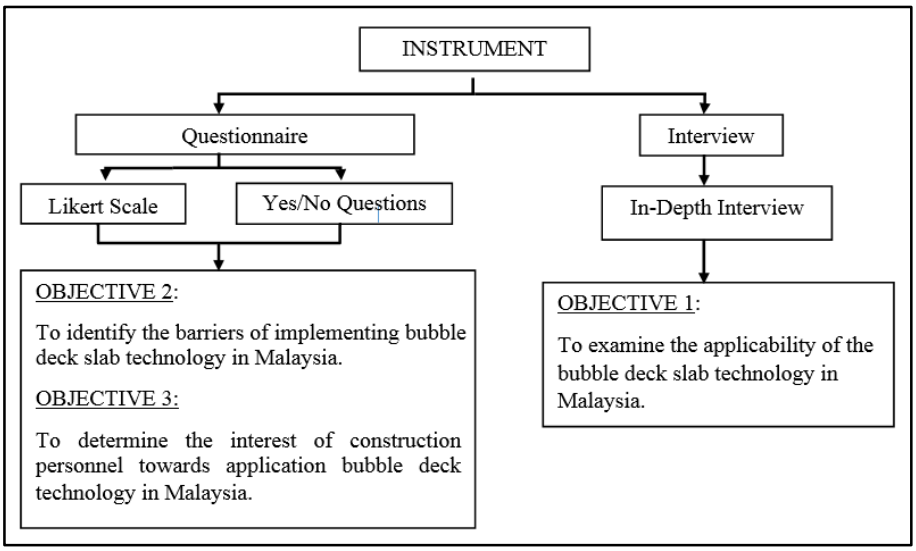


Figure 4: Instruments used in this research

***Research Respondents and Sampling Method***

The researchers conducted in-depth interviews with four personnel from Bubble Deck Construction Sdn Bhd to achieve the first objective. 100 sets of a questionnaire were distributed among contractors, engineers, project manager, architects, quantity surveyors and site supervisor in order to obtain second and third objectives. The questionnaire was distributed to respondents by using 2 ways, first a hardcopy was given directly to the selected respondents and second via google form where the link of the google form was sent to selected respondents. The link was sent via email, phone number and other social media; whichever was convenient for the respondents. Table 1 shows the list respondents for each methodology used.

Table 1: List of respondents for each methodology used

| Method | Respondents | Objectives |
|---|---|---|
| In-depth Interview | Bubbledeck Construction Sdn Bhd | 1. To examine the applicability of the bubble deck slab technology in Malaysia. |
| Questionnaire (close-ended) | Construction Personnel<br>i. Contractors<br>ii. Engineers<br>iii. Project Manager<br>iv. Quantity Surveyor<br>v. Architects<br>vi. Site Supervisor | 2. To identify the barriers in implementing bubble deck slab technology in Malaysia<br>3. To determine the interest of construction personnel towards application of bubble deck technology in Malaysia |

***Data Analysis***

Qualitative data obtained from the interview sessions with the four personnel from Bubble Deck Construction Sdn Bhd was analysed using manual comparative analysisto achieve objective number 1. While dta from the questionnaire was analysed using Microsoft Excel to achieve objectives number 2 and 3.

**RESULTS AND DISCUSSION**

Data collected from the questionnaire and interview sessions are analysed and discussed here. The interview sessions with the four personnel from Bubble Deck Construction Sdn, Bhd. were conducted in order to achieve objective 1 of this research. The questionnaire was developed and distributed to construction companies in Putrajaya, Kuala Lumpur and Selangor (Petaling Jaya, Subang Jaya, Bukit Jalil, Serdang) in order to achieve objectives 2 and 3. Table 2 shows the number of respondents for both data collection methods:

Table 2: Number of respondents

| Description | Number |
|---|---|
| Number of questionnaires were distributed | 100 |
| Number of answered questionnaires were collected | 75 |
| Number of interview sessions were conducted | 4 |

***Interview Data Collection and Result***

The selection of respondents are based on respondent's understanding and expertise in bubble deck slab technology. The interview sessions were conducted with four respondents from Bubbledeck Construction Sdn. Bhd. All four respondents' personal data such as their email addresses and phone numbers are kept strictly confidential in order to prevent any disputes or consequences that could emerge in the future. Table 3 shows the background of the respondents while Table 4 shows the responses gained from the interview sessions in order to examine the applicability of the bubble deck slab technology in Malaysia, which is the first objective of this research.

Table 3: Respondent's background

| Company Name and Address | Respondent | Name | Position |
|---|---|---|---|
| Bubbledeck Construction Sdn. Bhd No. 59, Jalan Kampung Pandan, 55100 Kuala Lumpur | A | Abg. Abadullah Abg. Josmani | Senior Design Engineer |
| | B | Fatin Mumairah | Engineer |
| | C | Norazlina | Chief Quantity Surveyor |
| | D | Mohamand Safuan Shahbudin | Site Supervisor |

Table 4: Responses gained from the interview sessions to examine the applicability of the bubble deck slab technology in Malaysia

| Section | Question | Answer |
|---|---|---|
| Section 1: The quality of bubble deck slab compared to conventional slab | 1. What is the difference between the bubble deck slab and the conventional slab? | The use of HDPE plastic balls to substitute the concrete in area of slab that does not carry any structural effect. |
| | 2. Is the bubble deck slab as strong as the conventional slab? | Yes, the bubble deck slab has same strength as conventional slab. |
| | 3. What are the physical properties of the bubble deck slab? | Bubble deck slab carries same physical properties as conventional slab, in term of weight, it is lighter than conventional slab, it is also fire proof, tested and certified by SIRIM. Lastly, it is can have seismic design upon request. |
| | 4. Can it be used for landed house? | Yes, bubble deck slab system can be used for all type of building. |
| Section 2: The cost of the bubble deck slab technology compared to the conventional slab | 1. How much is the cost of the bubble deck slab compared to the conventional slab | The cost of bubble deck is a bit higher than conventional slab. However, it can be fix in the future. |
| | 2. How much is the cost of the bubble deck slab transportation and how is the bubble deck slab transported? | The cost of transportation can be vary; it is depending on the project location and number of client demand.<br>It is transported by trailer. |

| | | |
|---|---|---|
| Section 3: The comparison between the bubble deck slab technology and the conventional slab in terms of construction time | 1. How long does it take to deliver the bubble deck slab to the project site? | It can be up to 8 weeks upon date of receipt of letter of award and down payment. |
| | 2. Does the bubble deck slab construction work faster than the conventional slab? | Yes, bubble deck slab is faster than conventional slab because it is pre-fabricated, which help the construction work cut down the duration of concrete curing. It is also reduce the amount of beams and column for the building. |
| | 3. What is the floor cycle for an area of 800m² of bubble deck slab system? | The floor cycle for 800m² can take up to 6 days, with project team of 6 members. |
| | 4. How many days can the scaffolding allow to be dismantled for the bubble deck slab system? | Depending on the concrete condition, but mostly once the concrete achieved its characteristic design strength the scaffolding can be dismantle. |

***Questionnaire Data Collection and Result***

Based on Table 5 all barriers are identified by the respondents. The highest ranked barrier is lack of awareness and knowledge among the construction community with a mean score of 4.23, 88% of the respondents are agree that this barrier is the highest barrier among all barriers, while 8% of the respondents show that it doesn't affect much the implementation of bubble deck slab technology. Whereas, 4% of respondents do not agree that this barrier will affect the implementation of the bubble deck slab technology. The lowest rank is easy accessible guidance on the bubble deck slab technology with a mean score of 3.87, which means it does not affect much the implementation of the bubble deck slab technology. Second to eighth ranked are the following: lack of marketing, low level of demand, lack of government support, lack of labour knowledge and skills, initial cost, and low awareness of benefits of the bubble deck slab technology.

Table 5: Barriers in implementing the bubble deck slab technology in Malaysia

| No | Barriers | Frequency | | | | | | Mean | Scale | Ranking |
|---|---|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | Total | | | |
| 1 | Does initial cost of the bubble deck slab technology affect implementation of this technology? | 0 | 5 | 9 | 36 | 25 | 75 | 4.08 | Agree | 6 |
| 2 | Does lack of labour knowledge and skills influence the implementation of the bubble deck slab technology? | 0 | 0 | 17 | 32 | 26 | 75 | 4.12 | Agree | 5 |
| 3 | Does awareness and knowledge among the | 0 | 3 | 6 | 37 | 29 | 75 | 4.23 | Agree | 1 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | construction community play an important role in implementing the bubble deck slab technology? | | | | | | | | | |
| 4 | Will awareness of benefits of the bubble deck slab technology give significant influence in implementing this technology? | 0 | 3 | 15 | 33 | 24 | 75 | 4.04 | Agree | 7 |
| 5 | Does the government provide support in implementing the bubble deck slab technology? | 0 | 1 | 15 | 33 | 26 | 75 | 4.12 | Agree | 4 |
| 6 | Does lack of marketing of the bubble deck slab Technology affect the implementation of this technology? | 0 | 0 | 12 | 34 | 29 | 75 | 4.23 | Agree | 2 |
| 7 | Is motivation and aspiration value on the bubble deck slab technology important for this technology? | 0 | 2 | 17 | 35 | 21 | 75 | 4.00 | Agree | 8 |
| 8 | Does easy accessible guidance on the bubble deck slab technology have significant influence on the success of this technology? | 0 | 1 | 26 | 30 | 18 | 75 | 3.87 | Agree | 9 |
| 9 | Does level of demand for the bubble deck slab technology and cultural change resistance have significant influence in the bubble deck slab technology implementation? | 0 | 1 | 19 | 25 | 30 | 75 | 4.12 | Agree | 3 |

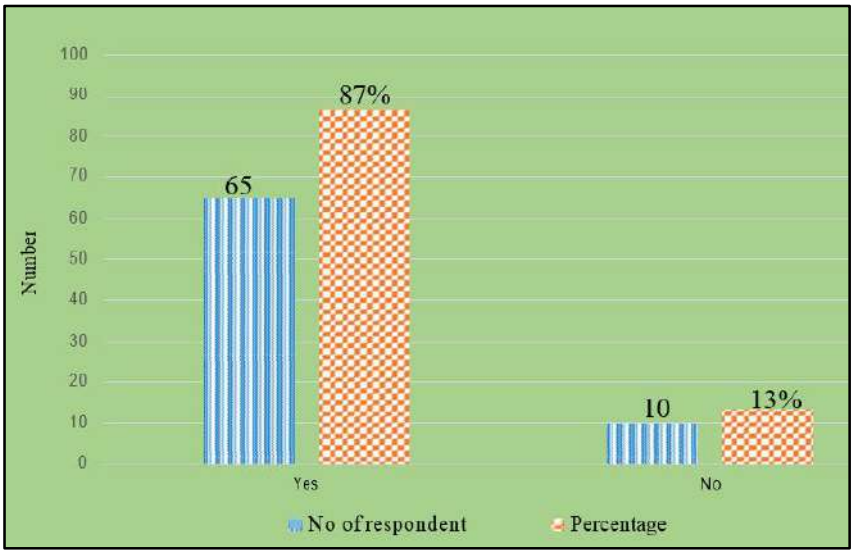


Figure 5: The frequency and percentage of interest level of the construction personnel's interest towards application bubble deck slab technology in Malaysia

Figure 5 shows that 87% of the respondents are interested to use the bubble deck slab technology on their next project, which is equivalent to 65 respondents out of 75 respondents. While 13% of the respondents are not interested to use this technology which is equivalent to 10 of the respondents.

## CONCLUSION

The applicability of the the bubble deck slab technology in Malaysia was examined by conducting interview sessions. Other than that, the barriers in implementing the bubble deck slab technology in Malaysia and the interest of construction personnel's towards the application of this technology was identified and determined by distributing questionnaires. Based on the objectives of this research study, it can be concluded that the bubble deck slab technology is applicable to all types of buildings. Moreover, it also has the same physical properties as the conventional slab and in terms of weight, the bubble deck is lighter compared to the conventional slab. Many barriers of the bubble deck implementation in Malaysia were identified. The highest ranked barrier is lack of awareness and knowledge among construction community while the lowest ranked is lack of easy accessible guidance on the bubble deck slab technology. 87% of the respondents are interested to apply bubble deck slab for their next project. The areas covered in this study are Selangor, Kuala Lumpur and Putrajaya, and the researchers conclude that the majority of the construction personnel in this area are interested to apply this technology.

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# WHIRLING OF SHAFT AND LATERAL VIBRATION ANALYSIS

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**ABSTRACT**
In mechanical engineering, some machine components can behave differently due to the design of machine elements, manufacturing processes, and selection of materials. To understand basic phenomena of any general dynamic stresses, it is good to understand adequate modeling of the system. To start with, a lateral vibration analysis of the shaft is considered. It is well known that lateral bending, whirling and transverse vibration of propulsion systems phenomenon is not as dangerous as the torsional vibration. This study is focusing on the lateral frequencies and the mode shapes of three different materials. The main issue of the lateral frequency is that could cause resonance and fatigue in the material. In this study, mild steel is used as the benchmark material in this study. While the other two types of materials are aluminum oxide and stainless steel. There will be lumped and distributed model will be considered in this study. The parameters to be determined include the mode shapes and natural frequencies of the whirling shaft. As a conclusion, aluminum oxide is the best material used for this study because it has a high value of natural frequencies to avoid the resonance happened.

**Keywords:**
*Lateral vibration; natural frequencies, mode shapes, resonance, steel, aluminum oxide.*

## INTRODUCTION

In mechanical engineering, some machine components can behave differently due to the design of machine elements, manufacturing processes, and selection of materials. To understand basic phenomena of any general dynamic stresses, it is good to understand adequate modelling of the system. It is well known that lateral bending, whirling and transverse vibration of propulsion systems phenomenon is not as dangerous as the torsional vibration. A shaft is a rotating machine element, usually circular in cross section, which is used to transmit power from one part to another, or from a machine which produces power to a machine which absorbs power. In general, a lumped-parameter approach is appropriate when the physical object has dimensions that are small relative to the wavelength of vibration. A distributed system is one in which all dependent variables are functions of time and one or more spatial variables [1].

Most shafts are subjected to fluctuating loads of combined torsion and bending with various degrees of stress concentration. For such shafts the problem is fundamentally fatigue loading. Failures of such elements and structures have engaged engineers and researchers extensively in an attempt to find their main causes and thereby offer methods to prevent such failures. Whirling is usually associated with fast speed of the rotating shafts. The speed in the shaft is called as “critical speed” and the act of vibrations called “whirling”. If the speed of the shaft remains to be the same then that will lead to damage in the shaft and will cause a failure. Moreover, if the shaft speed keeps increasing before any other effects happen then the shaft will continue working safely until other effect could interrupt the shaft. Leave one blank line between the heading and the first line of text [1].

Additionally, whirling of shafts occurs due to rotational imbalance of a shaft, even in the absence of external loads, which causes resonance to occur at certain speeds, known as critical speeds. Also, the whirling is happening when the resonance is occurring too. While the shaft is rotating, it could be affected by two forces: the radial and centrifugal forces; which will lead the shaft to move from its “safe” position. Also, the whirling of shafts is a serious problem in the most machines that use long shafts [1].


Figure 1: First three modes, Practical review of rotating machinery [1]

There are different modes and shapes formed due to the high speed and the lateral frequency met. It's all controlled by the boundary conditions that could happen. Whenever the speed increase then the frequency and the mode shapes will form more as it's mentioned in figure 1 these are the first three mode shapes in the simply supported boundary condition.

Based on the Vibration of Rotating Shafts 1959 journal by R.E. D. Bishop, the vibration of rotating shaft was established on rotational basis by Jeffcott. He noticed the effect that happen on the shaft from bending in the same or other as he follows the principle modes that occur when it reaches the running speed with natural frequency and explain the configuration of the shaft during the vibration. For the mathematical Jeffcott focused on the unbalance mass on the thin shaft then he explains the whirling of shaft in fundamental mode.

On the other hand, Lewis did the analytic process of the running shaft through the critical speed. While the other scientists Golomb and Roseberg have studied the whirling of shaft as a problem on uniform shaft which can transmit a torque. Also Lewis and Downham did their experimentation based on Jeffcott approach. Apart from that Johnsen who refers specifically to the rotating uniform shaft that is pined at the end from both sides. Tondl examine a different problem most of it is using Jeffcott approach and he assumed that the pin-pin shaft is so far as its unsymmetrical rotates. As William T. Thomson, Professor Emeritus mentioned in Theory of Vibration with Applications Fourth Edition 1993, Rotating shafts at some certain speeds tend to whirl in some complicated ways [2].

### *A review on materials*

The selection of the material is one of the most important elements in engineering design. Also it's an important stage to start the project because some material has its own optimum properties or sometimes it's a combination of properties between two materials to get the best properties needed. The benefits of material consideration are to reduce the cost and also to improve the performance. Additionally, elements of this materials selection process involve deciding on the problem and from those criteria can see which material is the best to maximize the performance. The component that been chosen to discuss on is a solid rod shaft that is used to transmit the movement. There are different materials can be used depend on the cost of the material, the weight and the strength [3].

A. *Mild steel*

The mild steel is one of the good materials that used in the shaft. In this journal there was a study on the elastic shaft that is whirling with the first three mode shapes by three different boundaries of conditions. The boundaries of conditions are simply supported, cantilever and fix end as it's mentioned. All the elastic shafts are suffering from natural frequency and that is depending mostly on the how many degree of freedom they are described. The shaft in the end will suffer from resonance when it matches with the natural frequency. As well as the amplitude is going to be high

value. For example, in rotating shaft the resonance is unwanted due to the rotor vibrate strongly and lead to break it [4].

*B. Aluminium Oxide and Stainless steel*

Each material has different property from young modulus and the yield strength which is important to decide in the software to get it started. Moreover, the author chose the carbon steel as it mentions in the journal. Additionally, the table below shows the other property of the materials.

Table 1: Materials property of shaft [5]

| Material | AISI 1018 mild Steel | Aluminum Oxide ($Al_2O_3$) | Stainless steel (304) |
|---|---|---|---|
| Density $p$ | $7830\,kg/m^3$ | $3960\,kg/m^3$ | $7800\,kg/m^3$ |
| Young modules $E$ | $205Gpa$ | $390Gpa$ | $210Gpa$ |
| Poisson Ratio | 0.33 | 0.26 | 0.3 |

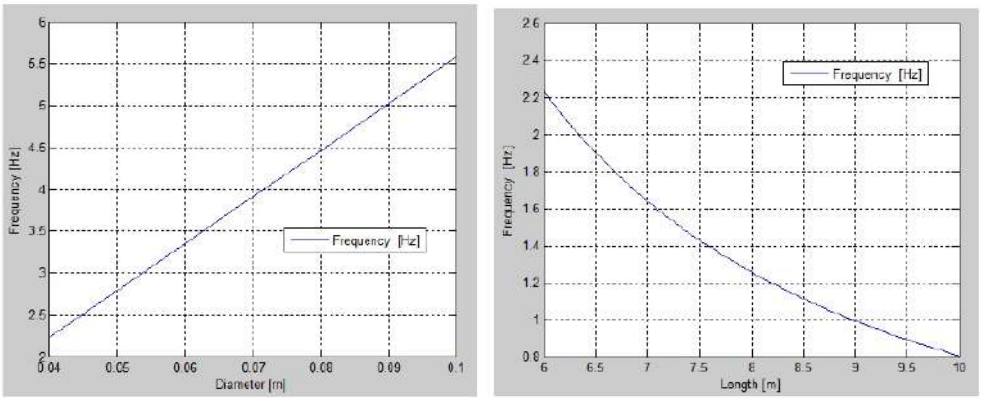


Figure 2: The diameter and length vs the frequency, Numerical and Analytical Analysis of Elastic Rotor Natural Frequency [5]

Figure 2 shows that the frequency is increasing when the diameter is getting bigger these values is being presented by the theoretical calculation. On the other hand, the frequency is decreasing when the length is increased.

Table 2: The results of the theoretical and simulation, Numerical and Analytical Analysis of Elastic Rotor Natural Frequency [6]

| Type of supports | First nat. fre. [Hz] | | Second nat. fre. [Hz] | | Third nat. fre.[Hz] | |
|---|---|---|---|---|---|---|
| | Analytical | Numerical | Analytical | Numerical | Analytical | Numerical |
| Simply sup. | 2.23 | 2.24 | 8.93 | 8.87 | 20.09 | 19.75 |
| Canti. | 0.55 | 0.79 | 5.02 | 4.95 | 13.95 | 13.95 |

*Equations of the manual calculation*

There are two main equations that been used in this study. A distributed parameter system as it's the opposite of lumped parameter system which is could also define as infinite dimensional due to the state space. Also the best example that can mention about this system is partial differential equations. To determine the equation for the vibration of the beam should be conceded that the forces and the moments acting on the element of the beam as it's shown below in the equation (1).

$$w_n = {\beta_n}^2 \sqrt{\frac{EI}{p}} = (\beta_n l)^2 \sqrt{\frac{EI}{pl^4}} \quad (1)$$

As for this equation the represent the boundary condition of this case if it's a simply supported or cantilever which it can get the value of by referring to the Table 3 as shown the first three modes.

Table 3: Euler equation table values, Theory of Vibration [7]

| *Beam Configuration* | $(\beta_1 l)^2$ *Fundamental* | $(\beta_2 l)^2$ *Second Mode* | $(\beta_3 l)^2$ *Third Mode* |
|---|---|---|---|
| Simply supported | 9.87 | 39.5 | 88.9 |
| Cantilever | 3.52 | 22.0 | 61.7 |
| Free-free | 22.4 | 61.7 | 121.0 |
| Clamped-clamped | 22.4 | 61.7 | 121.0 |
| Clamped-hinged | 15.4 | 50.0 | 104.0 |
| Hinged-free | 0 | 15.4 | 50.0 |

On the other hand, the other system is lumped parameter system. In this system is it's considering that all the mass in the middle/centre of the shaft not like the distributed system which can be less accurate to assume that. However, nowadays people been using the lumped parameter system because they have the programs to run the finite elements comparing to old days where they used the distributed system [8].

$$\omega_n = \left(\frac{k}{m}\right)^{1/2} \quad (2)$$

## METHODOLOGY AND FINITE ELEMENT ANALYSIS (FEA)

The first step in this study is to know the natural frequency that could happen to the shaft that rotate under high speed level. These speeds could match with the frequency that lead to fatigue or other issues to the shaft that can cause resonance. The researchers need to develop a 3D shaft modelling before starting the simulation analysis. Table 4 shows the dimensions and specifications of the shaft.

Table 4: Shaft measurements

| | |
|---|---|
| Shaft type | Solid shaft |
| Diameter | 0.04m |
| Length | 6m |

Meshing used in the Abaqus software are two types. The first one is the triangle shape and the second one is the square shape. Additionally, the writer is mixing between the triangle and the square shape to get the most accurate results. However, the meshing size is important to know about too as it's the distance between one element and another. So if the meshing size is large number then the

distance will be bigger and the result won't be an accurate. That's why it's important to make it small to get the high number of elements and also get an accurate result. For this project the author decided to use 5.7mm in meshing size to get the accurate. There are many types of boundary conditions that can be applied. However, the author decides to focus on two types only. The first boundary condition is called simply supported (SS) where the material is being supported from the two sides. Additionally, the other type is cantilever (C) where is being fixed from one side.

Table 5: Boundary conditions of shaft

| Condition | Section |
|---|---|
| Simply supported |  |
| Cantilever |  |

Each material has different property from young modulus and the yield strength which is important to decide in the software to get it started. Moreover, the researcehrs chose the carbon steel as suggested in a previous study and it is reasonable.

## RESULTS AND DISCUSSIONS

Figure 3 to Figure 5 show the simulation analysis results of the mild steel whirling shaft. Based on the results, it shows that the natural frequency of the first mode for the simply supported shaft is 2.19Hz. Figure 4 shows that the natural frequency of the second mode for the simply supported shaft is 8.78Hz and Figure 5 shows that the natural frequency of the second mode for the simply supported shaft is 19.75Hz.

*Mild Steel*

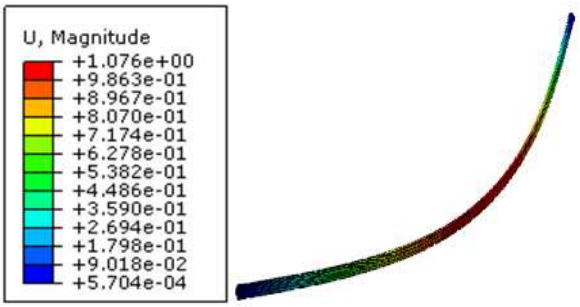


Figure 3: First mode simply supported 2.19 Hz

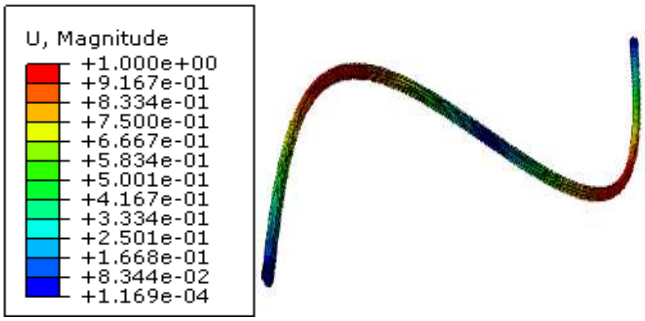


Figure 4: Second mode simply supported 8.78 Hz

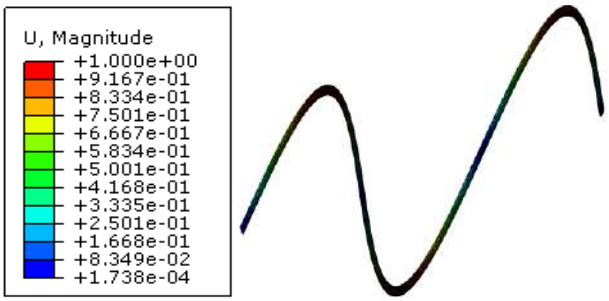


Figure 5: Third mode simply supported 19.75 Hz

These results later are tabulated in Table 6. Table 6 shows the validation of the theoretical calculations with the simulation analysis results with the percentage of errors. From Table 6, Table 7 and Table 8, it shows that Aluminium oxide has the highest natural frequency values.

Table 6: Lumped parameter system results of mild steel

| **Type and shape** | **Theoretical** $(Rad/s)$ | **Theoretical (Hz)** | **Simulation (Hz)** | **% error** |
|---|---|---|---|---|
| **Mild Steel AISI 1018** | | | | |
| **Lumped** | | | | |
| First mode SS | **9.84** | **1.56** | **None** | **None** |
| Second mode SS | **39.4** | **6.26** | **None** | **None** |
| Third mode SS | **88.7** | **14.13** | **None** | **None** |
| First mode C | **2.46** | **0.4** | **None** | **None** |
| Second mode C | **9.84** | **1.56** | **None** | **None** |
| Third mode C | **22.16** | **3.52** | **None** | **None** |

Table 7: Lumped parameter system results of aluminium oxide

| Type and shape | Theoretical $(Rad/s)$ | Theoretical (Hz) | Simulation (Hz) | % error |
|---|---|---|---|---|
| **Aluminum oxide (Al2O3)** | | | | |
| **Lumped** | | | | |
| First mode SS | **19.1** | **3.04** | **None** | **None** |
| Second mode SS | **76.4** | **12.15** | **None** | **None** |
| Third mode SS | **171.9** | **27.36** | **None** | **None** |
| First mode C | **4.77** | **0.76** | **None** | **None** |
| Second mode C | **19.1** | **3.04** | **None** | **None** |
| Third mode C | **42.99** | **6.84** | **None** | **None** |

Table 8: Lumped parameter system results of stainless steel

| Type and shape | Theoretical $(Rad/s)$ | Theoretical (Hz) | Simulation (Hz) | % error |
|---|---|---|---|---|
| **Stainless steel (304)** | | | | |
| **Lumped** | | | | |
| First mode SS | **9.98** | **1.58** | **None** | **None** |
| Second mode SS | **39.94** | **6.36** | **None** | **None** |
| Third mode SS | **89.9** | **14.3** | **None** | **None** |
| First mode C | **2.49** | **0.39** | **None** | **None** |
| Second mode C | **9.96** | **1.58** | **None** | **None** |
| Third mode C | **22.43** | **3.57** | **None** | **None** |

Table 9 shows the values from the simulation analysis in simply supported and cantilever aluminium oxide shaft for the first three mode shapes and it being validate with the theoretical calculations to see how much is difference between each results. This table is important because it shows that simulation result is much closer to the publish journal which mean it's accurate.

Table 9: Distributed system results of mild steel

| Type and shape | Theoretical ($Rad/s$) | Theoretical (Hz) | Simulation (Hz) | % error |
|---|---|---|---|---|
| Mild Steel AISI 1018 | | | | |
| **Distributed** | | | | |
| First mode SS | 14.03 | 2.23 | 2.19 | 1.8% |
| Second mode SS | 56.15 | 8.93 | 8.78 | 1.7% |
| Third mode SS | 126.38 | 20.1 | 19.75 | 1.7% |
| First mode C | 5 | 0.79 | 0.77 | 2.6% |
| Second mode C | 31.27 | 4.97 | 4.85 | 2.5% |
| Third mode C | 87.7 | 13.96 | 13.59 | 2.7% |

Table 10: Distributed system results of aluminium oxide.

| Type and shape | Theoretical ($Rad/s$) | Theoretical (Hz) | Simulation (Hz) | % error |
|---|---|---|---|---|
| Aluminum oxide (Al2O3) | | | | |
| **Distributed** | | | | |
| First mode SS | 27.2 | 4.33 | 4.26 | 1.6% |
| Second mode SS | 108.9 | 17.33 | 17.33 | 0% |
| Third mode SS | 174.32 | 39 | 38 | 2.6% |
| First mode C | 9.7 | 1.54 | 1.50 | 2.67% |
| Second mode C | 60.67 | 9.65 | 9.42 | 2.4% |
| Third mode C | 170.14 | 27.1 | 26.4 | 2.65% |

Table 11: Distributed system results of stainless steel.

| Type and shape | Theoretical ($Rad/s$) | Theoretical (Hz) | Simulation (Hz) | % error |
|---|---|---|---|---|
| Stainless steel (304) | | | | |
| **Distributed** | | | | |
| First mode SS | 14.23 | 2.26 | 2.22 | 1.8% |
| Second mode SS | 56.95 | 9.06 | 8.91 | 1.6% |
| Third mode SS | 128.17 | 20.4 | 20.04 | 1.8% |
| First mode C | 5.07 | 0.81 | 0.79 | 2.5% |
| Second mode C | 31.7 | 5.05 | 4.97 | 1.6% |
| Third mode C | 89 | 14.16 | 13.97 | 1.4% |

Table 10 shows the results of stainless steel from the theoretical calculations and simulation analysis. Also it shows the percentage of error and the difference between the theoretical and simulation results. From the error percentage it's noticeable that the value is less than 3% which is consider as accurate for this project.

Table 11 shows the values of stainless steel shaft with the first three mode shapes of the two boundary conditions. The table also shows all the results from calculation and simulation with the error column to observe the difference between theoretical calculation and simulation result.

## CONCLUSION

As a conclusion, this project has achieved its aims and objectives successfully. The natural frequencies and the mode shapes of the shaft using theoretical calculation method were obtained. The comparison between theoretical values and the simulation is calculated, from the results it shows the different frequencies of the first three mode shapes. There were three different materials of shafts to study the effect of the material on the lateral frequency. From the results above we can see each case and how it reacts to the frequencies. As the theoretical values have been obtained with the simulation and the percentage of error show the accuracy of these values. Later on the values have been verify with published paper for extra confirmation and it was showing low percentages of errors. From the results, it shows that Aluminium oxide has the highest natural frequency values and this material is the best material to avoid resonance in mechanical machines especially in shaft. The main point of this research is to avoid that type of dangers phenomenon which is known as 'resonance' which will lead to deflection and causes the structures to fail unexpectedly.

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# POTENTIAL OF ORANGE PEEL AS A COAGULANT FOR WATER TREATMENT

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## ABSTRACT
The effectiveness of chemicals as coagulants such as alum and ferric chloride is well recognized. However, there are many disadvantages associated with the usage such as high operational costs, detrimental effects on human health, production of large sludge volumes and the fact that it is significantly affect pH of treated water. It is therefore desirable to replace these chemical coagulants with natural-based coagulants such as from fruit peels to counteract the aforementioned drawbacks. Therefore, the aim of this study is to investigate the efficiency of fruits peel as natural coagulants in treating water over the use of alum and optimum dosage of natural coagulant used. In terms of selection of natural coagulants, this study focused on the local waste materials, which is orange peels. These peels were collected from neighbourhood and local stall and market. These peels were prepared by washing, drying, grinding and finally sieving, thus becoming powder of natural coagulants ready to be used. A series of jar test was then performed by using three different water sample which are Taman Metropolitan Kepong Lake, Seri Serdang Lake and Taman Cempaka Lake to determine the effect of individual natural coagulants on the efficiency of turbidity removal and coagulation activity under various operating factors such as pH and coagulant dosage. From the findings, optimum dosage for treating 300 ml individually for those 3 lakes water is 9mg/l, respectively showed turbidity removal of 68 - 80%. The results proved that the use of orange peels as new composite coagulant in water treatment is a feasible option in enhancing the reduction performance of turbidity. Moreover, the usage of this natural coagulant can reduce health risk from long term used of chemical coagulant along with lessen the chemical sludge product to the environment.

***Keywords:***
*Jar test, natural coagulant, optimum dosage, orange peels, pH, turbidity*

## INTRODUCTION

Water is one of the essential requirements for life. All living things need water for their survival. Water is used for a variety of purposes, including drinking, food preparation, irrigation and manufacturing. Although water covers more than 70% of the Earth's surface, less than 1% of that resource is available as fresh water and this is not evenly distributed throughout the world. Worldwide water demand is increasing day by day due to rapid population and industrial growth, and on the other hand there is continuous decline in ground and surface water levels due to over exploitation (R Subashree et al., 2017). Water contains many impurities which comprise mixture of dissolved solids, suspended solids and colloidal particles. Suspended solids - These may be inorganic in nature or mineral form (sand, silt, clay) or organic in nature including microorganism such as bacteria, virus, algae, etc. these substances are responsible for turbidity and colour of water (M Abdullah et al., 2017). More than one billion people worldwide, mostly in developing countries, lack safe drinking water. Apart from the scarcity of water, there are many other challenges in providing a safe, adequate and reliable water supply in many parts of the world. Many technologies are in practice to treat the wastewater and in the present study, an attempt was made to investigate the

application of natural coagulant from orange peels for the treatment by considering from 3 different sources Numerous of coagulants are widely used in conventional water treatment processes

The popular chemical coagulant is alum. However, the use of these chemical coagulants resulted in many downsides such as harmful voluminous sludge production. Despite the superiority of chemical coagulants in treating turbid water, they are still lacking in terms of green chemistry. In the 1960s, detrimental effects of chemical coagulants on the human health were published (Simate et al., 2012). The fundamental of this study is the potential for the natural coagulant as per used which is orange peels to occupied for water treatment like other conventional coagulant such as alum and other chemical derivative that available. The use of natural coagulant such as orange peel which is used as experimental material in water treatment is more economical instead of to produce treated water with high dosage of pH and highly ecological. These waste peels are low cost, non-hazardous and environment friendly bio-materials which can be used as coagulant in water treatment (Amir Hariz Amran et al., 2018). Coagulants derived from natural sources are usually considered safe for human health. While the commercial coagulants are effectual only at certain pH range and beneficial flocculation not be possible in some water.

## LITERATURE REVIEW

In the treatment of water, coagulation is essential step for removing odor, colour and suspended particles. The utilization of plant and fruit peels materials as selected coagulants for treatment of waste water has number of research exercises are going on. Coagulation process in raw water treatment is the procedure of charge balance of colloidal particles utilizing the addition of a chemical reagent or the formation toward conditioning suspended solids particles to promote their agglomeration thus produces bigger particles that can be more promptly evacuated in consequent treatment processes (AWWA et al., 1990). Flocculation is the procedure by which the destabilized particles agglomerate and shape flocculants particles, or "floc."(Crittenden et al., 2005).

Previous researchers mostly used Jar Test as their laboratory work to study the coagulation and flocculation of water treatment where it is a common experimental approach for the research. As for the materials, predominantly coagulant used of natural based was Moringa Oleifera with high percentage of turbidity removal while usual conventional coagulant used was Aluminium Sulphate. *Moringa Oleifera* is the most widely cultivated species of the genus moringa, which is the only genus in the family *moringaceae.* Crushed moringa seeds clarify and purify water to suit domestic use and lower the bacterial concentration in the water making it safe for drinking. It can be used as a quick and simple method for cleaning dirty river water. It also acts as an anti-bacterial agent removing 90-99% bacteria content in water (Nagarajan et al., 2018).

Utilizing some locally accessible natural coagulants, for instance banana strip and lemon strip significant improvement in removing turbidity and BOD from engineered raw water was found. Most extreme turbidity decrease was found for very turbid waters. After dosing, water-solvent Concentrate of banana strip and lemon strip diminished turbidity from 38 to 5.2 NTU after dosing and filtration. It was likewise discovered that these natural coagulants decreased about 89– 96% BOD. Among the regular coagulants utilized in this investigation for turbidity decrease, lemon strip was discovered most effective. It decreased up to 95.89% turbidity from the raw turbid water (R. Subashree et al., 2017).

According to Anju S et al (2016), Dairy wastewater was used for coagulation studies with orange peel powder as coagulant. Main object of coagulation studies is to explore effectiveness of orange peel coagulant for reducing wastewater characteristics parameter such as turbidity and measuring the pH, total solids through removal of organic colloidal suspensions. Five orange peel coagulant doses in range of 0.2 to 1g/l were applied to wastewater. The turbidity was found to be reduced from 260NTU to 8NTU with the dosage of 0.2g, 0.4g, 0.6g, 0.8g, 1g.

## METHODOLOGY

The methodology for this case study will be on intervention that is also known as experimental action research. The subject of this examination is to study the use of Orange Peel as a trademark coagulant for the refinement and illustration of raw turbid water and waste water from different sources.

### *Water Sampling*

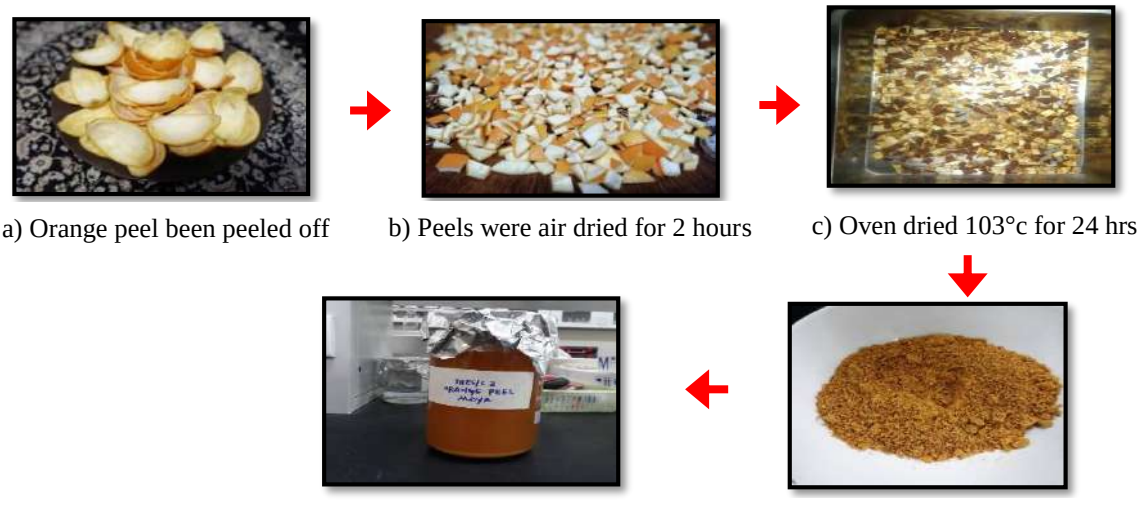
Collection of water samples were derived from 3 different sources. The water samples were taken as raw water of 4 litres amount per place in sterilized bottle. The crude water was basically from lake based which were obtain from Taman Metropolitan Kepong Lake, Seri Serdang Lake and last but not least Taman Cempaka Lake. The water samples then been taken to the laboratory for several test in order to get initial condition before proceed to jar test.

### *Preparation of Chemical Coagulant (Alum Solution)*

Alum solution was prepared by dissolving 1 gm of powder alum into 1000ml or 1 litre of distilled water and stir vigorously to produce a 1 % solution strength. Thus, 1 ml of this (stock solution) is equivalent to 10 mg of alum (or 10 mg/l dose when add to a 1-l raw water sample) (Al-Saati et al., 2016).

### *Preparation of Natural Coagulant (Orange Peel)*

Orange peel was collected from nearby market and wash a few times with tape water to evacuate the adhering dirt. Further the peels were air dried for 2 hours and cleaved by manual cutters into little pieces. Later on squashed to acquire small particle measure powder. Later the fresh peels were spread on trays and oven dried at 103 - 110 °C for 24 hours. The dried peels were blended into powder and sieved using mesh size of 600µm. The powdered peel was stored in an airtight container. Then 10 gram of powdered peels were taken and mixed with 1000ml (1 litre) of distilled water to produce orange peel stock solution. Figure 1 shows the process of preparing an orange peel stock solution as natural coagulant.



a) Orange peel been peeled off b) Peels were air dried for 2 hours c) Oven dried 103°c for 24 hrs

e) Orange peel powder mixed with 1000ml of distilled water d) Orange peel powder been sieved

Figure 1: Process of preparing an orange peel stock solution

### *Experimental Procedure*

Coagulation experiments were performed using jar test apparatus. Water samples were poured in 500 ml of 12 beakers with a volume of 300 ml each and varying doses alum were added in different 6 beakers containing 3ml, 6ml, 9ml, 12ml, 15ml and 18ml while of Orange Peel were added in different 6 beakers containing of 9ml, 18ml, 27ml, 36ml, 45ml, and 54ml. Initial pH and turbidity of the water samples was measured using pH meter and turbidity machine respectively. Samples were stirred at 100 rpm for 2 minute and slowly mixed at 40 rpm for 20 minutes followed by settlement of 30 minutes. Effectiveness of was evaluated by measuring removal of turbidity at various pH and coagulant doses, and river water. Turbidity of the settled samples was measured using turbidity meter. All the samples were tested three times and mean values are reported. The jar test experiment set up is shown in Figure 2.

Figure 2: Jar Test Method for both coagulants alum and natural in IUKL Laboratory

## RESULT AND DISCUSSION

### *Combination Results of pH and Turbidity for Sample 1, 2 And 3 by Using Alum*

The initial and residual value of pH and Turbidity for sample 1, 2 and 3 is shown as reference in Table 1. The results of pH and Turbidity (NTU) after the treatment is being done and the graph pattern for pH vs alum stock solution (ml) and turbidity vs alum stock solution (ml) are shown in Figure 3 and 4, where it clearly states that the highest residual pH level for sample 1, 2 and 3 with 8.04, 7.72 and 7.04 respectively using 3ml of alum stock solution and the lowest pH level is7.48, 7.33 and 6.51 individually with 18ml alum of stock solution added. According to Suleyman A. Muyibi et al., 2004, pH level which is in the range of 6.5 – 8 is acceptable as following to National Water Quality Index Standards for Malaysia (NWQS) (S. Suratman et.al. 2015).

Next, in the matter of turbidity, the initial value of turbidity removal for sample 1 and 3 was 45.43 NTU and 43.00 NTU where it is in the state of low turbidity (<50 NTU) while initial reading for sample 3 was 62.27 (50 < turbidity < 100) where it is in the state of moderate turbidity (Suleyman A. Muyibi et al., 2004). Once the treatment is carried out, the lowest residual turbidity removal for sample 1, 2 and 3 is 4.01NTU, 13.70 NTU and 13.53 NTU respectively with 3ml of alum stock solution added and the highest residual turbidity removal for sample 1 is 0.42 NTU with 9ml, 2.14 NTU with 18ml for sample 2 and 1.51 NTU with 15ml for sample 3. This corresponding to efficiency percentage removal of 99%, 96% and 95% individually for sample 1, 2 and 3. World Health Organization (WHO) has set the guideline value for the residual turbidity in drinking water at

5 Nephelometric Turbidity Units (NTU) where alum satisfied the criteria with turbidity removal less than 5 NTU (Eman N. Ali et.al 2010).

***Combination Results of pH and Turbidity for Sample 1, 2 And 3 by Using Orange Peel***

In reference to Table 1, it shows the results of pH after the treatment is being done, it stipulates that the highest residual pH level for sample 1, 2 and 3 is 8.09, 7.18 and 7.12 respectively with 9ml of orange peel stock solution and the lowest pH level is 7.31, 6.66 and 6.64 individually with 54ml of orange peel stock solution added. The graph pattern for pH vs orange peel stock solution (ml) and turbidity vs orange peel stock solution (ml) can be observed referring to Figure 5 and 6. Therefore, pH value for sample 1, 2 and 3 is classified as neutral which follows the standards as prescribed by World Health Organization (WHO) (Nagarajan et.al, 2018). Volume of dosage plays an important role where the higher the dosage of orange peel stock solution added the lower the pH value.

Other than that, in respect of turbidity, (<50 NTU) is categorized as low turbidity, (50 < turbidity < 100 NTU) is known as moderate turbidity and last but not least (> 100 NTU) is in the class of high turbidity (Suleyman A. Muyibi., 2004). The initial value of turbidity removal for sample 1 was 45.43 NTU, 62.27 NTU for sample 2 and 43.00 NTU for sample 3. In regards to Table 1, it shows the results of turbidity removal once the treatment is done, the lowest turbidity removal for sample 1, 2 and 3 is 21.77 NTU, 30.53 NTU and 28.23 NTU accordingly with 54ml of orange peel stock solution. The highest turbidity removal is 9.16 NTU, 13.87 NTU and 13.93 NTU consequently with 9 ml of orange peel stock solution which adequate to efficiency turbidity removal percentage of 80%, 78% and 68% respectively. As for natural coagulant, less concentrated solution which refers to lower dosage of coagulant will act effectively in turbidity removal where it produced less colloidal solution. This is the reason that the result in turbidity removal is increasing as dosage of orange peel stock solution increasing. Accordingly, 9 ml of orange peel stock solution is satisfactory as an optimum dosage of those 3 water samples which it reduces the most colloids from the solution compared to the highest dosage which is 54ml in resulting to low turbidity removal.

According to the Malaysian Department of Environment-Water Quality Index (DOE-WQI), the orange peel results closely suitable for class IIA and IIB. Class IIA refers to Water Supply II – Conventional treatment and Fishery II – Sensitive aquatic species. While for Class IIB relates to Recreational use body contact (S. Sutratman et.al. 2015). As a whole of view, residual pH for those 3 lakes indicates a decrease in level which it neutralized the water sample in between the range of 6.5 to 8.0 as shown in Table 1 as equivalent to the range recruited by the standards where for both class IIA and IIB pH value should be in the series of 6.0 to 9.0. While in the matter of turbidity, The Malaysian Department of Environment-Water Quality Index (DOE-WQI) has resolute that for class IIA and IIB, the turbidity value shall be 50 NTU (S. Suratman et.al. 2015). This point out that the residual turbidity obtained from the analysis is satisfactory which less than 50 NTU. In this manner, orange peel as a natural coagulant has a potential in water treatment process precisely in colloids removal.

Table 1: Initial and Residual Reading of pH and Turbidity (NTU) for sample 1, 2 and 3

| **INITIAL READING** | | | | | | | |
|---|---|---|---|---|---|---|---|
| **WATER SAMPLE** | | **pH** | | **Turbidity (NTU)** | | | |
| **Sample 1 (Taman Metropolitan Kepong Lake)** | | 7.90 | | 45.43 | | | |
| **Sample 2 (Seri Serdang Lake)** | | 7.78 | | 62.67 | | | |
| **Sample 3 (Taman Cempaka Lake)** | | 7.89 | | 43.00 | | | |
| **RESIDUAL READING** | | | | | | | |
| **Coagulant** | **Dosage (ml)** | **Sample 1 (Taman Metropolitan Kepong Lake)** | | **Sample 2 (Seri Serdang Lake)** | | **Sample 3 (Taman Cempaka Lake)** | |
| | | **Residual pH** | **Residual Turbidity (NTU)** | **Residual pH** | **Residual Turbidity (NTU)** | **Residual pH** | **Residual Turbidity (NTU)** |
| **Alum** | 3 | 8.04 | 4.01 | 7.72 | 13.70 | 7.04 | 13.53 |
| | 6 | 7.85 | 0.98 | 7.50 | 8.58 | 6.86 | 6.15 |
| | 9 | 7.66 | 0.42 | 7.43 | 6.53 | 6.83 | 2.64 |
| | 12 | 7.61 | 0.85 | 7.27 | 3.38 | 6.68 | 2.17 |
| | 15 | 7.59 | 0.64 | 7.40 | 3.73 | 6.60 | 1.51 |
| | 18 | 7.48 | 0.48 | 7.33 | 2.14 | 6.51 | 2.02 |
| **Orange Peel** | 9 | 8.09 | 9.16 | 7.18 | 13.87 | 7.12 | 13.93 |
| | 18 | 7.80 | 12.83 | 7.20 | 17.93 | 7.04 | 16.70 |
| | 27 | 7.76 | 19.07 | 6.91 | 21.40 | 6.90 | 21.23 |
| | 36 | 7.63 | 19.63 | 7.29 | 25.47 | 6.81 | 22.43 |
| | 45 | 7.53 | 20.23 | 6.68 | 28.40 | 6.73 | 24.40 |
| | 54 | 7.31 | 21.77 | 6.66 | 30.53 | 6.64 | 28.23 |

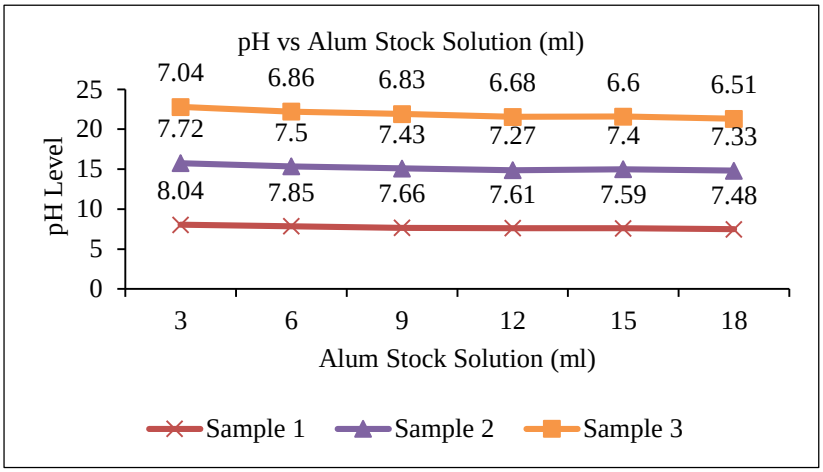



Figure 3: pH versus Alum stock solution (ml) for water sample 1, 2 and 3

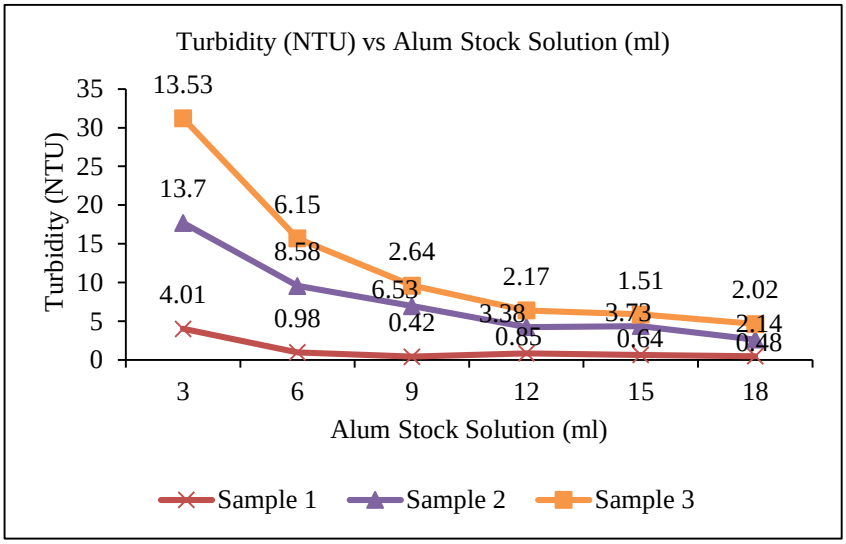



Figure 4: Turbidity (NTU) versus Alum stock solution (ml) for water sample 1, 2 and 3

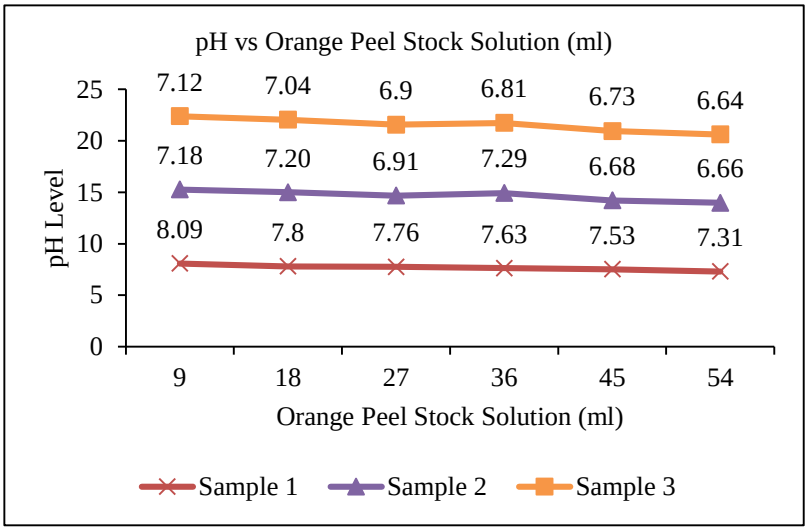



Figure 5: pH versus Orange Peel stock solution (ml) for water sample 1, 2 and 3

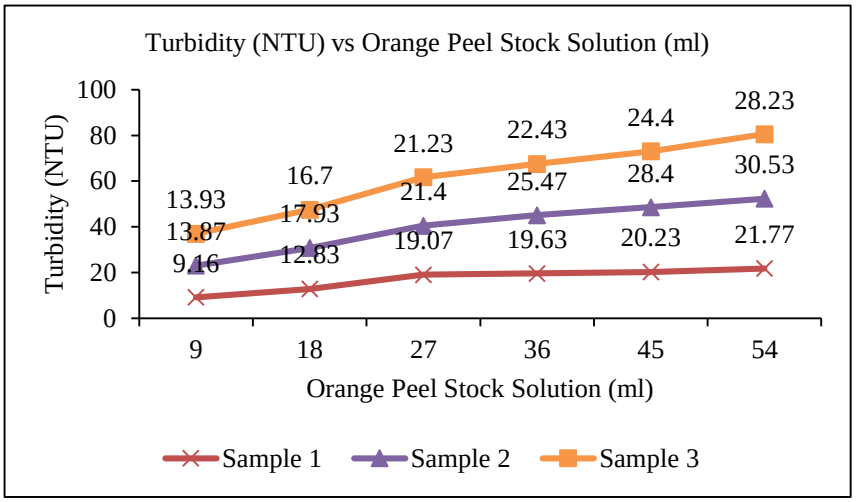



Figure 6: Turbidity (NTU) versus Orange Peel stock solution (ml) for water sample 1, 2 and 3

## CONCLUSION

This chapter broadly explains on the whole perspective specifically in coagulation process in water treatment with the used of conventional and natural coagulant which is alum and orange peel respectively by taking results as reference in order to satisfy the objectives stated as follows.

**Objective 1: To determine pH and turbidity of orange peel and alum by comparing the results of 3 different sources by using Jar Test**.

The results shown includes the initial and residual reading in the aspect of pH and turbidity of the water sample of 3 different lakes which are Taman Metropolitan Kepong Lake, Seri Serdang Lake and Taman Cempaka Lake. Different lake has different properties and characteristics, therefore, the first objective is utmost important in order to determine its features precisely. Appertaining to the previous statement, those 3 water samples indicates pH level within the range of 6-8 which it is classified as natural state after the treatment is carried out. Next in the matter of turbidity, alum as a conventional coagulant shows greater results in turbidity removal up to 99% compared to orange peel as natural coagulant up to 80%.

**Objective 2: To determine the optimum dosage of the Orange Peel by using Jar Test.**

For the Jar Test process, various dosages of orange peel stock solution were used in order to observe maximum reduction of colloids in the water sample. Therefore, optimum dosage is a vital element in order to examine the turbidity removal at higher proportion. From the results, stated that 9ml of orange peel stock solution was defined to be the optimum dosage in the treatment process for those 3 lakes. This is because 9ml dosage was applicable and utilizable which shows a great turbidity reduction compared to the highest dosage used which is 54ml.

**Objective 3: To compare the effectiveness of alum with Orange Peel as a natural coagulant.**

Both coagulant used which are alum (conventional) and orange peel (natural) presents an effective results in turbidity removal and pH balance. Alums demonstrated tremendous outcomes which resulting of 69% to 99% of turbidity removal. However, as mentioned in statement of problem, it proves that by using chemical based of coagulant will leads to many downsides such as detrimental effects on the human health (Simate et al., 2012). Even though, orange peel does not presents the results of turbidity removal as high as alum, but it still effective and well worked in turbidity reduction resulting greater than 50% which it removes 69% to 80% of colloids throughout the treatment. Therefore, a prominent solution by using orange peel (natural-based) as coagulant is accepted while not leading to adverse impact to the consumers where it is safe and environmental friendly.

## ACKNOWLEDGEMENT

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# HIGH GAIN TWO-STAGE CLASS-AB OPERATIONAL TRANSCONDUCTANCE AMPLIFIER

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**ABSTRACT**
A new two-stage class-AB operational transconductance amplifier that is suitable for analog-to-digital converters (ADC) and switched capacitor (SC) filters is presented. The proposed design is based on adaptive biasing at the input stage, cascoding and class-AB output stage techniques. The OTA have been designed in 0.18 µm CMOS technology with simulation results showing gain and gain bandwidth improvements of 201% and 12% respectively when compared to a conventional Class-AB OTA. The circuit is operated at 1.8V supply voltage.

**Keywords:**
*Integrated circuits, analog CMOS circuits, amplifiers, two-stage, class-AB, adaptive biasing, high gain, gain bandwidth, operational transconductance amplifier (OTA).*

## INTRODUCTION

Nowadays, CMOS Operational Transconductance Amplifier (OTA) is one of the most used and a crucial building block in analog circuit application (Nguyen & Lee, 2006), used in applications like switched-capacitor filters, continuous-time filters and high-speed A/D converter circuits (Lopez-Martin, Baswa, Ramirez-Angulo, & Carvajal, 2005) (Rambabu, Majumder, & Mondal, 2017). OTA has a very high output impedance; hence, OTA is best defined in terms of transconductance (Parveen, 2013). The ability of the operational transconductance amplifier to operate in both voltage and current mode, enables diversity in circuit design (Lim, 2000).

The advancements achieved in MOS technology have resulted in downscaling the dimensions of the transistors, leading to reduced intrinsic voltage gain. As a result, the upper limit of the open-loop gain achievable by OTA is reduced. Moreover, low gain OTAs have direct effect on the accuracy of systems such as analog to digital converters (ADC) and switched capacitor circuits (Yang & Roberts, 2016) (S. I. Singh, 2017). To achieve higher gain, employing class-AB at the second stage of the OTA can result in larger gain bandwidth due to higher output voltage swing, which can't be achieved using a class-A output stage due to its characteristics (Nur, Baharudin, Jambek, & Ismail, 2014) (Noormohammadi, Lazarjan, & HajSadeghi, 2012).

## TWO-STAGE CLASS-AB OTA

Proposed OTA is designed based on adaptive biasing and current boosting techniques. It consists of three main OTA techniques in OTA design which are adaptive biasing at the input stage, push-pull amplifier at the output stage and cascoding. For the input stage, it consists of two input matched transistors M1 and M2 cross coupled with two level shifters. Furthermore, each one of the level shifters is made of two flipped voltage followers (FVF) consisting of transistors M5, M6, M7 and M8 and two current source transistors M9 and M10. Further, when there is a large differential input signal applied, the current delivered becomes much larger than the quiescent current. therefore, this technique uses class-AB operation which makes it preferable in low power devices. Adaptive biasing technique prevents settling time limitations by slew rate and improves small signal characteristics

such as gain-bandwidth product and achieving near optimal current efficiency without increasing the power consumption (Galan et al., 2007).

Additionally, the proposed OTA design has a class-AB output stage that consists of a common source amplifier or push-pull consisting of transistors M17, M18, M25 and M26. Class-AB at the output maintains a low quiescent current and improve the slew rate as well as generating the maximum output current (Kim et al., 2009) (Nur et al., 2014).

The third main building technique in the proposed design is cascode amplifier consisting of transistors M19, M20, M21, M22, M23 and M24 where three transistors are cascoded in each side of the proposed OTA. Further, cascoding increases the frequency response due to its ability to reduce the input capacitance. On the other hand, this configuration requires additional headroom voltage where the minimum output voltage of a triple cascode is equal to the sum of three overdrive voltages which makes it unsuitable for low voltage applications. Also, this configuration increases the output impedance which causes voltage gain reduction when the output voltage is maximized (Razavi, 2016).

The signal through the OTA starts flowing in the input stage at transistors M1 and M2 then flows to adaptive biasing circuit that is part of the input stage. Further, the signal flows to the flipped voltage follower (FVF) and then to the cascode amplifier and ends up at the push-pull amplifier at the output stage.

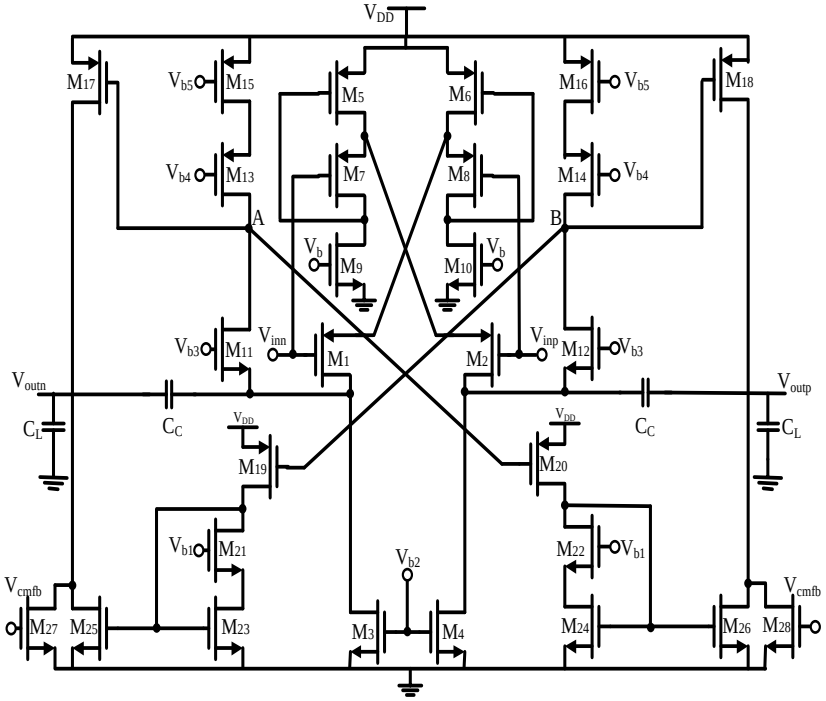


Figure 1: Two-Stage Class-AB OTA

The DC gain of each stage of the two-stage class-AB OTA is calculated through the impedance and transconductance produced by each transistor on the input and the output path considering the type of amplifier created by the CMOS devices arrangement such as common source amplifier, common gate amplifier, cascode amplifier and push-pull amplifier. The gain of an OTA is the ratio of output signal to input signal given as:

$$A_V = \frac{V_{outp} - V_{outn}}{V_{inp} - V_{inn}} \tag{1}$$

Due to transistors' matching, the transconductance and the resistance of transistors on the opposing sides are the same. Therefore:

$$A = \frac{V_{outp} - V_{outn}}{V_{in}} = \frac{g_{m2}\left(r_{o2} \,//\, r_{o4}\right) \cdot r_{o12} \cdot \left(g_{m19} r_{o19} \,//\, g_{m21} r_{o21} r_{o23}\right) \cdot g_{m19} r_{o19} \cdot g_{m18} g_{m26} \left(r_{o18} \,//\, r_{o26}\right)}{1 / g_{m2}} \tag{2}$$

Generally, two-stage amplifiers are unable to achieve such stability without a compensation method because the architecture causes two pole phase margin. Moreover, each pole contributes to a 90 degrees of phase margin degradation where if both dominant and non-dominant pole fall inside the range unity gain frequency, the amplifier destabilizes and oscillates. Therefore, a functional method to improve the OTA's stability is Miller compensation which adds a compensation capacitor from the input stage to the output stage. Also, the compensation works to move the dominant pole closer, and the non-dominant pole away from the unity-gain frequency which if it falls in that range results in destabilization of the OTA. Therefore, the dominant pole can be expressed as:

$$P_1 = -\frac{1}{\left(r_{o1} \,//\, r_{o3}\right) \cdot C_C} \tag{3}$$

Whereas, the non-dominant pole can be expressed as:

$$P_2 = \frac{1}{\left(1 / g_{m25}\right) \cdot C_L} \tag{4}$$

## SIMULATION RESULTS

The two-stage class-AB OTA was designed using Silterra 0.18 µm standard CMOS technology with a supply voltage of 1.8 V and load capacitance 1pF with a threshold voltage for NMOS and PMOS of 0.45 V. Also, a comparison is provided with other OTA techniques. Figure 2 shows the gain of the two-stage class-AB OTA in comparison with other topologies and the advantage the proposed OTA has over other designs in terms of gain.

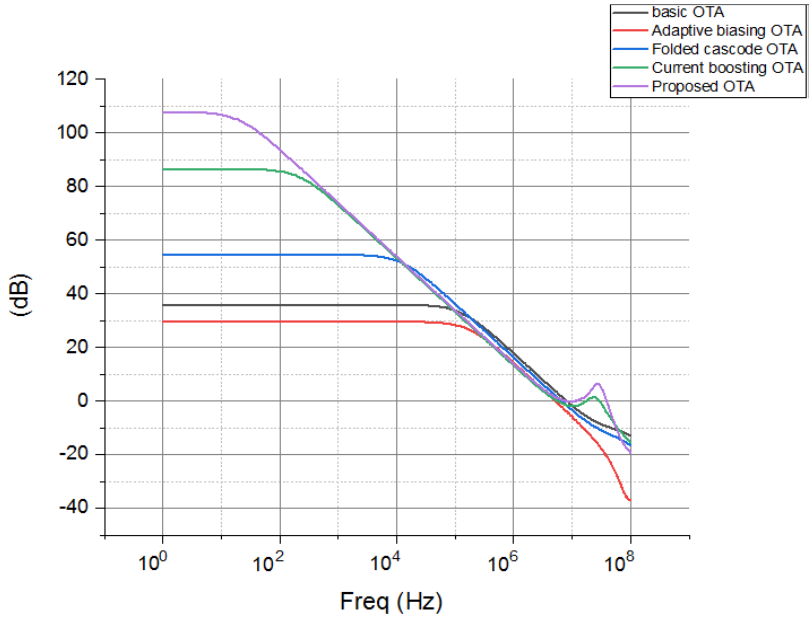


Figure 2: Gain

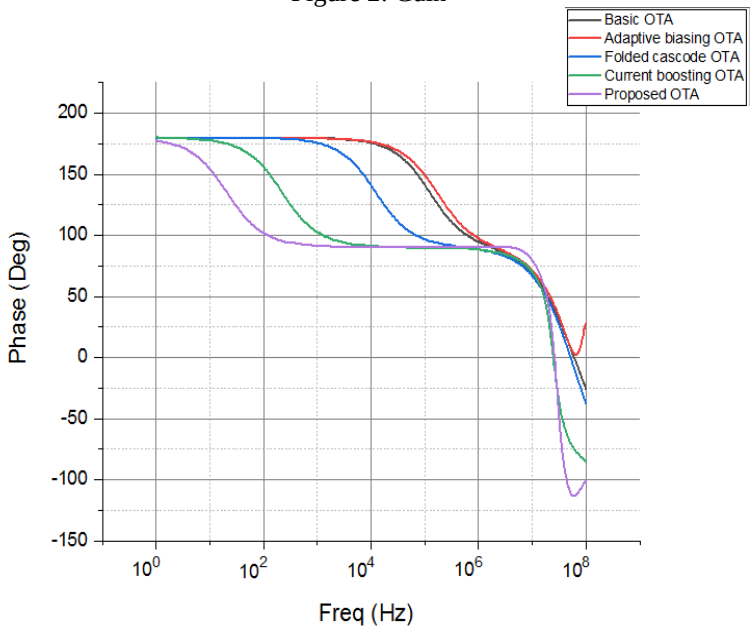


Figure 3: Phase

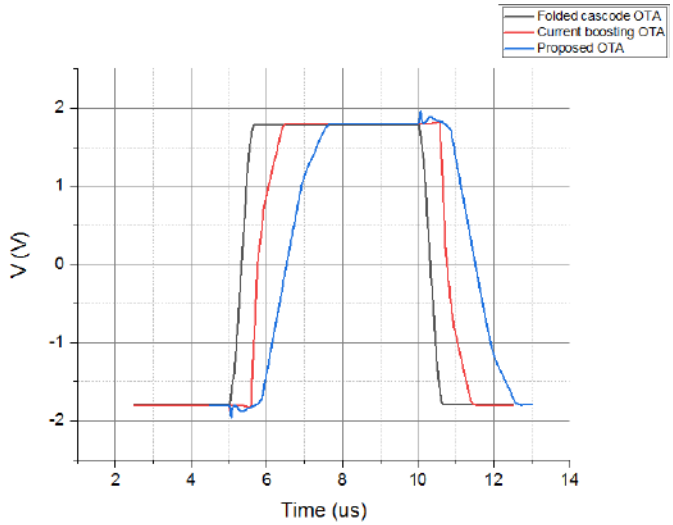


Figure 4: Transient Response

Figure 3, shows the phase margin of the proposed OTA against other topologies where it has the highest gain of 8.8 MHz and ha a stable operation with a phase margin greater than 60 degrees. Also, Figure 4 shows the slew rate where the proposed OTA slew rate suffers due to using a large compensation capacitor to achieve stability in the operation of the proposed OTA. Table 1 shows performance comparison between the proposed OTA and other topologies.

Table 1: Performance Comparison

| **OTA** | **(林伸行, 2017)** | **(Galan et al., 2007)** | **(Rezaei & Ashtiani, 2008)** | **(Noormohammadi et al., 2012)** | **Proposed** |
|---|---|---|---|---|---|
| **Power Supply** | 1.8 V | 1.8 V | 1.8 V | 1.8 V | 1.8 V |
| **Technology** | 0.18 µm | 0.18 µm | 0.18 µm | 0.18 µm | 0.18 µm |
| **Gain** | 35.7 dB | 29.5 dB | 55 dB | 86 dB | 107.5 dB |
| **Bandwidth** | 125 KHz | 174 KHz | 9.3 KHz | 221 Hz | 20 Hz |
| **GBW** | 7.9 MHz | 5 MHz | 6.6 MHz | 5.6 MHz | 8.8 MHz |
| **Phase Margin** | 73 º | 81 º | 90 º | 86 º | 77 º |
| **Slew Rate** | 94.9 V/µS | 89.3 V/µS | 7.3 V/µS | 4.6 V/µS | 2.4 V/µS |
| **Power Dissipation** | 145 µW | 142 µW | 163 µW | 175 µW | 160 µW |
| **$C_L$** / **$C_C$** | 1pF / 3pF | 1pF / 1pF | 1pF / 2pF | 1pF / 4pF | 1pF / 8pF |
| **FOM** | 0.09 | 0.06 | 0.08 | 0.07 | 0.11 |

## CONCLUSION

The proposed OTA was designed using Silterra 0.18-µm standard CMOS technology. Moreover, proposed OTA consists of three main techniques used in the design to improve the performance. The first technique the proposed OTA consists of is adaptive biasing at the input stage to increase the input impedance and improve the DC gain. Then, push-pull amplifier at the output stage which maintains low quiescent current and improves the slew rate. Furthermore, cascoding technique that

improves the frequency response. The techniques used also improved the gain bandwidth of the proposed OTA as they improve small signal characteristics. As a result, the proposed OTA achieved a gain of 107.5 dB and a gain bandwidth of 8.8 MHz where it can be used in high precision application such analog-to-digital converters and high-performance switched capacitor filters. Further, RC miller compensation was used to achieve a stable operation in the proposed OTA with a phase margin of 77 degrees.

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# INFLUENCE OF AGGREGATE REPLACEMENT UPON THE CHARACTERISTIC STRENGTH OF CONCRETE CONTAINING MALAYSIAN LATERITE

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## ABSTRACT
Strength development of concrete indicates the significance of curing temperature in the activation of hydration process. This study addresses the effect of aggregate replacement upon the characteristic strength of concrete containing Malaysian laterite aggregate (MLA). In this study, MLA was utilized to partially replace of coarse aggregate at 0%, 10%, 20%, 30%, 40% and 50% (by weight of coarse aggregate) and cured at three different curing regime (water curing, natural curing and air curing) until the testing day. The results show that up to 30% in concrete mix, showed that the concrete is able to attain the targeted strength which is 30 MPa.

**Keywords:**
*Laterite Aggregate, Partial Coarse Aggregate Replacement, Laterized Concrete, Alternative Concrete Mix, Concrete Strength*

## INTRODUCTION

Concrete is a composite material consists of cement, water, fine and coarse aggregates. Generally, about 60–75% of the volume concrete occupies by the fine and coarse aggregates form the skeleton of the concrete. The properties and types of aggregate would affect the performance and economical value of the concrete (Rawaz Kurda, 2018). The upsurge in demand for concrete every year has become a massive pressure on supply of constituent materials of concrete to satisfy the demands (Natt Makul, 2020). Utilization natural resources such as river sand and granite as aggregates in concrete have led to deterioration of ecosystems. Therefore, the current research focus is on alternate materials for fine and coarse aggregates.

Laterite has been applied as an aggregate in construction field at early 1800s in South India (Basavana Gowda *et. al.*, 2018). The term Laterite was introducing by Francis Buchanan in 1807 during a surveillance trip through the western piece of peninsular India. It was derived from the Latin word 'later' to illustrate a ferruginous, vesicular, unstratified and porous material with yellow ochre (Zubair Saing et. al., 2018). Large deposits of laterite in Malacca, Johore, Negeri Sembilan, Kedah, Pahang, Kelantan and Selangor which have not been completely utilized even though it is a popular building material in Malaysia (Mohammad Razip Selamat et. al., 2017). Therefore, to add value toward this waste by using it as a partial replacement of aggregate and it's achieve towards sustainability.

The main focus of this study to investigated the properties of laterite aggregate according to BS EN 12620 (2008) and the effect of curing regimes on workability and characteristic strength of concrete (compressive strength, flexural strength and modulus of elasticity) containing Malaysian laterite aggregate (MLA) as partially coarse aggregate replacement.

## METHODOLOGY

### *Materials*

In this study, the laterite aggregate was taken from Kampung Jawa, Damansara, Bukit Setongkol and Mempaga while granite was obtained from Bukit Rangin. All aggregate that been used in this study were obtained from Kuantan, Pahang. The coarse aggregate used is in the size range from 5mm to 20mm with the accordance to the standard (BS EN 12620, 2008).

### *Experimental Programme*

The 20 mm laterite aggregate particles which were in saturated surface-dry condition were used as the alternative coarse aggregate. Then, the physical and mechanical characteristic of MLA was determined to choose the best laterite aggregate and can be used further as a partial replacement of coarse aggregates. Approximately 216 concrete samples were prepared by using three types of mould's dimension. For compressive strength, cube size with 150 mm dimension was use whereas for flexural strength, the size for the beam was 150 mm x 150 mm x 750 mm was adopted. For modulus of elasticity experiment, the dimension of the specimen's cylinder mould is 300 mm height with 150 mm diameter was used. To determine the compressive strength, flexural strength and modulus of elasticity of concrete specimens towards the replacement of coarse aggregate with laterite aggregate, the tests were conducted with accordance to BS EN 12390-3 (2009); BS EN 12390-5 (2009) and BS 1881-121 (1983) respectively. The mix proportion was designed by using DoE mix design with 0%, 10%, 20%, 30%, 40% and 50% replacement upon coarse aggregate weight. Complete mixture compositions are described in Table 1.

Table 1: Proportion of Concrete

| | Cement($kg/m^3$) | Granite($kg/m^3$) | Laterite($kg/m^3$) | Sand($kg/m^3$) | Water ($kg/m^3$) |
|---|---|---|---|---|---|
| Control | 365 | 1170 | - | 660 | 164 |
| LC10 | 365 | 1053 | 117 | 660 | 164 |
| LC20 | 365 | 936 | 936 | 660 | 164 |
| LC30 | 365 | 819 | 819 | 660 | 164 |
| LC40 | 365 | 702 | 702 | 660 | 164 |
| LC50 | 365 | 585 | 585 | 660 | 164 |

## RESULT AND DISCUSSION

### *Workability*

Figure 1 presents the workability result of inclusion MLA in OPC concrete. From the result, higher replacement percentage of MLA, show lower workability of fresh concrete. However, it is still within the range of design slump; 30-60mm. This is due to the water absorption mechanism of MLA which reduces the water content in fresh concrete. The MLA properties has slightly higher of porosity might contributing to the higher absorption of water or mitigation inside the particle arrangement (Samuel et. al., 2019). That is why, the MLA tends to absorb more water as compared to granite aggregates. Thus, higher replacement percentage of MLA in concrete mix would exhibit lower slump value trend.

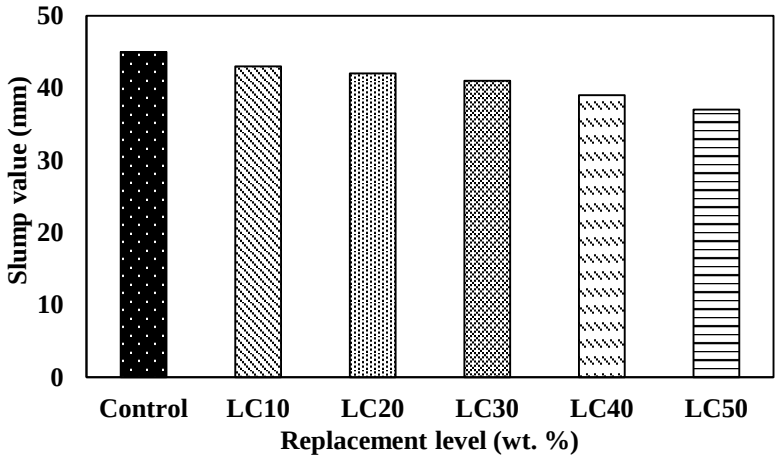


Figure 1: Workability Result Inclusion of Malaysia Laterite Aggregate in Concrete

***Characteristic Strength of Concrete***

*Compressive Strength, Flexural Strength and Modulus of Elasticity*

Figure 2 illustrates the compressive strength on 7, 14, 28 and 60 days of concrete age for 0%, 10%, 20%, 30%, 40% and 50% MLA replacement. It is presented that the compressive strengths of concrete samples were affected directly by the aggregate replacement percentages. It can be seen also from the graphs that the compressive strengths of concrete samples were similar to the control sample. However, the strength development is limited to certain replacement percentage which is up until to 30% only. It is evidence that by replacing 30% of MLA, it is still meeting the desired design strength at 28 days which is 30 MPa. The strength deterioration might occur due to the absorptive characteristic of MLA (Richard Ohene Asiedu, 2017) which tends to absorbs more water in the concrete mix proportion and led to structural disintegration. The importance of complete hydration process was highlighted by Vytautas Jocius (2016) that leads to the hardening of concrete specimens to achieve designed concrete strength (Wenhui Zhao et. al., 2020; Yan Feng et. al., 2019; El-Gamal, 2014).

The pattern of the flexural test results could be observed is similar to the compressive strength result, as presented in Figure 3. The flexural strength of the control specimen is higher than MLA concrete specimen. It was also observed that the flexural strengths decrease with increment inclusion of MLA in concrete and continued to increase with age of curing. Under the flexure loading, the cracks were initiated in the interfacial zone at low stresses and extend into the mortar matrix at high stresses and the resistant to cracks results from the cement paste only (Mohd, 2014). Therefore, it shows that the aggregates might influence the strength and flexibility of concrete performances (Sneka, 2018) as aggregates contain approximately 70 to 80 % of constituents of concrete.

Figure 4 shows the result of modulus of elasticity inclusion of MLA in concrete in different percentage of replacement. The modulus of elasticity of concrete (Ec) is associated with structural deformations that must be kept within limits to prevent excessive deformations that cause cracks and other pathologies in concrete structures especially in alternative concrete mixtures (Antonio Carlos, 2017). Based on the observation, the modulus of elasticity is increases as the concrete age increases. In addition, the modulus of elasticity of control concrete is significantly enhanced than the MLA concrete due to the properties of aggregate. Based on the experimental results, the modulus of elasticity can be increased by changing the mineralogical source of the coarse aggregate.

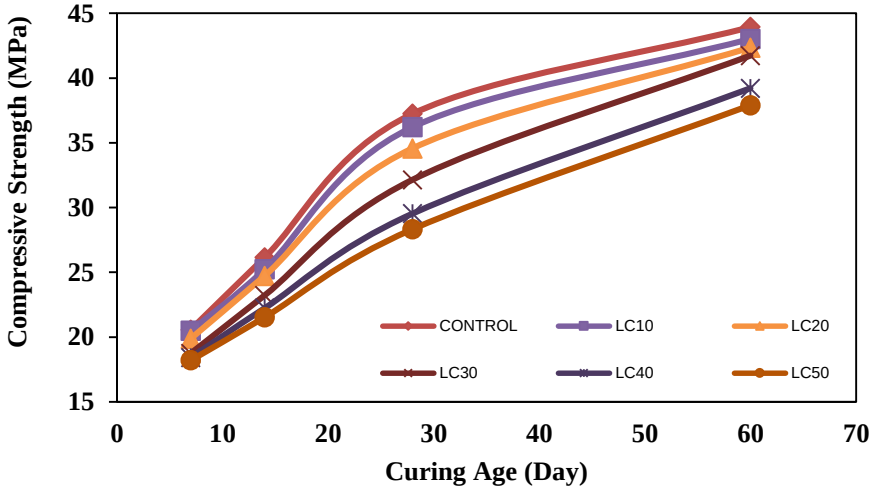


Figure 2: Compressive Strength of Concrete

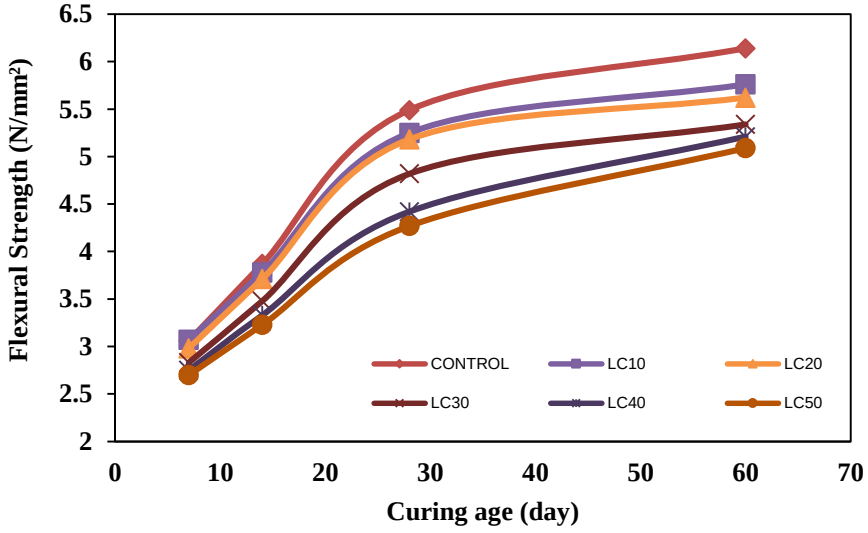


Figure 3: Flexural Strength of Concrete

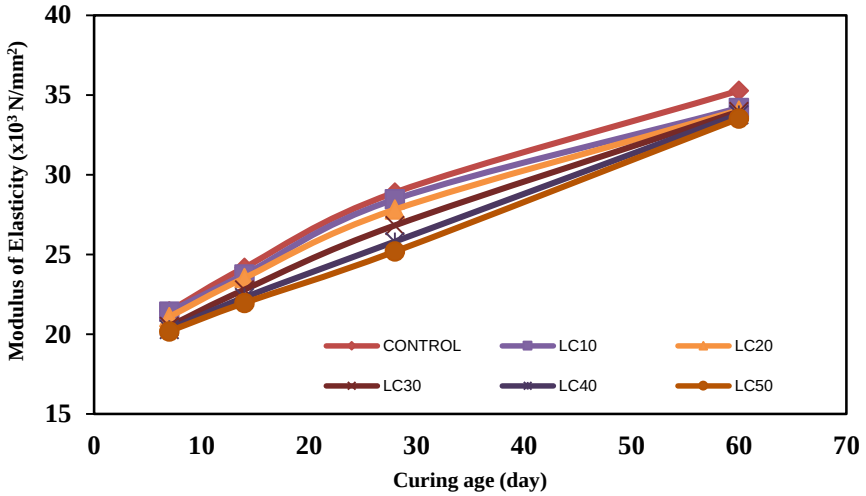


Figure 4: Modulus of Elasticity of Concrete

## CONCLUSION

Based on the results on compressive strength, flexural strength and modulus of elasticity of concrete containing laterite aggregate as a partial replacement, it can be concluded that Malaysia Laterite Aggregates (MLA) can be used as partial replacement of coarse aggregate up to 30% replacement as it able to achieve targeted strength at 28 days of concrete age.

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# THE EFFECTS OF HOSPITAL EFFLUENT DISCHARGES ON THE QUALITY OF WATER

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## ABSTRACT

Wastewater which comes from the hospital is very dangerous for the environment if the hazardous waste is disposed to the river without a proper treatment. The current research will investigate the common pollutant that is generated from the hospital wastewater such as BOD, COD, TSS, Phosphorus, Ammonia, total pH, Microbacterial, and some of the heavy metals such as Zn, Cu, and Fe. And, it is compared with the National Water Quality Index of Malaysia and Environmental Quality Act (EQA) 1974 for the allowable range of healthy water in current river which is connected with hospital sewerage system. The experimental method is used to take the concentration of each element and the result is very significant because the concentration from the hospital sewerage system is very high such as 16.84 mg/L BOD, 60.67 mg/L COD, TSS is 0.01 mg, 6 mg/L $NH_3$ –N, 3.22 mg/L $PO_4^{3-}$. Except the result for Microbacterial and pH which is 10.67 CFU and $^{pH}$ is 6.43. And heavy metals concentration such as Fe, Cu and Zn is very satisfied which is Fe is 0.02 mg/L, Cu is 1.03 mg/L and Zn is 0.20 mg/L. All the result is compared to the National Water Quality Index of Malaysia and Environmental Quality Act 1974.

***Keyword:***

*Experimental Method, Hospital Wastewater, Heavy metals, Urban Sewerage system, River, Total Coliform*

## INTRODUCTION

Water is the important thing for the life of the surrounding species such as Animal and Plant. It can support their need during the metabolism process. But, water can be a disposal place also which contain some contaminants which dangerous for the human being (Ojo et.al, 2012). Water which contains some contaminants or a pollutant can be generated from the activities near surrounding such as Residential Place, Hospital, Factory and Agriculture. Each of the wastewater have some characteristic and it can affect the surrounding environment especially hospital wastewater. Because the waster contain some dangerous material from each of activities in the hospital like clean the equipment after surgery, clean the floor, water from clinical laboratory and etc. (Amirhossein & Bahareh, 2016)

Some hospital can give a serious damage to the environment if the pollutant such as Pharmaceutical, Heavy metals and Microbacterial cannot be treated properly. These are the common pollutant which the most hospital generates especially in Hospital Pantai Ampang (Al-ajlouni, et. al 2009; Kumarathilaka, et al. 2015). The common Pharmaceutical contaminant like BOD, COD, ph, Total Suspended Solid, Ammonia and Phosphorus. The salmonella and E.coli is classified as the Microbacterial contaminants and the common Heavy Metals which appears in the hospital wastewater are Zinc (Zn), Ferrous (Iron), and Copper (Cu). The flow of water that flows before the hospital is very smooth and there are no obstacles at all to the water conditions that are very turbid and dirty because it is contaminated with residential activities that occur around the area. But the pollutants that affect only a little compared to pollutants produced after the hospital. Hence, the aim of the study is to determine the pollutant

## LITERATURE REVIEW

The characteristic of the hospital wastewater has a similarity with other wastewater from other place. Hospital need more water with the average of ranging from 400 to 1200 L/day/bed. Then, the average amount of the wastewater generates with the hospital activities is ranging from 362 to 745 L/day/bed. There are a few parameters which are considered as the criterion of good quality of the water. Those parameters are Physiochemical, Metal and heavy metal and Microbiological. The physiochemical elements consist of BOD and COD, Total Suspended Solid (TSS), Ph, Ammonia, Chlorine, phosphate, while the heavy metal elements consist of Zinc, Copper (Co), Fe and The Microbiological element consists of total coliform to investigate the total amount of the bacteria contaminate in the wastewater of the hospital. (Akin, 2016; Meo et. al, 2014; Kusuma et. al, 2013).

Some contaminants has been investigated by the researchers. Some of the contaminant in hospital wastewater is a common contaminant that has been generated by other places also but the amount of the contaminant is higher than other places. There are a lots of activities that can make some pollutant is higher and it can disturb the ecosystem. They can make growth of wild algae is very high and it can make the amount of the oxygen is low. And it can make the fish died. Others, it can disturb the food chain of the organism also. But, all the hospital have a pretreatment that can make the contaminant treated properly so that the dangerous material cannot make some issues for the river water (Emmanuel et. al, 2002; (Mesdaghinia et.al, 2009).

Some of the country have their standard guideline for the water quality index that can be a main safety purposes for the water. It can show the range of the safety and healthy water for the living things in the surrounding environment. In Malaysia, they used NWQS (National Water Quality Standard) for Malaysia and EQA 1974 (Environmental Quality Act) 1974 for Industrial waste. But the investigation of the hospital wastewater is very rare in Malaysia. Malaysia have a lots of sophisticated hospital and their hospital is well-known. It is very necessary to make the investigation for the hospital wastewater because Malaysia is developed country.

Hence, the prevention of the contaminants of the wastewater is very important to keep the environment healthy and safe for all living things in surrounding of environment. It can keep the sustainable ecosystem to make the living things is prosperous afterwards.

Table 1: Classification and status of water quality based on WQI calculation
(Department of Environment Malaysia 2004)

| WQI (CLASS) | CATEGORY | CLASSIFICATION IN TERMS OF WATER USAGE |
|---|---|---|
| 0-25 (V) | Very bad | Extensive treatment is required<br>Irrigation |
| 26-50 (IV) | Bad | Recreational use with body contact |
| 51-70 (III) | Medium | Water supply – conventional<br>treatment required |
| 71-90 (II) | Good | Conservation of natural environment.<br>Water supply – practically no treatment necessary<br>except disinfection or boiling |
| 91-100 (I) | Excellent | |

Table 2: National Water Quality Standard (NWQS) in Malaysia
And the definition for each class (Harun et. al, 2015)

| *Parameter | Unit | Class | | | | | |
|---|---|---|---|---|---|---|---|
| | | I | IIA | IIB | III | IV | V |
| pH | | 6.5-8.5 | 6.5-9.0 | 6.5-8.5 | 5.0-9.0 | 5.0-9.0 | - |
| DO | mg/L | 7 | 5-7 | 5-7 | 3-5 | < 3 | < 1 |
| Temperature | ºC | - | Normal + 2ºC | - | Normal + 2ºC | - | - |
| TDS | mg/L | 500 | 1000 | - | - | 4000 | - |
| Conductivity | µS/cm | 1000 | 1000 | - | - | 6000 | - |
| Salinity | % | 0.5 | 1 | - | - | 2 | - |
| SS | mg/L | 25 | 50 | 50 | 150 | 300 | 300 |
| AN | mg/L | 0.1 | 0.3 | 0.3 | 0.9 | 2.7 | > 2.7 |
| BOD | mg/L | 1 | 3 | 3 | 6 | 12 | > 12 |
| COD | mg/L | 10 | 25 | 25 | 50 | 100 | > 100 |

Table 3: Environmental Quality Act (EQA) 1974
*Source: Lakasa Environment Quality Act (EQA) 1974*

***Parameter Limits Of Effluent Of Standards A and B***

| No | Parameter | Unit | Standard A | Standard B |
|---|---|---|---|---|
| I. | Temperature | °C | 40 | 40 |
| II. | pH Value | -- | 6.0-9.0 | 5.5-9.0 |
| III. | $BOD_5$ at 20°C | mg/l | 20 | 50 |
| IV. | COD | mg/l | 50 | 100 |
| V. | Suspended Solids | mg/l | 50 | 100 |
| VI. | Mercury | mg/l | 0.005 | 0.05 |
| VII. | Cadmium | mg/l | 0.01 | 0.02 |
| VIII. | Chromium, Hexavalent | mg/l | 0.05 | 0.05 |
| IX. | Arsenic | mg/l | 0.05 | 0.10 |
| X. | Cyanide | mg/l | 0.05 | 0.10 |
| XI. | Lead | mg/l | 0.10 | 0.50 |
| XII. | Chromium, Trivalent | mg/l | 0.20 | 1.00 |
| XIII. | Copper | mg/l | 0.20 | 1.00 |
| XIV. | Manganese | mg/l | 0.20 | 1.00 |
| XV. | Nickel | mg/l | 0.20 | 1.00 |
| XVI. | Tin | mg/l | 0.20 | 1.00 |
| XVII. | Zinc | mg/l | 1.00 | 1.00 |
| XVIII. | Boron | mg/l | 1.00 | 4.00 |
| XIX. | Iron (Fe) | mg/l | 1.00 | 5.00 |
| XX. | Phenol | mg/l | 0.001 | 1.00 |
| XXI. | Free Chlorine | mg/l | 1.00 | 2.00 |
| XXII. | Sulphide | mg/l | 0.50 | 0.50 |
| XXIII. | Oil and Grease | mg/l | Not Detectable | 10.00 |

## METHODOLOGY

Some experiment has been conducted to perform the data and analysis the effect of the hospital wastewater for the river. The location of the hospital is in Pantai Hospital Ampang and then it is located between the residential house and urban city. There are 3 points of the data taken which is located on the urban drainage and the hospital sewerage is connected with it and the final disposal is going to the river. The other points is located after and before the sewerage system and it can make the good comparison of the water which is affected by after drainage of the hospital that is connected with the urban sewerage system. The water sample is taken with the amount of the bottle is 5 litres of the bottle for each point. And then the water sample is going to the lab to be tested. The result will be performed by the Excel to show the data about the experiment result for each parameter such as BOD, COD, TSS, Ph, Ammonia, Phosphorus, Microbiological and Heavy Metals like Fe, Zn and Cu.

## RESULT AND DISCUSSION

### BOD and COD

From the data obtained during the experiment, the concentration of the BOD is within the range for point 1 and point 3. And, for the second point that is located in the drainage is very high because the water is contaminated from the hospital sewerage system. The sewerage system of hospital is connected to the sub part of the urban sewage system and the final disposal is connected to the river. Point 1 is showing the result 1.44 mg/L BOD, point 2 has the result 16.84 mg/L BOD, and the last point has the result 1.01 mg/L BOD. And the amount COD in the wastewater from hospital is very high. Point 1 is showing the result 73.33 mg/L COD, Point 2 is showing the result 60.67 mg/L COD and Point 3 is showing result 20 mg/L COD. Those result can be affected by the others activities in the surrounding environment. The disposal of waste from surrounding urban area can increase the amount contaminant in the water. The result of BOD and COD show that the point 3 is lesser than the point 1 even it is affected by the second point from the sewerage system which is connected with hospital drainage. Because at 1 point there are disposal activities from the residential area and make concentration of contaminant increase respectively.

The presence of BOD in current of wastewater is low for the point 1 and point 3 even it is affected by the BOD from the drainage or point 2 which has a higher concentration from other point. The hospital is treated properly for the BOD so that it can be decomposed with the water after the discharge. The efficiency of the BOD treatment is affected by the pretreatment plant that the hospital provided. It can treat the 31 % of the BOD while the overall efficiency of the wastewater treatment is 58 % percent (Kusuma et al., 2013). In Iran the total of the BOD treated is very good which has a significant of the result which has a 67.5 % and 64.3 % of the pretreatment plant that has been used for the treatment plant (Majlesi et al,. 2008). So the research shows that the efficiency of the current hospital treatment is good to treat the BOD and it is near to the present study. The concentration of the COD in current wastewater show a good result even it is affected by the second point which is high. The contaminant can be decomposed naturally after the flow is passing through the discharge. It can be shown with the effective of hospital pretreatment to treat the COD as the harmful contaminant. The other study shows that the current treatment of the hospital have the similar efficiency with the other treatment plant to treat COD. It has 84 % efficiency of the hospital pretreatment plant to make the treatment properly (Prayitno et al,. 2017).

Table 4: Test result of Biological Oxygen Demand Chemical Oxygen Demand.

| | BOD1 | | BOD5 | |
|---|---|---|---|---|
| POINT | SAMPLE | mg/L | SAMPLE | mg/L |
| 1 | 1 | 7.42 | 1 | 7.92 |
| | 2 | 7.45 | 2 | 7.8 |
| | 3 | 7.43 | 3 | 7.88 |
| | Average | 7.43 | | 7.87 |
| **Total BOD** | | **1.44** | | |
| | BOD1 | | BOD5 | |
| POINT | SAMPLE | mg/L | SAMPLE | mg/L |
| 2 | 1 | 8.43 | 1 | 3.74 |
| | 2 | 8.43 | 2 | 3.02 |
| | 3 | 8.46 | 3 | 3.4 |
| | Average | 8.44 | | 3.39 |
| **Total BOD** | | **16.84** | | |
| | BOD1 | | BOD5 | |
| POINT | SAMPLE | mg/L | SAMPLE | mg/L |
| 3 | 1 | 8.22 | 1 | 7.42 |
| | 2 | 7.63 | 2 | 7.44 |
| | 3 | 7.6 | 3 | 7.68 |
| | Average | 7.82 | | 7.51 |
| **Total BOD** | | **1.01** | | |

| | COD | |
|---|---|---|
| POINT | SAMPLE | mg/L |
| 1 | 1 | 69 |
| | 2 | 55 |
| | 3 | 96 |
| | **Average** | **73.33** |
| | | |
| | COD | |
| POINT | SAMPLE | mg/L |
| 2 | 1 | 67 |
| | 2 | 66 |
| | 3 | 49 |
| | **Average** | **60.67** |
| | | |
| | COD | |
| POINT | SAMPLE | mg/L |
| 3 | 1 | 36 |
| | 2 | 12 |
| | 3 | 12 |
| | **Average** | **20.00** |

**PH and TSS**

The concentration of PH, Total Suspended Solid, Ammonia, Phosphorus and Microbacterial is very significant. Total Ph at point 1 is 6.71, Point 2 is 6.43 and Point 3 is 6.87. For the Total Suspended Solid at Point 1 is 0.02 mg, Point 2 is 0.01 mg and Point 3 is 0.01 mg. The amount of the pH can determine the condition of the water. The performance of the hospital to keep the range of the pH can be shown with the good result in some studies. The mean pH value of raw wastewater of all studied hospitals was 7.5. In a study on Turkey hospitals, the mean pH of raw wastewater hospitals was 7.3 (Altin et al., 2003). In another study on hospitals wastewater, somewhere in the globe, the mean pH value in health-care centers wastewater was about 7.2. According to the standards of IREPA, the acceptable level of PH to discharge of effluent to receiving water is 6.5 to 8.5 (IR EPA, 2003), considering our study findings it is clear that pH of studied hospital wastewater were compatible with this standards using NWQS (National Water Quality Standard). For the total suspended solid the performance of the pretreatment plant of the current hospital is very good. All studied that has been conducted in Iran with some hospital shows the good efficiency of the total suspended solid pretreatment for the current hospital. It shows the result of between 66 % until 87.9 %. The range of performance efficiency of the current treatment is near to the result.

Table 5: Test result of Total Suspended Solid (TSS) and Ph

| | TSS | | | | |
|---|---|---|---|---|---|
| POINT | SAMPLE | | | before | after |
| 1 | 1 | 0.01 | | 0.11 | 0.1 |
| | 2 | 0.02 | | 0.11 | 0.090 |
| | 3 | 0.02 | | 0.11 | 0.090 |
| | **Average** | **0.02** | | | |
| | | | | | |
| | TSS | | | | |
| POINT | SAMPLE | | | before | after |
| 2 | 1 | 0.02 | | 0.11 | 0.090 |
| | 2 | 0.00 | | 0.11 | 0.11 |
| | 3 | 0.00 | | 0.11 | 0.11 |
| | **Average** | **0.01** | | | |
| | | | | | |
| | TSS | | | | |
| POINT | SAMPLE | | | before | after |
| 3 | 1 | 0.02 | | 0.11 | 0.090 |
| | 2 | 0.01 | | 0.11 | 0.1 |
| | 3 | 0.01 | | 0.11 | 0.1 |
| | **Average** | **0.01** | | | |

| | PH | |
|---|---|---|
| POINT | SAMPLE | |
| 1 | 1 | 6.70 |
| | 2 | 6.71 |
| | 3 | 6.72 |
| | **Average** | **6.71** |
| | | |
| | PH | |
| POINT | SAMPLE | |
| 2 | 1 | 6.42 |
| | 2 | 6.43 |
| | 3 | 6.43 |
| | **Average** | **6.43** |
| | | |
| | PH | |
| POINT | SAMPLE | |
| 3 | 1 | 6.86 |
| | 2 | 6.87 |
| | 3 | 6.89 |
| | **Average** | **6.87** |
| | | |
| with 60 ml of Water | | |

**AMMONIA, PHOSPHORUS, MICROBACTERIAL TOTAL COLIFORM**

The concentration of the Ammonia at Point 1 is 4.58 mg/L $NH_3$ -N, Point 2 is 6 mg/L $NH_3$ -N and Point 3 is 5.22 mg/L $NH_3$ -N. Phosphorus at Point 1 is 1.65 mg/L $PO_4^{3-}$, Point 2 is 3.22 mg/L $PO_4^{3-}$ and Point 3 is 1.75 mg/L $PO_4^{3}$. And total Microbacterial in the water for Point 1 is 33.67 CFU, Point 2 is 10.67 CFU, and Point 3 is 61 CFU. The presence of Ammonia of the current hospital wastewater is higher if it is compared to National Water Quality Standard (NWQS) for Malaysia. The other study shows that the phosphorus is the micro pollutant also which is very difficult to be treated. It must have a good treatment plant which can treat properly. The range of the ammonia is shown up with the range of 1.5 mg/L to 100 mg/L (Geissen et al., 2015; Kumarathilaka et al., 2015). And the maximum range of the current hospital is 3.55 mg/L but it is still high compare to the guideline. The pretreatment still need some development for the better quality of the water. And the presence of Phosphorus of the current hospital wastewater is higher if it is compared to National Water Quality Standard (NWQS) for Malaysia. The other study shows that the phosphorus is the micro pollutant also which is very difficult to be treated. It must have a good treatment plant which can treat properly. The range of the ammonia is shown up with the range of 1.5 mg/L to 100 mg/L (Geissen et al., 2015; Kumarathilaka et al., 2015). And the maximum range of the current hospital is 3.55 mg/L but it is still high compare to the guideline. The pretreatment still need some development for the better quality of the water. The result determine the amount of E.coli and Salmonela which is contains in the current wastewater. Since, the total amount of dangerous bacteria is less than the 1000 CFU/100 ml water sample so it can be a good condition for the water itself. The amount of the Microbacteria for another study shows a good value for the safe water. The performance of the water

treatment plant is 99.74 % and 99.36 % respectively (Beyene et al,. 2011). In Iran, the study about treatment plant for the microbacterial using the appropriate treatment plant shows the better result also. The pretreatment plant can reduce the microbacterial 95 % (Amirhossein et al,. 2016; Amouei et al., 2012). For the present study, the result is very near which the microbacterial is treated properly and the amount is within the safety water quality index.

Table 6: Test result Phosphorus, Ammonia and Microbacterial

| | PHOSPHORUS | |
|---|---|---|
| POINT | SAMPLE | mg/L |
| 1 | 1 | 1.76 |
| | 2 | 1.83 |
| | 3 | 1.37 |
| | Average | 1.65 |
| | | |
| | PHOSPHORUS | |
| POINT | SAMPLE | mg/L |
| 2 | 1 | 3.98 |
| | 2 | 3.43 |
| | 3 | 3.23 |
| | Average | 3.55 |
| | | |
| | PHOSPHORUS | |
| POINT | SAMPLE | mg/L |
| 3 | 1 | 1.76 |
| | 2 | 1.83 |
| | 3 | 1.67 |
| | Average | 1.75 |

| | AMMONIA | |
|---|---|---|
| POINT | SAMPLE | mg/L |
| 1 | 1 | 4.54 |
| | 2 | 4.58 |
| | 3 | 4.62 |
| | Average | 4.58 |
| | | |
| | AMMONIA | |
| POINT | SAMPLE | mg/L |
| 2 | 1 | 6 |
| | 2 | 6 |
| | 3 | 6 |
| | Average | 6.00 |
| | | |
| | AMMONIA | |
| POINT | SAMPLE | mg/L |
| 3 | 1 | 5.22 |
| | 2 | 5.2 |
| | 3 | 5.23 |
| | Average | 5.22 |

| | MICROBACTERIAL | |
|---|---|---|
| POINT | SAMPLE | CFU |
| 1 | 1 | 32 |
| | 2 | 22 |
| | 3 | 47 |
| | Average | 33.67 |
| | MICROBACTERIAL | |
| POINT | SAMPLE | CFU |
| 2 | 1 | 10 |
| | 2 | 0 |
| | 3 | 22 |
| | Average | 10.67 |
| | | |
| | MICROBACTERIAL | |
| POINT | SAMPLE | CFU |
| 3 | 1 | 124 |
| | 2 | 30 |
| | 3 | 29 |
| | Average | 61.00 |

**HEAVY METAL**

The common heavy metals which contain in the hospital wastewater are Fe, Cu, and Zn. The range of each heavy metals is within the range according to the EQA 1974 for industrial. The safe water must have maximum value of Fe is 4 mg/L, Cu is 1.0 mg/L and Zn is 2.0 mg/L. The total concentration of Fe is 1.03 mg/L, Cu is 0.2 mg/L and Zn is 0.02 mg/L.

Presence of the heavy metal in the hospital wastewater can determine the quality of treatment plant which is used for the current waste. The study show that heavy metal is dangerous material with all the characteristic problem to make some diseases. The result shows that the heavy metal for the hospital wastewater is within the range. Even for some hospital in the other country with a lot of hospital which is provided with the variety of the pretreatment plant, the presence of the heavy metal is lower compare to their current wastewater quality standard (Akin, 2016; Amirhossein et al, 2016; Kümmerer, 2009). The current hospital treatment plant performance is very good to the heavy metals such as Fe, Cu, and Zn. It is near to the other researcher which is used particular water treatment plant.

Table 7: Test result of Heavy Metals

| | Zn | |
|---|---|---|
| POINT | SAMPLE | mg/L |
| 2 | 1 | 0.02 |
| | 2 | 0.02 |
| | 3 | 0.02 |
| | **Average** | **0.02** |
| | Fe | |
| POINT | SAMPLE | mg/L |
| 2 | 1 | 0.75 |
| | 2 | 0.67 |
| | 3 | 1.67 |
| | **Average** | **1.03** |
| | Cu | |
| POINT | SAMPLE | mg/L |
| 2 | 1 | 0.24 |
| | 2 | 0.13 |
| | 3 | 0.22 |
| | **Average** | **0.20** |

## CONCLUSION

Wastewater is one of environmental issue that can damage the aquatic environment. It can break the food chain in the aquatic environment and it can endanger the ecosystem. So, treatment plant is very important to make the water healthy for all living things in surrounding area. There are a lots of type of the wastewater such as factory, storm water, hospital wastewater and etc. Hospital wastewater is very dangerous also. Because it contains harmful material that can make imbalance in surrounding environment.

The experimental work show the significant result of effect hospital wastewater and all the activities in surrounding area. The parameter of BOD, COD, and pH, Ammonia, Phosphorus, Microbacterial, Zn, Cu and Fe is the common parameter for hospital wastewater and the result is higher compare to the National Water Quality Standard (NWQS) for Malaysia. River water should be in Class IIA for the allowable range but most of the result shows within class VI and above. So, the water needs more treatment to make it healthy and it is safe for all species in neighborhood. From the data obtained some of the result for each contaminant is high in point 2 because of the activities of the hospital and surrounding. But the hospital contribute 50 % of the wastewater which came out from the drainage.

Therefore, the amount of the contaminants is out from the standard that has been determined. And the effect of the hospital wastewater will increase some contaminant such as Ammonia and Phosphorus in the river water. And heavy metal is within the range for safe and healthy water. The pretreatment of the hospital can treat some of the contaminant and they can decomposed well in the water so that they cannot disturb the ecosystem. But, the other contaminant is very small and it is called micro contaminant which cannot be treated properly by the treatment.

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