Infrastructure University Kuala Lumpur Research Journal

IUKLRJ

Vol.3 No.1 2015

ISSN 2289-4144
PP 18094/04/2014 (033449)

INFRASTRUCTURE UNIVERSITY KUALA LUMPUR RESEARCH JOURNAL

Submission of manuscripts should be addressed to:

Editor
Infrastructure University Kuala Lumpur Research Journal
Research Management Centre
INFRASTRUCTURE UNIVERSITY KUALA LUMPUR
Corporate Block, Unipark Suria, Jalan Ikram-Uniten
43000 Kajang, Selangor Darul Ehsan, Malaysia.
Tel: (603)-89266993 Fax: (603)-87341021
E-mail: iuklrj@iukl.edu.my

Published by
IKRAM Education Sdn. Bhd. *for*
Research Management Centre
INFRASTRUCTURE UNIVERSITY KUALA LUMPUR

Printed by
Printing Unit
KUMPULAN IKRAM SDN. BHD.
Unipark Suria, Jln Ikram-Uniten
43000 Kajang, Selangor D.E., Malaysia

Graphic Design by
Nur Amalina Samusi

INFRASTRUCTURE UNIVERSITY KUALA LUMPUR RESEARCH JOURNAL
Vol. 3 No. 1 2015

CONTENTS

THE ACCEPTANCE LEVEL OF INDUSTRIALISED BUILDING SYSTEM (IBS) IMPLEMENTATION IN SARAWAK

Dyg. Siti Quraisyah Bt. Abg. Adenan[1] and Wan Azri B. Wan Abu Bakar[2]
[1] Research Associate, I-Geo Disaster Research Centre
[1,2]Department of Civil Engineering, Faculty of Engineering and Technology Infrastructure, Infrastructure University Kuala Lumpur (IUKL)

ABSTRACT
The primary purpose of this research is to investigate the extent to which construction companies in the state of Sarawak accept the technology of Industrialised Building System (IBS) in their projects. In Sarawak`s case, it is a new technology which is expected to reign in most projects. Many experts in the field of construction theorised that the invention of IBS and its implementation as enhancing the quality of construction not only in terms of workmanship, but also time and costs, particularly suitable for a rapidly developing state like Sarawak. As an interpretive orientated study, this research had an interest in understanding the level of acceptance towards IBS as well as the general perception of the technology. As it is, this study sought to investigate the level of acceptance regarding IBS in Sarawak`s current economic climate. The findings of this study suggest that IBS technology has been embraced by local construction companies to a certain extent. There are potentially positive aspects that have been brought by contractors, namely, openness to implement the technology in future designs. However, the study has depicted a lack of extensive knowledge on the side of some contractors and this hinders the acceptance of IBS technology. The study has also revealed that there are challenges facing contractors in terms of trying to implement the IBS in Sarawak. Challenges such as the poor availability of material and logistics are a big issue that influence the level of acceptance of IBS among contractors.

Keywords:
Acceptance, Construction Industry, Industrialised Building System (IBS), Sarawak.

INTRODUCTION

Industrialised Building System (IBS) was defined as "a total integration of all subsystems and components into an overall process fully utilising industrialised production, transportation and assembly methods" (Zuhairi, 2011). The implementation of Industrialised Building System (IBS) in constructions promised to make construction phase of a project more efficient. IBS has been introduced in Malaysia since the early 1960s when the Ministry of Housing and Local Government of Malaysia visited several European countries and evaluate their housing development program (Thanoon et al., 2003).

After their successful visit in 1964, the government had started the first project on IBS, just a year later aims to speed up the delivery time and built affordable and quality houses. IBS is defined as a construction technique in which components are manufactured in a controlled environment (on or off site), transported, positioned and assembled into a structure with minimal additional site work. It consists of precast component systems, fabricated steel structures, innovative mould systems, modular block systems and prefabricated timber structures as construction components (CIDB, 2003).

In theory, the utilisation of precast components would lead to reduced construction time, less material wastage, cleaner and safer site, and a higher-quality build. This study will discuss on the issue of acceptance level of construction players in east Malaysia, specifically Sarawak, toward IBS. The reason is to see the factors or barriers of implementing IBS and the

reason of it not being fully utilised in Sarawak. In terms of project management, IBS promised reduction in the overall construction period, a more fixed costs in terms of materials, and a cleaner site (Aziz, 2012).

However, even after five decades of introduction, it appears that the level of acceptance towards IBS in Malaysia is still low compared to that of other developed countries such as Japan, UK, Australia and US. It is a loss for the local construction industry players as IBS offers obvious benefits such as reduced construction time, minimised use of timber form works on site, enhanced quality of buildings, reduced number of workers on site, and decreased air pollution which would definitely exert a major impact on the industry productivity, quality, health and safety, and the environment (Kamarul Anuar, 2009).

According to (Yahya & Safwan, 2012), two specific questions were addressed for guiding the study. Firstly, why has IBS technology not been fully accepted in the Malaysian construction industry. Secondly, what are the risks involved in selecting IBS in construction projects. The results in this study supported the hypothesis that IBS has not been fully accepted in some quarters of the local construction industry. In general, 50% of the parties involved quoted that the implementation of IBS reduced profit margins as to the conventional method, where the 30% suggested that lack of availability of material that discouraged them from using the technology and the 20% argued that lack of skilled labours and knowledge of the newly introduced system, especially in the developing regions of East Malaysia.

Problem Statement

Since the early 1960`s, Malaysia has adopted the technology of Industrialised Building System (IBS) in its construction industry (Nur Hazreeni, 2010). Even though the progress made since then was slow and gradual, the majority of those progress were focused on the West or Peninsular Malaysia compared to East Malaysia which are the states of Sabah and Sarawak due to the fact that development was rapid surrounding the capital state and other neighbouring states within the region. As for Sarawak, a slowly developing economy led to a more controlled growth by using safer and more traditional ways to prevent unnecessary risks to be taken that could stunt the economic growth. For this very reason, the construction industry in Sarawak didn't embrace the idea of a new technology that promised to make the industry more efficient. It was seen as an unnecessary risk that without full understanding may lead to unwanted and unforeseen problems even though many of the construction players and researchers in the industry stated that IBS will help the construction phase towards greater concentration on achieving a better construction which meets the needs of the client rather than the conventional method which contributes to wastage.

In lieu of the unexpected level of acceptance towards IBS in Sarawak, this paper wishes to look at the nature of the problem and the factors that contributed towards the level of acceptance of IBS.

Objectives

The objectives for this study are shown as follows:

i. To assess the overall level of acceptance regarding IBS in Sarawak.
ii. To identify the factors contributing to the level of acceptance towards IBS in Sarawak, Malaysia.
iii. To identify the future outlook of IBS technology in Sarawak.

METHODOLOGY

The first step in this study is identifying the research problems and the formulation of objectives to be achieved regarding the identified problems. Then, the scope of work can be determined as well as starting with secondary sources such as books, articles, thesis and dissertations, and journals for detailed references, and followed by primary data collection (interviews and questionnaire surveys) and data analysis, and finally with the formulation of conclusion and report writing. The flow chart of the methodology for this research study is shown in Figure 1.

The questionnaire is a set of pre-formulated and written questions that the researchers would like to ask for respondents and record their given answers. The questionnaire can be an efficient data collection tool when the researcher knows exactly on the information that is required and how to measure the variables of interest. All questions should be clear, understandable and unambiguous. Data validation will be after the questionnaires had been collected and in the process of validating the data, the answers obtained from the questionnaires will be checked for accuracy and relevancy with the research objectives. Respondents to the questionnaire in this study focus on contractors, consultants, and suppliers only. It was designed to gather information which is unavailable from literature reviews.

All the data acquired will be analysed using software such as Microsoft Excel. Two statistical methods will be applied in the study, which are descriptive statistic and inferential statistics. The data generated from the question was first analysed by using frequency analysis. The data were then analysed using Reliability Index (RI) for the questions which uses an ordinal scale of 1 to 5 (in descending order).

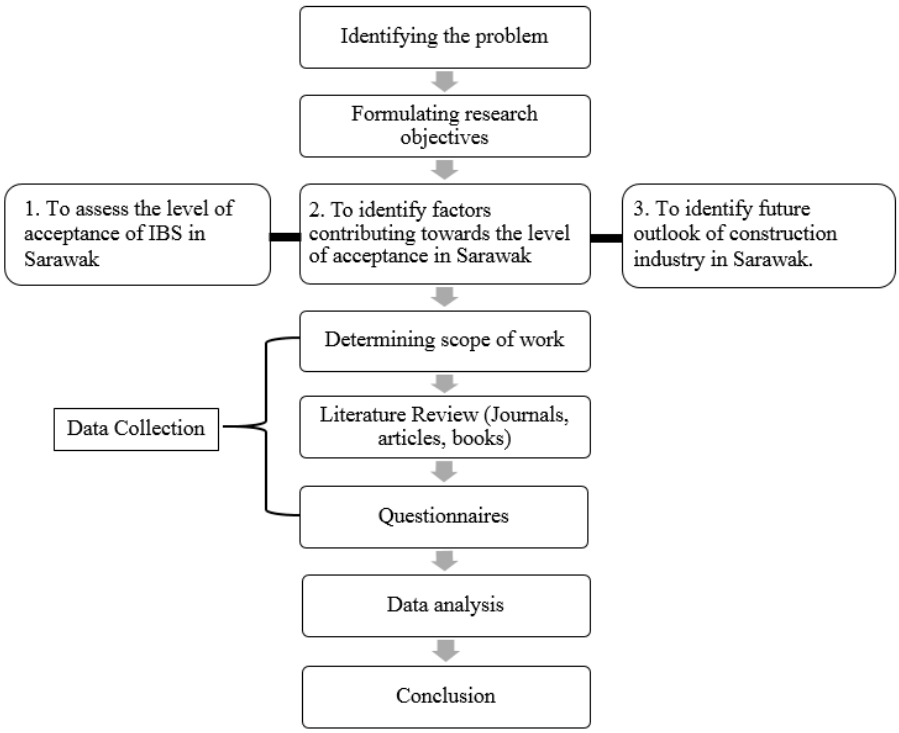


Figure 1: Flowchart of Research Methodology

DATA AND ANALYSIS

Table 1 indicates the respondents` background. Based on the survey, 43 respondents were individuals working in a Class A contractors, while 35 respondents were individuals working in consultancy firms whereas 2 respondents were working in IBS supplier companies. For the subjects, 70% of respondents were males, and 30% of the remaining respondents were females. Amongst 80 respondents, 37.5% were aged between 31-40 years old, whereas respondents of age under 30 years old, cover 45% of all the respondents which is the largest group. The two smallest age groups in for this survey are the 41-50 years old group at 10% and above 51 years old at 7.5%.

Table 1: Respondents` Demographic

Background	Frequency	Percentage
Contractors	43	53.75%
Contractors	35	43.75%
Suppliers	2	2.5%
Gender	Frequency	Percentage
Male	56	70%
Female	24	30%
Working Experience	Frequency	Percentage
< 3 Years	5	6.25%
3-5 Years	19	23.75%

Respondents were asked to give their opinions on a scale of 1 to 5 as stated in Table 2. Scale 1 being “strongly disagree and scale 5 being “strongly agree” based on criteria such as costs, speed, ease of use, quality, and other factors as a gauge to determine the level of acceptance towards IBS technology in the construction industry of Sarawak.

Table 2: Likert Scale

Scale	Scale
1	Strongly Disagree
2	Disagree
3	Neutral
4	Agree
5	Strongly Agree

The rating given by respondents were summed and analysed, and the results acquired are as shown in Table 3. From the results shown in the Table 3, for the first factor which is the high construction cost of IBS, roughly 44% of respondents surveyed agreed that it is expensive, whereas 36.25% of the respondents were neutral in their opinion on the matter. Only 6.25% of the overall respondents disagree with IBS is expensive in terms of construction.

From the results shown, in terms of costs, the majority of the respondents generally agreed that IBS implementation in Sarawak is costly in terms of construction and transportation of the materials. It is, however, the respondents generally disagree that IBS technology is expensive, mainly because of high labour and maintenance cost if implemented.

Table 3: Respondents` Opinion Regarding Cost

Criteria (Cost)	1 Strongly Disagree	2 Disagree	3 Neutral	4 Agree	5 Strongly Agree
High construction cost	1.25%	5%	36.25%	43.75%	13.75%
High transportation cost	0%	15%	28.75%	48.75%	7.5%
High labour cost	22.5%	42.5%	16.25%	15%	3.75%
High maintenance cost	6.25%	22.5%	46.25%	17.5%	7.5%

According to Table 4, 73.75% of the respondents agreed that implementing IBS construction is faster than traditional construction method, whereas 5% of the respondents disagree that IBS implementation does not reduce construction time. They argued that the reduced construction time of IBS may be substituted by production time and transportation time in certain cases.

For ease of construction, the majority of the respondents (55% strongly agree followed by 37.5% whom agree) does think that by using IBS, not only the construction is easier, but also for individual components, installation and assembly is easier than to construct from start. No respondent`s disagree with the fact that IBS is easier to construct and easier to implement in the overall project rather than the traditional methods.

The third criteria is flexibility of design, with the largest group indecisive in their opinion on the matter by 37.5%. The second largest group with 31.25% agreed that IBS is flexible in terms of design, followed by 12.5% of the respondents who strongly agreed with this sentiment. The majority of the respondents being neutral in this matter may be a slight indicator of the lack of expert knowledge regarding IBS.

Based on less site material criteria, a total of 16.25% for the whole group strongly agreed that IBS implementation produced less materials in construction sites, with the majority of the group at 77.5% agreeing to this. The smallest group is neutral at 6.25% with no respondents disagreeing with this criteria.

The next criteria for construction is minimal wastage, not to be confused with the previous criteria “less site materials” where minimal wastage is by-products from the installation or implementation of IBS where the latter is, in other terms, is more to storage on site. 69 (86.25%) out of 80 respondents agreed that IBS implementation reduces wastage on site as it is precast. 7 individual (8.75%) strongly agreed with this criteria, with the small group of 5%

is neutral and no respondents surveyed disagree with this criteria regarding IBS implementation. One of the key advantages of using IBS is that it has minimal wastage. This indicates that most of the contractors or consultants surveyed know about IBS and understand this benefit.

The majority of the respondents (70%) agrees that basically IBS implementation creates a safer construction site. This is based on the idea that IBS is a precast system that correlates to the cleanliness of the construction site. Without in-situ casting, sites can be cleaner and safer. According to the data presented, 40% of the respondents disagree and strongly disagree that the barriers to IBS implementation is because of difficulty in obtaining advanced machinery despite 12.5% strongly agree, 25% agree with that notion and with 22.5% of the respondents surveyed were neutral regarding these criteria.

Table 4: Respondents` Opinion Regarding Design

Criteria (Construction)	1 Strongly Disagree	2 Disagree	3 Neutral	4 Agree	5 Strongly Agree
Rapid completion time	0%	5%	18.75%	73.75%	2.5%
Ease of construction	0%	0%	7.5%	37.5%	55%
Flexibility of design	0%	18.75%	37.5%	31.25%	12.5%
Less site materials	0%	0%	6.25%	77.5%	16.25%
Minimal wastage	0%	0%	5%	86.25%	8.75%
Clean & safe construction site	0%	0%	13.75%	70%	16.25%
Difficulty in obtaining advanced machinery	10%	30%	22.5%	25%	12.5%

CONCLUSION

The conclusions are based on the three (3) objectives of this study:

i. **To assess the overall level of acceptance regarding IBS in Sarawak.**
   After all the research on the internet, libraries, books and surveys, it can be concluded that the level of acceptance towards IBS in the state of Sarawak is at a satisfactory level (CIDB, 2013). The awareness is already established regarding the technology, but implementation is steadily increasing as more and more developers understand and try to look for an opportunity to implement IBS in their design.

ii. **To identify the factors contributing to the level of acceptance towards IBS in Sarawak, Malaysia.**
   The results clearly demonstrate that most contractors in Sarawak are unwilling to take new risks in that may affect their business is one of the main factors that influence the acceptance of implementing IBS. As being the largest state in the country, the distance to be covered are greater thus increasing the transportation costs, also indirectly affects the time of delivery and construction. Even though the advantages of IBS implementation may be clear to the industry`s communities, but the "Play-safe" attitude and costs are the drawback in accepting IBS in Sarawak as of current time.

iii. To identify the future outlook of IBS technology in Sarawak.
Awareness and knowledge are keys to increase the level of acceptance regarding IBS in Sarawak. Based on the survey done, the future of IBS technology in Sarawak looks bright as the state`s construction industry, as well as the country`s construction industry as a whole, is increasingly aware of the system and demands are increasing as stated by CIDB (CIDB, 2011).

This paper has briefly reviewed the knowledge of the contractor and the general level of acceptance on IBS in Sarawak. There are strong suggestions by the contractors to implement IBS systems in future construction projects in the state. To promote and adopt the IBS in Sarawak`s construction industry, it is a never ending effort and it requires serious participation from all parties involved in the construction industry.

RECOMMENDATION

Further study should be conducted to overview the implementation of IBS for construction in Sarawak. In addition, the survey also must take into account of other parties involved in the construction industry such as the local authority and also the clients to better understand their knowledge and determine their acceptance of the IBS system more accurately.

ACKNOWLEDGEMENTS

The author of this research paper would like to thank the Department of Civil Engineering, Faculty of Engineering and Technology Infrastructure, Infrastructure University Kuala Lumpur for the support and also guidance in successfully conducting this research.

REFERENCES

Aziz, S. A. (2012). The Application of Industrialised Building System in Residential Project. Faculty of Civil Engineering & Earth Resources. UMP, Pahang, Malaysia.

CIDB, I. R. (2003). Survey on the Usage of Industrialised Building System (IBS) in Malaysia Construction Industry. *Construction Industry Development Board (CIDB)*(ISBN No: 1675-6991).

Kamarul Anuar, M. A. (2009). Barriers to Industrialised Building Systems: The Case of Malaysia. *BuHu 9th International Postgraduate Research Conference (IPGRC 2009).* Salford, United Kingdom.

Nur Hazreeni, M. N. (2010). A Study on the Acceptance of IBS in Construction Industry in Kelantan: Application of Logistic Regression Analysis. *Regional Conference on Statistical Sciences.*

Thanoon, W., Peng, L., Abdul Kadir, M., Jaafar, M., & Salit, M. (2003). The experiences of Malaysia and Other Countries in Industrial Building System in Malaysia. *IBS Seminar, UPM, Malaysia*.

Yahya, M. A., & Safwan, M. N. (2012). Level of Acceptance Towards Industrialised Building System (IBS) in Malaysia. *International Journal of Sustainable Construction Engineering & Technology, Vol. 3,* Issue 1.

Zuhairi, K. A. (2011). Industrialised Building System (IBS): Revisiting Issues of Definition and Classification. *International Journal of Emerging Science and Engineering*.

THE STABILIZATION OF COMPRESSED EARTH BLOCK USING FLY ASH

Noorbaya Mohd Salleh[1] and Muhammad Hanif Roslan[2]
[1,2]*Faculty of Engineering and Technology Infrastructure, Infrastructure University Kuala Lumpur*

ABSTRACT
The research described in this paper focused on the study of earth bricks made with fly ash known as compressed stabilized earth block (CSEB). This earth block was made by using 50% of laterite soil, 30% of fine aggregate, 20% of coarse aggregate and few percentages of fly ash as a stabiliser. The laterite soil, which was taken around Infrastructure, University of Kuala Lumpur was classified as well graded with about 73% of fine soil and 27% of course soil. Optimum moisture content and maximum dry density of the soil compaction test were 20% and 1.60 Mg/cm^3 respectively. The CSEB with 10% fly ash had the highest compressive strength which was 1.09 MPa after 28-day curing. Durability tests improved the compressive strength of the earth block with 10% of fly ash after 21 days of freezing and drying, 21 days of drying and 24 hours of heating in the oven. The lowest water absorption percentage was 12.17%. Abrasive test showed that the earth blocks with 10% of fly ash gave the lowest amount of particle abraded away. Finally, conclusions were drawn and further works were proposed.

Keywords:
CSEB, laterite soil, fly ash, compressive strength, water absorption, freezing, drying, heating, abrasive.

INTRODUCTION

With the increase in population and high demand for dwelling houses the price of such houses has increased and is increasing tremendously in recent years. This is compounded by the fact that the available land for this development is becoming scarce, especially in the urban and sub-urban areas. Many people, especially the lower and middle income groups can no longer afford to buy them. One of the factors which contribute to the problem is the high cost of building materials which at the present time use the conventional materials and method of construction.
One of the ways to alleviate the problem is to use cheap building materials available locally. This can be done either by using re-cycled or sustainable raw materials for houses which are comparable to the conventional materials made from cement, sand and aggregates to give an acceptable level of quality and comfort.

This paper reported an attempt on the possibility of using building blocks made from earth stabilised with fly ash known as compressed stabilized earth block or CSEB. Laterite soil is easily available in Malaysia while fly ash, which is a by-product in the manufacture of cement can be obtained from cement factories. The earth blocks would replace the conventional bricks normally used in building houses.

In this study laterite soil was chosen as one of the components for CSEB because it was readily available in Malaysia and it was cheap. This study is expected to have a significant impact on the building industry in terms of design, cost and level of comfort. It would also give a wider choice for designers and contractors on the availability of building materials in the market. This would result in cheaper house price which many people could afford to buy.

The objectives of the study can be summarised as follows:

- To produce earth block comprised of laterite soil, coarse aggregate, fine aggregate and stabilizer (fly ash).
- To determine the compressive strength of CESB at different ratios of fly ash added to laterite soil, fine aggregate and coarse aggregate.
- To assess the water absorption and durability of the compressed stabilized earth blocks.

The study was limited to earth soil available locally and all tests were conducted in IUKL laboratory. The tests were divided into two parts, i.e. firstly the soils were subjected to engineering tests and finally to more specific tests which were strength and durability tests.

LITERATURE REVIEW

Laterite soil comprised of iron, aluminium oxides and other mineral. The laterite soil was easily identified by its colour which could come yellowish to reddish colour depending on the iron oxides concentration. Laterite usually found in subtropical area or tropical climate and the formation of laterite was through decomposition and weathering process. In order to enhance the Geotechnical properties of the CSEB in term of strength and durability, mechanical and chemical stabilization method should be applied Keller, (2011). The mechanical stabilization method was carried out by mixing and compressing the CSEB components in order to eliminate the void or gap between the CSEB components Makusa, (2012). This could increase the strength and durability of the CSEB. However, mechanical stabilization could not withstand water and due to that chemical stabilization was needed to provide water resistant properties as well as to improve the strength and durability. Fly ash was chosen as a chemical stabilizer in this study as it was able to improve strength, durability and water resistant properties.

Previous study described various results of compressive strength after 28 days of curing from different combinations of earth block with stabilizer as shown in Table 1. This research study was compared closely to a research study by Chimuanya (2014) that using lime and cement incorporated with various proportions of CSEB with its basic proportion of laterite soil, fine and coarse aggregate that showed outstanding results. This study could be said as a continuation of a research study by Chimuanya (2014) taken into account the best CSEB basic proportion but considered fly ash as a stabilizer. His study indicated that the best basic proportion of CSEB was the combination of 50% of laterite soil, 30% of fine aggregate and 20% of coarse aggregate. This proportion also was the best proportion to be incorporated with 10% of cements that given the maximum compressive strength after 28 days curing period as stated by Chimuanya, (2014). Thus, this research study focused on the same material and mix proportion of CSEB but considering different stabilizer which more economical and environmentally friendly in order to see its performance whether could give better outcomes or not. There were a lot of researches regarding earth block with fly ash, but yet the chemical composition of the earth element could vary due to weather processes on that particular sole location, as well as implementation of the method of testing and different chemical composition of fly ash which made this research study differed from other study involving earth block incorporated with fly ash. All of this could affect the results of testing for both compressive strength and durability testing. The findings of this study also were compared with other researchers. The comparison was done to see the performance of CSEB incorporated with fly ash and other stabilizers instead of comparing within fly ash categories in order to see it can perform better or about the same range of strength to other stabilizers.

Table 1: Compressive Strength Result From Previous Research of CSEB

Author/Year	Stabilizer	Test	Result (N/mm^2)
Chee Ming & Liang-pin (2010)	Cement at 5%, 8% and 10%.	Compressive Strength Test	1.2, 1.9 and 2.4
Raheem et al. (2010)	Cement at 5%, 10%, 15%, 20% and 25%	Compressive Strength Test	1.63, 2.60,2.78, 2.82 and 3.12
Raheem et al. (2010)	Lime at 5%, 10%, 15%, 20% and 25%	Compressive Strength Test	0.92,1.25, 1.15, 1.06, and 0.94
Chimuanya (2014)	Cement at 5%,10% and 15%	Compressive Strength Test	4.19, 6.00 and 8.55
Chimuanya (2014)	Lime at 5%,10% and 15%	Compressive Strength Test	1.03,1.34 and 2.34

For water absorption test, Akeem, Olugbenro & Kehinde (2012) reported their findings of laterite interlocking block incorporated with cement stabilizer at 5%, 10% and 15% were turned out to be 7.62%, 6.07% and 5.32% of water absorption respectively. While for the durability testing, the results from previous study were tabulated in Table 2.

Table 2: Durability Test Result From Previous Research

Author/Year	Earth Block & Stabilizer	Test	Result (N/mm^2) / %
Chimuanya (2014)	CSEB with cement 5%,10% and 15%	Durability Test: 21 days freezing & drying	4.87, 7.35 and 9.94
Chimuanya (2014)	CSEB with lime 5%,10% and 15%	Durability Test: 21 days freezing & drying	2.16, 2.23 and 2.72
Chimuanya (2014)	CSEB with cement 5%,10% and 15%	Durability Test: 21 days drying	4.61, 6.91 and 9.67
Chimuanya (2014)	CSEB with lime 5%,10% and 15%	Durability Test: 21 days drying	1.88, 2.04 and 2.17
Chimuanya (2014)	CSEB with cement 5%,10% and 15%	Durability Test: Abrasive Test	0.09, 0.06 and 0.02
Chimuanya (2014)	CSEB with lime 5%,10% and 15%	Durability Test: Abrasive Test	0.23, 0.20 and 0.17.

RESEARCH METHODLOGY

There were five major classes of experiment that were carried out in the laboratory as shown in Table 3. The selected soil was subjected to preliminary tests in order to determine the physical properties of the soil and an optimum amount of water needed for making the CSEB. Three major tests were done on CESB i.e. compressive strength test, water absorption test and durability test.

Table 3: List of Experiments on CSEB

Major Class Testing	Activities/Testing
Preliminary Test / Physical Properties Test (Classification of Soil)	1. Moisture Content 2. Plastic Limit 3. Liquid Limit 4. Hydrometer Analysis 5. Sieve Analysis
Compaction Test (Determining Optimum moisture content & the maximum dry density)	1. Compaction Test
Engineering Test	1. Compressive Strength
Water Absorption Test	1. Water Absorption Test
Durability Test	1. Freezing & Drying 2. Drying 3. Heat / Oven Dry 4. Abrasive

The composition of materials that involved in this research study in forming CSEB were laterite soil, fine and coarse aggregate, fly ash and water. Soil compaction test was one of the most important testing in order to determine the exact amount of water to be added to mix proportion of CSEB formation to ensure they achieve their optimum performance in engineering, water absorption and durability tests. The mix proportion of the main component for CSEB as well as stabilizer was shown in Table 4. This proportion was selected based on previous research studies done by Chimuanya, (2014) where his study was about the compressed of stabilized earth block using cement and lime that focusing on the best ratio of the CSEB main component as well as the best percentage of stabilizer that given the optimum performance of that particular CSEB. Due to that, the same basic proportion of earth block has been chosen due to its outstanding performance as stated by Chimuanya, (2014). The proportion of CSEB main materials was based on the total weight of all materials for that particular block formation. This was due to the amount of water to be added to the mix proportion was considering based on the total weight of the soil not the volume. The typical average weight of CSEB was 3.4 kg, which made of 50% of laterite soil, 30% of fine aggregate and 20% of coarse aggregate which equal to about 1.7 kg, 1.02 kg and 0.68 kg of laterite soil, fine aggregate and coarse aggregate respectively. As for the amount of water to be added to the mix would be based on a certain percentage of the total weight of total soil exist in the CSEB sample which will be discussed further in result and discussion section.

Table 4: Mix Proportion of CSEB Incorporated With Fly Ash

Sample	Mix Proportion (%) Laterite Soil : Fine Aggregate : Coarse Aggregate	Fly Ash (%)
C(i)F0	50:30:20	0
C(ii)F5		5
C(iii)F10		10
C(iv)F15		15

Fly ash was selected as stabilizer in order to see its optimum performance to compare with the previous study by Chimuanya, (2014), that using lime and cement as stabilizers to produce the maximum strength and highest durability of the block. Consequently, this research study incorporated various percentages of fly ash to be mixed with CSEB to study their performance on compressive strength, water absorption and durability. The main proportion of CSEB were dried for 24-48 hours under infra ray before it can be tested. The main materials together with stabilizer and water were mixed homogeneously altogether manually by using a couple of trowels. The mixture then was filled inside the mould with a size of 225mm x 113mm x 75mm that specially carpentered. The mixture was poured into three equal layers and each layer were compacted up to 25 times using a manual computer. The mixture inside the mould was then compressed up to 60 kN by using compressing machine. Once finished with the compression process, the mould was disassembled and CSEB samples were air dried for 24 hours before proceeding with the curing process. The curing process for 28 days was done by sprinkling water at the sample along the duration of the curing period. The blocks were covered with wet fabric in order to avoid water loss along the curing process which might affect the strength build up process within the CSEB. After curing, the engineering test, water absorption test and durability test were carried out. Table 5 demonstrates compressive strength, water absorption and durability test conducted on the blocks.

Table 5: Detail of Engineering and Durability Testing

Engineering Test		
Test	Duration (Days)	Description
Compressive Strength	7, 14, 28	The compressive strength of the sample was conducted at 7 days, 14 days and 28 days
Water Absorption	1	Tested after 28 days of curing. The sample was immersed in the water for 24 hours where the weight of the sample was taken before and after immersion to see the percentage of water absorption.
Durability Test		
Test	Duration	Description
Freezing and Drying	21	Tested after 28 days of curing. 7 days in refrigerator, 7 days normal air dry and 7 days in refrigerator. Tested for compressive strength.

Drying	21	Tested after 28 days of curing. Dried at room temperature before being tested for compressive strength
Heat	1	Tested after 28 days of curing. Samples were oven dried at 800℃ before being tested for compressive strength.
Abrasive	-	Tested after 28 days of curing. The surface of the block was stroked for 50 times back and forth by using metal comb.

RESULTS AND DISCUSSION

Preliminary and Compaction Test Results

From preliminary testing, the results of liquid limit, plastic limit, moisture content and plasticity indices were 39.0%, 30.0%, 28.0% and 9.0%.

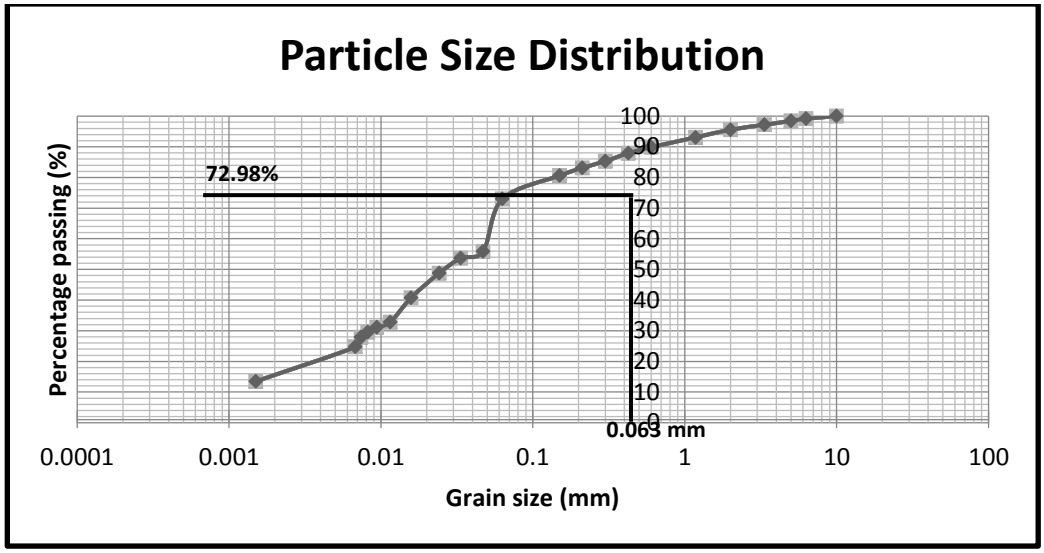


Figure 1: Particle Size Distribution

Based on the data obtained from sieve analysis and hydrometer analysis, the particle distribution curve was produced. The curve showed that it was a well graded curve that comprised of 72.98% of fine soil and 27.02% of coarse soil. According to BS 882 (1973), the soil can be classified as fine soil due to more than 35% of soil was finer than 0.06 mm which was 72.98% as can be seen in Figure 1. Major component of this fine particle was silty material since the percentage of silt was about 61%. Therefore, the soil was classified as silt with intermediate plasticity or can be said plasticity subdivisions as for the clays. The other way of classification was by referring to the plasticity chart where liquid limit and plasticity indices of the soil were considered. The soil was classified as MI which represents silt with an intermediate plasticity. Both ways represented the same outcome on soil classification. For the soil compaction test, the optimum moisture content is 20%, while the maximum dry density of

the soil is 1.60Mg/cm^3. The amount of water added to the CSEB mix was 20% of the total weight of the soil during the mixing process.

Engineering Test Results

Engineering test involved of two types of testing, which are compressive strength and durability test. The mix proportion of CSEB with 50% of laterite soil, 30% fine aggregate, 20% aggregate was then mixed with 5%, 10% and 15% of fly ash.

Compressive Strength Test

For the compressive strength of the block at 7, 14 and 28 days, the results were shown in Table 6 and illustrated in Figure 2.

Table 6: Compressive Strength of CESB of Different Fly Ash %

Fly Ash Percentage (%)	Compressive Strength (MPa)		
	7 days	14 days	28 days
F0	0.40	0.84	0.97
F5	0.83	0.87	1.00
F10	0.85	0.92	1.09
F15	0.44	0.46	0.51

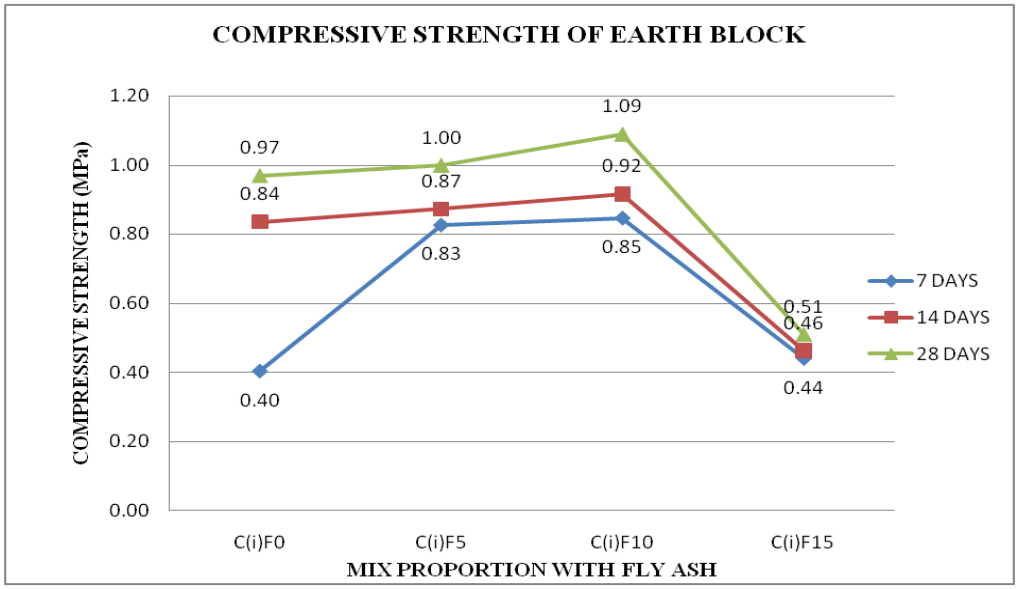


Figure 2: Compressive Strength Test of Earth Block With 0%, 5%, 10% And 15% Fly Ash

Table 6 and Figure 2 above illustrated the change in strength of CESB at different ratios of fly ash. The highest compressive strength obtained was 1.09 MPa with fly ash of 10%, and after 28 days of curing. In comparison with the previous study from Chimuanya (2014) showed that when 10 % of cement and lime incorporated with CSEB has given the compressive strength of 6.00 N/mm^2 and 1.37 N/mm^2. Thus, the highest compressive strength from this study still lower compared to CSEB incorporated with cement and lime stabilizer. In addition, the results did not achieve the minimum requirement based on MS72 for earth brick which supposed to be 5.2 MPa.

Water Absorption Test

For the water absorption test, the finding was demonstrated in Figure 3 below.

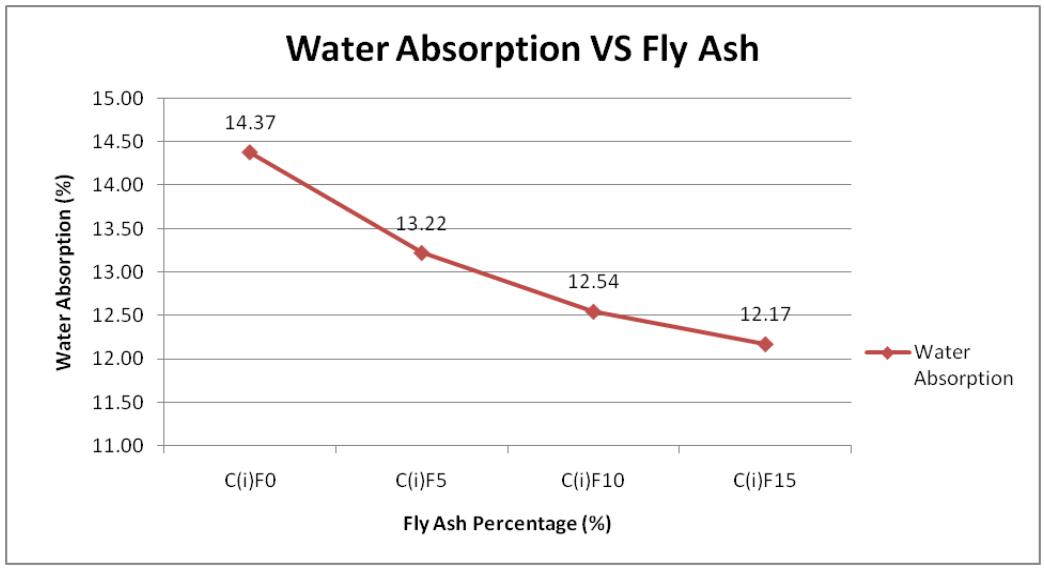


Figure 3: Water Absorption for All CSEB Samples

Based on the result obtained from water absorption test as plotted in Figure 3, the lowest water absorption experienced by CSEB was when it was incorporated with 15% of fly ash. This is due to the higher amount of fly ash that would cause to higher amount of void been eliminated. Consequently, it would reduce the amount of water penetrates the CSEB sample as most of the voids have been occupied by fly ash.

Durability Test

Four different durability tests were carried out involving 21 days of freezing and drying, 21 days of drying, heat test and abrasive test. These durability tests have been carried out to see the performance of CSEB under extreme condition and how the durability and strength of the block were affected compared to the previous normal condition.

Freezing & Drying, Drying, Heating (Oven Dried)

Table 7 demonstrates the result of durability tests at 21 days of freezing & drying, 21 days of drying and heating (oven dried) after 24 hours.

Table 7: Compressive Strength of CSEB after 21 Days of Freezing & Drying, 21 Days of Drying, Heating (24 hours)

Mix Proportion (%) Laterite Soil: Fine Agg: Coarse Agg	Fly Ash (%)	Compressive Strength (MPa)		
		21 Days Freezing & Drying	21 Days Drying	Oven Dried 24 hours
50 : 30 : 20	F0	0.98	0.98	0.99
50 : 30 : 20	F5	1.07	1.01	1.10
50 : 30 : 20	F10	1.12	1.07	1.14
50 : 30 : 20	F15	0.54	0.52	0.56

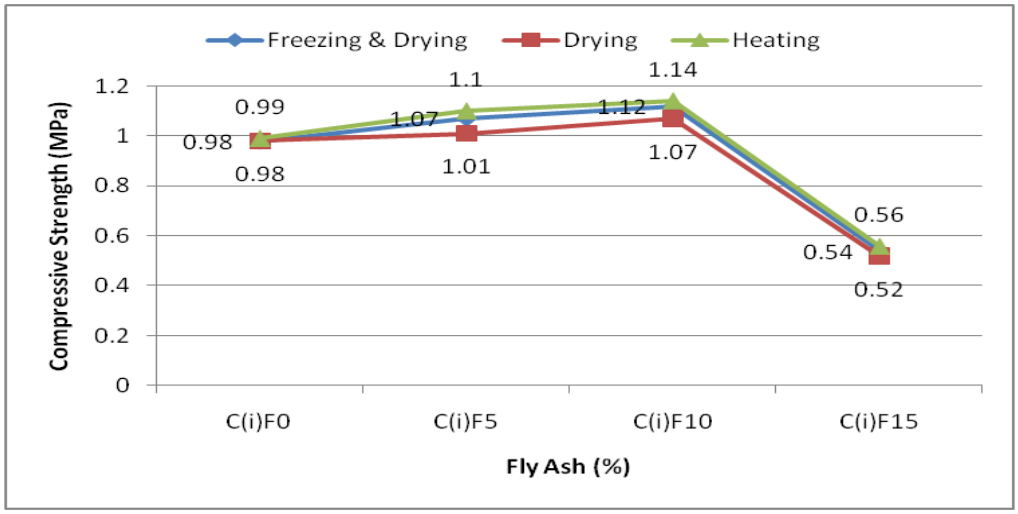


Figure 4: Compressive Strength of 21 Days Freezing & Drying, 21 Days Drying and Heating

Results obtained from the freezing & drying and drying test showed that the highest values of compressive strength were 1.12 MPa and 1.07 MPa. Whereas the heat test has encountered the highest compressive strength was 1.14 MPa. All of this result was obtained when the CSEB incorporated with 10% of fly ash. Freezing test was considered for durability test in this study because its funding would be useful by other researchers in four seasons country which, considering the innovation of earth block stabilized with fly ash. However the properties of laterite soil still need to be analysed since it could be different from one country to another taking into account the decomposition and weathering process involved. Even though most of the testing has enhanced the strength of the CSEB sample, but it still did not achieve the

minimum requirement of MS72 standard for compressive strength that should reach up to 5.2 MPa for earth brick. Previous studies conducted by Chimuanya (2014) on freezing and drying test, the CSEB with 10% of cement and 10 % of lime have obtained compressive strength of 7.35 MPa and 2.23 MPa. As for the drying test, the results of compressive strength of cement and lime at 10% were 6.91 MPa and 2.04 MPa. Both testing showed obviously higher value compared to results obtained from this study. There could be certain reasons that lead to such results, such as improper equipment for compaction test, insufficient quantity of water, improper material as stabiliser and other reasons.

Abrasive Test

Another durability test was abrasive test. The results were shown in the graph below.

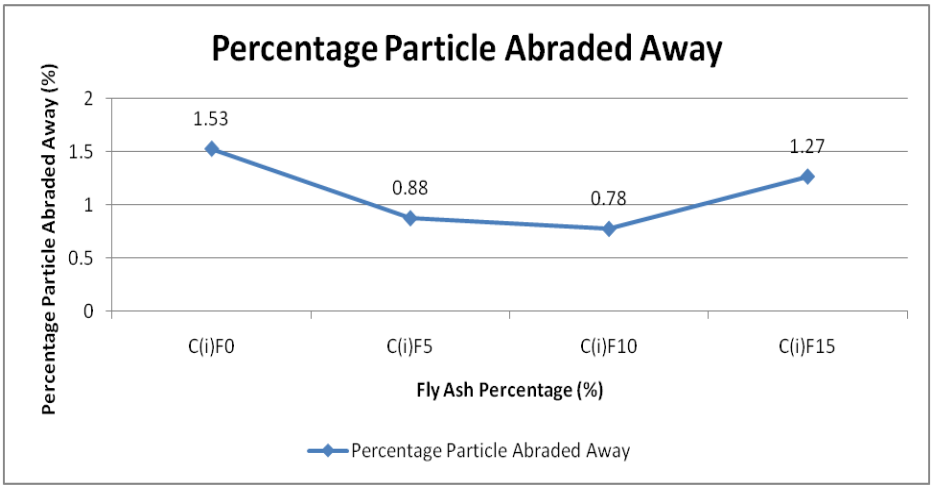


Figure 5: Percentage Particle Abraded Away With Fly Ash

Abrasive test results illustrated in Figure 5 show that CSEB had the lowest percentage of particle abraded when it was incorporated with 10% of fly ash which was 0.78%. In comparison with the previous study from Chimuanya (2014), CSEB incorporated with 10% of cement and lime showed that the particles abraded away were 0.06% and 0.20% respectively which were slightly lower compared to the result obtained from this study. It seems that fly ash did not have high cement-like element when mixed with laterite soil in order to bind the particle of CSEB strongly.

CONCLUSION

From the results obtained from engineering and durability testing, the compressed earth blocks that stabilized with fly ash gave a better compressive strength and durability to the earth block compared to the control sample. The result obtained from 28 days of curing with 10% of fly ash incorporated into the mix proportion showed the highest compressive strength of CSBE which was 1.09 MPa but did not reach the standard by MS72 with minimum amount of of 5.2 MPa. This result was better than the control sample which only 0.97 MPa. However, CSEB had the

lowest water absorption rate when added to the fly ash at 15%, which is 12.17% compared to control sample with a higher percentage of water absorption of 14.37%. In terms of durability testing that obtained after freezing & drying, drying and heating process demonstrated that the highest compressive strength from all of this testing was when fly ash was at 10%. The compressive strengths attained were 1.12 MPa, 1.07 MPa and 1.14 MPa respectively. Even the durability testing has enhanced the strength of the CSEB but the strength still did not reach the minimum standard of MS72. Lastly, the abrasive test encountered that the lowest percentage of particles abraded away was 0.78% when fly ash was at 10%. From this research study, 10% of fly ash is recommended in term of providing better strength and durability to the earth block.

RECOMMENDATION

There are few improvements that can be considered in future research in order to enhance the performance of the CSEB by using fly ash or other elements of stabiliser.

The compaction process must be carried out with the presence of all elements in CSEB to avoid insufficient quantity of water which would affect CSEB in term of strength and durability. Moreover, a flaky and elongated shape of coarse aggregate must be avoided as they break easily when force is applied upon them which affect the strength and durability. For further study, any fine aggregate that could affect the durability of the CSBE sample like sea sand which would highly absorb water and fragile when in a dried state must be avoided which made the CSEB sample to break easily when force applied upon them. It is very essential to confirm the class of the fly ash to be used for CSEB as the class C is self-cementing and class F required activator such as lime to produce cement-like properties.

Besides, the curing day should not be skipped and curing process must be carried out properly to avoid problems such as the insufficient amount of water which could affect the strength and durability of CSEB sample. Likewise, a compressor machine is recommended to be used during the moulding process to standardize the force that will be applied in order to mould the CSEB sample.

Lastly, freezing & drying and heating should be applied in the future in order to enhance the strength, durability and water resistant characteristic of the CSEB sample. This has been proved in this research and previous research with the enhancement of compressive strength after durability test. This compressed stabilized earth block should be encouraged to be used in many countries and not only for developing country in order to reduce the cost of construction, environmental impact and many other benefits.

REFERENCES

A R Akeem, O. F. (2012). Production and Testing of Lateritic Interlocking Blocks. *Journal of Construction in Developing Countries*.

Bell, F. (1993). Engineering Treatment of Soil: soil stabilization. *London, UK: E and FN SPON*.

C Chee-Ming, L. L. -p. (2010). Development of a Strength Prediction Model for Green Compressed Stabilize Earth Bricks. *Journal of Sustainable Development*.

Chimuanya, O. T. (2014). The Stabilization of Compressed Earth Block Using Lime and Cement.

Fly Ash Concrete - Advantages and Disadvantages of using Fly ash in Concrete. (N.d). Retrieved 2 8, 2015, from the Civil Engineering Forum: http://civilengineersforum.com/fly-ash-in-concrete-advantages-disadvantages/

Gidigasu, M. D. (1976). Laterite Soil Engineering. Amsterdam: Elsevier Scientific Publishing Company.

Glaser, B. (2005). Boden umdlandnutzung in den humidenTropenFerralsole (FR). *Department of Soil Physics*, University Bayreuth.

H Abdullah, K. A. (2013). Retrieved 1 August, 2015, from Compressed Earth Bricks (ICEB) Wall: http://www.zwgm.org/index.php/construction/article/view/17

K J Osinubi, T. I. (2008). *Book of Abstracts of the 2nd international conference on Engineering Research and Development: Innovations (ICER & D 2008).*

Keller, I. (2011). Improvement of Weak Soils by the Deep Soil Mixing Method.Keller Bronchure.

Kumutha, R., Prakash, K. V. S., Rajeshkumar, K., Sakthi, S., &Marthong, S. (2013). Feasibility Study On Utilisation Of Laterite Soil For Stabilized, 2 (3), 229–236.

Makasa, B. (2004). International Institute for Aerospace Survey and Earth Sciences Delft. Retrieved 1 August, 2015, from http://www.itc.nl.

Makusa, G. P. (2012). Soil stabilization methods and materials, 38. Retrieved from http://pure.ltu.se/portal/files/42050076/Soil_stabilization_methods_and_materials.pdf

National Brick Research Centre. (2015). Retrieved 28 August, 2015, from ASTM C97 Standard Test Methods for Absorption and Bulk Specific Gravity of Dimension Stone: http://www.brickandtile.org/testing-2/physical-properties/dimension-stone/astm-c97-absorption/

Nations, U. (1964). Soil Cement: Its Used in Building. sales No.4. New York, USA: United Nations Publication.

Norton, J. (1986). Building with Earth. A Handbook. London, UK: IT Publications Ltd.

O Esther, E. J. (2010). Soil type and different stabilization. Gainesville: Rink school and building construction university.

Raheem, aa, Ph, D., Bello, O. A, Tech, B., &Makinde, O. a. (2010). A Comparative Study of Cement and Lime Stabilized Lateritic Interlocking Blocks., 11(2), 27–34.

Satprem, M. (2010). Compressed stabilized earth block and stabilized earth technique. Auroville Earth Institute.

Schellmann, W. (2010). An Introduction in Laterite. Hannover, Germany: Federal Institute for Geosciences and Natural Resources.

RELEVANCY OF MODEL TERMS OF CONSTRUCTION CONTRACT FOR SUBCONTRACT WORK

Sharifah Huda Syed Mohd[1], and Zulhabri Ismail[2]
[1]*Faculty of Architecture and Built Environment, Infrastructure Universiti Kuala Lumpur*
[2]*Fakulti Senibina, Perancangan dan Ukur, Universiti Teknologi MARA*

ABSTRACT
In Malaysia, there is no standardized form or terms for domestic subcontract. A domestic subcontract is procured directly by the main contractor to carry out part of the work for which the main contractor has undertaken under the main contract. In this case, the need for subcontracting, the terms of the subcontract and the choice of a subcontractor are left to the commercial discretion of the main contractor. Problems arising from the usage of non-standard form are getting more serious. In 2007, the Malaysian Construction Industry Development Board (CIDB) entrusted with the responsibility to address pertinent issues and problems faced by the industry drafted and issued the Model Terms of Construction Contract for Subcontract Work. Based from the literature based research and qualitative method, it was found that payment is the highest major contribution to the critical subcontracting issues and problems faced when using non-standard form. Apart from that, based from the case analysis, Model Terms have the ability to minimize the problems faced when using non-standard form.

Keywords:
Model Terms of Construction Contract, Subcontract, Subcontractors, Standardized Form, Payment Issues.

INTRODUCTION

In Malaysia, like in many other countries, many construction works are subcontracted. CIDB (2007) stated whilst there are various standardized contracts for main contracts and the corresponding 'nominated' subcontracts, there are no published standardized forms or terms of contract for 'domestic' subcontract works in Malaysia.

Records from CIDB (2007) indicated that over the last five years, an average of 5,000 main contracts exceeding RM500,000 each are entered into each year. It is a common practice in the construction industry that for each main contract awarded; various subcontracts are let out to domestic subcontractors. Uff (1999) mentioned domestic subcontractors are selected by the contractors to do all the small construction works usually the outdoor work such as entrance road, fencing, pipe works etc**.**

As a result, many subcontracts are entered into based on various in-house contracts drafted by the main contractors. A significant numbers are let out on an ad-hoc basis and often incomplete in addition to many being let out entirely verbally. Problems arising from the usage of non-standard form are getting more serious. Construction Industry Development Board Malaysia (CIDB) entrusted with the responsibility to address pertinent issues and problems faced by the industry drafted and issued the Model Terms of Construction Contract for Subcontract Work 2007 on September 13, 2006.

The study looked into the relevancy of Model Terms of Construction Contract for Subcontract Work. The study determined the critical issues of subcontracting in construction projects and identifying the problems faced by main contractor and domestic subcontractor

when using non-standard form. Finally the study identified whether Model Terms could minimize the problems.

NATURE OF SUBCONTRACTING

The subcontracting system is usually described as the contracting process in which a main contractor subcontracts part of the job to another contractor, who may also subcontract to another firm or further subcontract as mentioned by Chiang (2009).

Subcontractors play a vital role when they are hired to perform specific tasks in a project. Shimizu & Cardoso (2002) agreed that subcontractors are specialist agents in the execution of a specific job, supplying manpower, besides materials, equipment, tools or designs. The larger and more complex the project, the larger will be the demand for subcontracting. To raise awareness within the industry about subcontracting, the parties involved must understand the nature of subcontracting first before they start to carry out the work efficiently.

CONTRACTUAL ISSUES IN SUBCONTRACTING

Payment Issue

A survey was conducted by MBAM (2005), among its members who comprised of contractors and sub-contractors. It was about 80.3% indicated that they had encountered slow progress payment. The respondents who encountered difficulties in getting progress payment were involved equally in public and private sector's projects. The survey also showed that the contractors are facing delays of payment for more than 91 days and up to 12 months compared to the contractual date.

Forty four percent of the contractors reported that they had encountered late payment situations in government funded projects while 53.5% had experienced late payment in private funded project CIDB (2006).

Retainage Withheld by Main Contractor

Sears & Clough (1994) stated that retainage can produce cash flow problems for contractors and subcontractors, resulting in substantial borrowing at a sometimes hefty interest rate, which results in higher construction costs for owners. In a study conducted by Hinze (2006), more than a third of the subcontractors surveyed stated that on periodic payments, the retainage withheld from their payments was equal to that withheld by the owner from the general contractor.

Incorporation by Terms

Where terms are not expressly stated in the articles of agreement or in an accepted offer, they may be incorporated by reference to other documents. In construction subcontract, the most common documents implied into a subcontract by reference will be a standard form of subcontract terms and conditions, either an industry standard or a form bespoke to the contractor, and / or by reference to the terms and condition of the main contract (McGuinness, 2007).

STANDARD FORM OF CONTRACT

The use of standardized forms of contracts has been generally considered practical and economical in the construction industry (Rashdi & Sutrisna, 2010). In many transactions, contracts are no longer negotiated between the parties as more and more contracts are entered into in standard form contracts where the terms of the contract are already printed on these documents (Sinnadurai, 2003). So, it indicates that the usage of standard form was globally used around the world in many businesses.

Pathmavathy (2005) summarized that the standard form of construction contracts provides a basic legal framework identifying the right, obligations and duties of the parties; establish the ambit of the powers and duties of the contract administrator.

Therefore, standard form generates many benefits as covers of terms of contract in agreement, established clear meaning, familiarity and the most important it provides roles and obligations of each party.

PURPOSED STANDARD FORM OF CONTRACT

The Objectives of Standard Form of Contract as mentioned by Harbans (2001) are:

a) To provide the basic legal framework evidencing the legal relationship between the parties.
b) To furnish a mechanism for regulating the conduct of the commercial relationship between the parties.
c) To put in place the administrative procedures necessary to affect the legal and commercial relationship between the parties for achieving the purposes of the contract.
d) To establish the ambit of the powers and duties of the contract administrators under the contract between the parties.

The use of standard forms of contract intends to ensure that all parties are familiar with the terms as a result of common usage that reduces the likelihood of disputes arising over the interpretation of the clauses. The parties are then aware of their rights and obligations under the terms of the contracts that are well documented.

NON-STANDARD FORM OF CONTRACT

Nonstandard form of contract is also known as bespoke contract. Standard forms generally adopt a balanced risk between the parties, however bespoke contracts often favour the owner or person drafting the contract. McGuinness (2004) found out that one-off or bespoke contract gives high expectancy of disputes.

Mills (2010) mentioned that bespoke forms of contract are not to be recommended. They create doubt and uncertainty in the minds of the contracting parties, and prevent those operating the procedures for drawing upon previous experience. This leads to uncertainty, inefficiency and misunderstanding. They often lead to extensive qualifications and negotiation and, by their very nature, are untested in court.

Standard forms generally adopt a balanced risk between the parties, however bespoke contracts often favour the owner or person drafting the contract. McGuinness (2004) found out that one-off or bespoke contract gives high expectancy of disputes.

THE CICC MODEL TERMS OF CONSTRUCTION CONTRACT FOR CONSTRUCTION WORKS

The CICC Model Terms of Construction Contracts for Subcontract Work, CIDB (2007) adopts plain language throughout, has no multiple cross-referencing, and is drafted in gender-neutral style. Ali (2008) stated that the CICC Model Terms had / has an average of 19 words per sentence. One notable feature is the unique structure of the contract which clusters the entire contract under 7 broad main clauses: (1) general obligations, (2) administration and changes to the work, (3) time obligations, (4) payment, (5) quality, safety, health, and environmental obligations, (6) legal rights and termination, and (7) disagreement and resolution of disagreement. This logical structure is intuitive to those familiar with the 3 tenets of project management – time, cost, and quality, and makes the contract relatively easy to navigate despite it being a relatively new contract. These broad main clauses and the sub-numbered clauses are set out in the contents pages of the contract (CIDB, 2007).

CHARACTERISTICS OF MODEL TERMS

The model terms are drafted entirely in modern plain language, adopts a project management approach and it had endorsement of 14 professional and trade organizations in Malaysia. According to Ali (2007) there are some key characteristics of Model Terms, which are:

a) Modern plain English.
b) Structure – project management approach. Terms grouped by issues on time, cost and quality.
c) Generic terms – usable with all main contracts.
d) Stand-alone – not 'back-to back'. But conversion to back-to-back is made easily possible using the appendix.
e) No deeming provisions – and no 'legal fiction' (e.g. dogs are deemed to be cats or minor defective works are deemed not to be defective works).

By having all the characteristics above, it specifies that Model Terms are flexible enough to be used easily anywhere around the world with minimal or no modifications.

RESEARCH METHODOLOGY

The research methodology proposed to be employed in this research consists of:

Literature Review and Literature- Based Research

A literature review was carried out to gather and establish some sound knowledge of the research. Researchers typically look at the literature, prior to scheduling the particulars of a study, to discover what has been printed concerning a subject they are attracted in investigating. Attention is given to both the view of experts in the field and other research studies (Mahmud, 2009). The literature part of this study that gives a thorough understanding what is this research is all about in order to achieve one of the objectives which to determine critical issues of subcontracting in construction projects. This is done by exploring the current and past research on the subject-matter locally and internationally through journals, books, conference proceedings, internet and standard forms of contract.

Qualitative Method

Qualitative research involves the studied use and collection of a variety of empirical materials such as a case study, personal experience, introspective, life story, interview, observational, historical and visual texts that describe routine and problematic moments and meanings in people's lives (Denzin & Lincorn, 1994; Thomas, 2003). Zulhabri (2006) and Holmes et al. (2005), pointed out that the qualitative research was used if the researcher wants to understand a phenomenon about which he knows very little about, or when he does not have a complete knowledge of a particular entity. Therefore, for this research, in order to have more detail information on the area of a particular entity, the legal research was used as an instrument for qualitative data collection for all objectives.

By using the words 'subcontract', 328 cases from the judgment date as reported by the Malayan Law Journal were analysed. The cases were subjected to screening. At the first screening, the 242 cases were from the year 1996 until 2011. From second reading and screening, the court of 165 cases did hold cases in the construction industry. Further third screening only 61 cases were selected. For the first objective, 51 cases have been analysed. The cases were located under the terms of subcontract which are payment, performance bond, delay, arbitration, termination, variation and also damages. The gist of subcontracting issue from every case was highlighted and tabulated while another 10 cases have been analysed for the second objective. The same cases were used to achieve the last objective. The difference in the number of cases between objective 1 and objective 2 was due to lack of cases related to non-standard form.

Findings & Discussion: Critical Issues of Subcontracting In Construction Projects

There were 51 number of cases identified. The percentages of each are shown in the Table 1.0 below.

Table 1.0 Percentages of Case Analysis For Critical of Subcontracting Issues

Critical subcontracting issues	No of cases	Percentage (%)
Payment	17	33.3
Damages	8	15.7
Termination	6	11.8
Variation	6	11.8
Arbitration	6	11.8
Delay	5	9.8
Performance Bond	3	5.8
TOTAL	**51**	**100**

As illustrated in Table 5, it was found that 33.30% of critical subcontracting issues are payment. This is followed by damages, 15.7%, termination, variation and arbitration, each 11.8%, respectively; delay 5% and performance bond 5.8%. The results indicated and confirmed that the most critical issue in subcontracting was a payment problem. Not fully paid by amount certified / claim for outstanding payment and non-payment affecting the entire delivery chain. It is believed that the consequences of subcontractors being not fully paid and non-payment is grave, caused financial hardship to them.

From the finding, subcontractors are normally the financially weakest participant in the project. It is clear that the greater the percentage of subcontracted work, the greater would be the tendency of payment disputes.

Similarly, this finding is in line with research conducted by Master Builders Association Malaysia (2005) and Construction Industry Development Board (2006). They reported construction parties, namely subcontractors and main contractors had encountered payment problems for both public and private sector's projects.

Problems Faced By Main Contractors and Subcontractors When Using Non Standard Form

Table 2.0: Summary of the Cases Analysed

No	Cases	Problems	Judgment Priority to:
PAYMENT			
1.0	Mahkota Technologies Sdn Bhd (formerly known as the General Electric Co (M) Sdn Bhd) v Bs Civil Engineering Sdn Bhd [2000] 6 MLJ 505	No intention to exclude the right to set off in the contract	Main Contractor
2.0	Antara Elektrik Sdn Bhd v Bell & Order Bhd [2002] 3 MLJ 321	A dispute regarding term of payment when various form applied.	Subcontractor
3.0	Casmet Sdn Bhd v Unipac Engineering (M) Sdn Bhd [2009] MLJU1065	The subcontractor is entitled to payment due unsigned of the agreement.	Subcontractor
4.0	Globe Engineering Sdn Bhd v Bina Jati Sdn Bhd [2010] MLJU 311	Main contractor would be paid to subcontractor when they are paid by employer (pay when paid).	Subcontractor
5.0	United Exploration (M) Sdn Bhd v Ijm Corp Bhd [2011] 8 MLJ 161	The right to claim the balance of the sum owing under the subcontract due scope of works reduced.	Main Contractor

6.0	Ak Translogic Sdn Bhd v Kausar Corp Sdn Bhd [2011] 9 MLJ 415	Main contractor refused to pay a subcontractor's claim due to delay in completion & defective works occurred.	Subcontractor
PERFORMANCE BOND			
7.0	Lec Contractors (M) Sdn Bhd (formerly known as Lotteworld Engineering & Construction Sdn Bhd) v Castle Inn Sdn Bhd & Anor [2000] 3 MLJ 339	Subcontractor reluctant to release a performance bond to main contractor when demand was made.	Main Contractor
VARIATION ORDER			
8.0	Esajadi Sdn Bhd v Ybs Tenaga Sdn Bhd [2011] MLJU 148	Main contractor refused to pay the amount of variation under subcontract claimed by the subcontractor.	Subcontractor
ARBITRATION			
9.0	Ng Ki Sian v Petaling Jaya Asset Sdn Bhd [1998] MLJU 403	Main contractor refused to settle the problem through the arbitration	Subcontractor
TERMINATION			
10.0	Kah Seng Construction Sdn Bhd v Selsin Development Sdn Bhd [1996] MLJU359	Termination of contract due suspension of work by subcontractor	Main Contractor

Table 2.0 shows some cases derived from problems when using the non-standard form. There were ten cases selected which involved were in various kinds of problems. The problems were performance bond (1 case), terms of payment (6 cases), variation order (1 case), arbitration (1 case) and termination (1 case). Payment problem contributed most when using non-standard form. This is because non-standard form do not create the possibility of a more balanced allocation of risk between the contracting parties. Hence, it creates a higher chance of disputes, especially in term of payment which is believed as the lifeblood of the construction industry.

Based on the case analysis, the judgment priorities to subcontractor were 6 of 10 cases (60%). In Malaysia construction industry, most of domestic subcontractors are in class E and F under PKK registration. Not all of them came from a technical background and some of them from low educational background but enrich with skills and expertise. In spite of lot of expertise in construction, their levels of understanding in the contract are still low. This is one of the constraints / reasons for the late implementation of standardized forms for domestic subcontract in Malaysia.

Whether Model Terms Can Minimize the Problems

Based from the case analysis, 9 out of 10 above cases can be minimized by Model Terms which payment (5 cases), variation order (1 case), termination (1 case), performance bond (1 case) and arbitration (1 case).Case of *Antara Antara Elektrik Sdn Bhd v Bell & Order Bhd [2002] 3* MLJ *321* was cannot be minimized the problem since dispute regarding terms of payment when various form applied not stated clearly in Model Terms but in law of contract, both parties must have mutual agreement regarding terms of payment.

Payment problem generally can be minimized by using Model Term as covers all the main payment provisions relating to the contract including payment claims, loss and expense claims, payment certificates, retention amounts and many others.

Undoubtedly, this finding is in line with research conducted by Hinze (2006) which mentioned more than a third of the subcontractors surveyed stated that on periodic payments, the retainage withheld from their payment was equal to that withheld by the owner from the general contractor. In addition, according to Sears & Clough (1994), retainage can produce cash flow problems for contractors and subcontractors, resulting in substantial borrowing at a sometimes hefty interest rate, which results in higher construction costs for owners.

CONCLUSIONS & RECOMMENDATIONS

The case analysis reveals that payment was the critical issue of subcontracting followed by damages, termination, variation, arbitration, delay and performance bond. Payment issues covered retainage withheld by main contractor, incorporation of the terms, claim for outstanding payment for work done / not fully paid, pay when paid clause etc.

Of the problem faced when using non-standard form, payment issues contributed most. The payment's cases covered in terms of set off by main contractor, incorporation by terms of payment, certificates and payment, claim for work done and pay when paid clause. It was found that Model Terms has a great possibility to minimize the problems faced by main contractor and subcontractors when using non-standard form

For better improvement in the construction industry, it is recommended the major organizations entrusted to play the important role in the construction industry such as Construction Industry Development Board (CIDB), Pusat Khidmat Kontractor (PKK) and other non-government agencies should take a proactive solution to encourage the usage of Model Terms among the contracting parties. For examples, conducting seminars, Roadshows in order to enhance parties' awareness about standardized form.

Moreover, main contractors and subcontractors, especially domestic subcontractors need to shift their paradigm for choosing Model Terms as part as their contractual agreement. Thus, their right and duties will be protected and problems can be minimized under this standardized form of contract.

REFERENCES

Ali, N. (2007). Model Terms of Construction Contract for Subcontract Works. *Seminar on the Construction Industry Contracts Committee (Cicc).* Taiping, Perak, Malaysia.

Ali, N. (2008). *Paperwork: Modern Plain English Drafting & Construction: The Malaysian Subcontract of Model Terms.* CIDB Malaysia.

Chiang, Y. (2009). Subcontracting and its ramifications: a survey of the building industry in Hong Kong. *International Journal of Project Management 27 (1)*, 80-88.

CIDB. (2006). *A Report of a Questionnaire Survey on Late and Non Payment Issues in the Malaysian Construction Industry.* Kuala Lumpur: Construction Industry Development Board Malaysia.

CIDB. (2007). *CICC Model Terms of Construction Contract for Subcontract Work 2007.* 3rd print, CIDB.

Denzin, N.K & Lincorn, Y.S. (1994). *Handbook of Qualitative Research.* Sage: Thousand Oaks, CA.

Harbans, S. (2001). *Engineering and construction contract management.* Kuala Lumpur: LexisNexis.

Hinze, J. (2006). *Construction Contracts.* McGraw Hill.

Holmes, R., Hazadiah, M.D & Habibah, A. (2005) A Guide to Research In The Social Sciences. Kuala Lumpur: Prentice Hall

Mahmud, Z. (. (2009). *Handbook of Research Methodology: A Simplified Version.* Shah Alam: University Publication Centre (UPENA), UiTM.

MBAM. (2005). *MBAM Quartely Survey on Progress Payment Issue in the Construction Industry.* Kuala Lumpur: Master Builders Association Malaysia (MBAM).

McGuinness. (2007). *The Law and Management of Building Subcontracts.* Wiley-Blackwell Publishing.

McGuinness, D. (2004). *The Law of Management and Building Subcontract.* United Kingdom:: Anthena Press.

Rashdi & Sutrisna. (2010). Evaluation of the Standardised form of contract at ultanate Oman. *Concept, Tools & Techniques for Managing Successfu Projects.* Heraklion, Crete, Grece.

Sears & Clough. (1994). *Construction Contracting.* Wiley, New Work.

Sinnadurai, V. (2003). *Law of Contract. 3rd Edition.* 3rd Edition, Butterworth: Lexis Nexis.

Shimizu, J.Y & Cardoso,F.F. (2002). Subcontracting and Cooperation Network in Building Construction: A Literature Review. *Proceedings IGLC, 10 August.* Gramado, Brazil.

Thomas, R. (2003). *Blending Qualitative & Quantitative Research Methods in Theses and Dissertations.* California: Corwin Press, Inc.

Uff. J (1999). *Construction Law*. Sweet & Maxwell.

Zulhabri, I. (2006). *The Application of Alternative Dispute Resolution in the Malaysian Construction Industry; PhD Research Proposals.* Kuala Lumpur: Paper presented at the 2nd ASEAN Post Graduate Seminar: University of Malaya

AGRICULTURAL WASTE AS LOW COST ADSORBENT FOR THE REMOVAL OF FE (II) IONS FROM AQUEOUS SOLUTION

Manal Mohsen Abood[1], Jeyaletchumy Rajendiran[2] and Nik Nuraini Azhari[3]
[1,2,3]*Department of Civil Engineering, Faculty of Engineering and Technology Infrastructure, Infrastructure University Kuala Lumpur, Malaysia (IUKL)*

ABSTRACT
This study investigates the efficiency of durian leaves as a low cost agriculture waste (bio adsorbent) that could remediate aqueous solution free of Fe (II) ions. The influence of four parameters, namely pH, initial metal concentration and contact time, mixing rate and particle size of adsorbent on the performance of durian leaves have been studied in batch method at room temperature. It was found that the maximum adsorption is reached at pH 6. Moreover, the process tends to be rapid the initial 5 minutes and equilibrated in 60 minutes with uptake of more than 45%. The Freundlich and Langmuir isotherm models are used to describe the biosorption of Fe(II) ions onto durian leaves. The Langmuir model tends to fit the equilibrium data better by giving a correlation coefficient of 0.7736 and maximum adsorption capacity is found to be at 3.914 mg/g. The results obtained prove that durian leaves have great potential to be used as low cost bio adsorbent in order to remove heavy metals in wastewater.

Keywords: *Agricultural Waste, Aqueous Solution, Adsorbent, Fe (II) Ions, Durian leaves, Low cost.*

INTRODUCTION

Wastewater is any water that has been critically damaged by human's anthropogenic domination. It is generated by the means of domestic, industrial, commercial, or agricultural activities as well as surface runoff or storm water. Since the emergence of the Industrial Revolution, industrial wastewater has become one of the crucial sources of water pollution. Heavy metals are among the significant pollutants that have been adversely affecting the purity of surface water. They enter the aquatic environment through the discharge of industrial wastes, storm water runoff, mining activities, smokestack discharge, and automobile emission. Many heavy metals are necessary elements for humans, animals, and plants in trace amounts. Howsoever, consumption of large amounts leads to acute and chronic toxicity which are linked to learning disabilities, cancers and even death. Chaturvedi and Dave (2012) stated that iron is a standout amongst the richest heavy metals found in the earth's crust. It happens normally in water, insoluble forms. This characteristic of the element leads to the excessive iron presence in groundwater. The origin of this particular heavy metal is not only by nature but also industrial.

Common industrial sources of iron pollution comprise mining, steel and iron production, and metal corrosion. Iron remediation is considered among the puzzling issues in producing consumable water due to its aesthetic problems, health concerns and economical controversy. Terrible metallic taste, reddish brown discoloration, blemishing nature and high turbidity are the major aesthetic problems caused by the iron existence in water. Iron compounds absorbed by the soil, rocks and minerals infiltrate towards groundwater that is further used for drinking and crop irrigation purposes. Corrosion is also a major dispute caused by iron occurrence. Greater water acidity and increased level of dissolved oxygen in water with the presence of iron leads to greater corrosion. Certain microscopic organisms flourish with

raised levels of iron, and might stick to pipe surfaces as a suitable natural surroundings. These microscopic organisms might get to be sufficiently dense in population to cause clogging in pipes and deflate flow rates. This may head towards puncture or leakage in pipes if the pipes are constructed of iron. Propitiously, iron uptake has no clinical effects on our health if it's consumed in average amount as it is considered as a necessary nutrient in our body (Josoh et. al., 2005)

In current years, researches of the removal of heavy metals such as lead, copper, cadmium, zinc nickel and iron from solutions by adsorption using agricultural materials were given ample attention such as Sawdust (Yasemin and Zeki, 2007), Pomegranate (El-Ashtoukhy, et.al., 2008), Micro particles of dry plants (Benhima, et.al., 2008), waste tea leaves (Ahluwalia and Goya, 2005), saraca indica leaf (Goyal, et.al., 2008), tobacco stems (Li, et.al., 2008), neem leaf powder (Bhattacharyya and Sharma, 2004]. Removal of iron have been studied by (Anusha and RajaMurugadoss, 2014) using Almond shell as adsorbent, Tilapia Mossambica Fish scale-Adsorption has been used by (Zayadi and Othman, 2013), while (Kadir, et.al., 2013) used rice bran as adsorbent for the ferum ion removal from the solution.

There are existing technologies such as precipitation, ion exchange, solvent extraction and liquid membrane that are presently in use in order to remove heavy metals from wastewaters. But these natural materials have the aptitude to be utilized as low cost adsorbents because they serve as unused resources, are generally at hand and are also environmentally friendly (Abdel-Ghani, 2007) Natural adsorbents or more fondly known as biosorbents that were previously used for research of removal of heavy metal such as maize bran, sawdust, tea leaves, pomegranate peel, wood ash, neem leaf and more. In this study, durian leaf is being used as a low cost adsorbent.

Durian (Durio Zibethinus) is an exotic fruit which is well known within South East Asia regions. It is being consumed in massive amount all over many tropical countries and therefore huge areas are being reserved for durian plantations. According to the Agriculture Department Fruit Crop Statistics, 2013 the hectarage value for durian plantation has been 75,713.1 ha for the year 2013 whereas the annual production was 373,087 tonnes. It is found to be the largest fruit plantation within Malaysia.

Durian is one of the most available agricultural waste found in the South Asia region. Due to the high consumption of durian, massive amount of the peels and leaves are disposed, causing a severe problem in the community. The largest amount of durian leaf waste is also generated that subsequently is thrown into landfills thereby taking the landfill space. This study is conducted based on the utilizations of durian leaves as low cost adsorbent for the removal of ferum ions from aqueous solution and to determine the effect of pH, the effect of initial concentration of Fe (II) ions and contact time, effects of mixing rate and the effect of particle size on the adsorption of Fe(II) ions on the surfaces of durian leaves.

MATERIALS AND METHODS

Preparation of Adsorbent

The durian leaves were collected at a fruit yard situated in Mentakab, Pahang, Malaysia and Hulu Langat, Selangor, Malaysia. Mature leaves were collected to ensure the cell walls of the leaves are still rigid and functional. These leaves were then rinsed thoroughly to remove all impurities and dust on the leaves. Rinsed leaves were dried under the sunlight for 7 days and made sure the leaves turned golden brown. Further drying was done using heat of an oven at 105^{o}C for 24 hours. The dried leaves were then ground into fine powder form using a blender.

An airtight container was used to store and seal the ground powder to ensure no contact of atmospheric moisture.

Preparation of Adsorbate

Fe(II) stock solution was prepared at a concentration of 500 mg/l by the dilution of exactly 1.464 g of $PbSO_4$ with 500 ml of distilled water in a 500 ml volumetric flask. This particular stock solution was then further diluted to preferred concentrations that were required during the later stage of the experimental study.
Molecular weight of $FeSO_4$ = 278.02 g/mol
Formula weight of Fe = 55.845 g/mol

$$\frac{500 \text{ mg of Fe}}{\text{L}} \times \frac{1\ g\ of\ Fe}{1000\ mg\ of\ Fe} \times \frac{278.02\ g/molof\ \text{FeSO4}}{55.845\ g/mol\ of\ Fe} \times 1L. \quad (1)$$
$$= 1.25\ g\ of\ \text{PbSO4}$$

Procedure

Batch experiments were conducted by mixing 1.5 g of durian leaf powder with 300 ml of Fe solution in a 500 ml beaker using the jar, tester at desired initial Fe concentration, pH of the solution, contact time and mixing time. The mixing rate was given at 100 rpm for 2 hours until equilibrium was reached. Then, the mixing was halted and the powder was removed from the solution using a filter paper. The filtrate was then sampled to measure the concentration of Fe(II) ion using a spectrophotometer. All samples were carried out under the same standard condition as stated and the average results are computed.

The effect of pH on this particular study was investigated over a PH range 2 – 8. The batch experiment was carried out by mixing 1.5 g of durian leaf powder in 300 ml of Fe (II) stock solution at concentration of 10mg/L in a 500 ml beaker. The sample was mixed at a mixing rate of 100 RPM with 2 hours of contact time. The mixing rate was constant until the experiment reaches equilibrium. The pH of the solution is altered by dropping appropriate addition of 1.0 M of Hydrochloric acid (HCl) and/or 1.0 M of Sodium hydroxide (NaOH) to the 10mg/L lead solution.

The effect of both these scopes upon the rate of adsorption of durian leaf powder and Fe ions was investigated simultaneously. The study was conducted by mixing 1.5 g of durian leaf powder with 300 ml of 5 mg/L Fe(II) solution using a 500 ml beaker. Jar test was then carried out to mix the sample at 100 rpm over various time periods such as 5, 10, 20, 30, 60, and 120 minutes. The step above was then repeated at different concentrations of Fe(II) solution (3.0 mg/L, 10 mg/L, 20 mg/L and 30 mg/L).

The effect of mixing rate upon the rate of adsorption of durian leaf powder and Fe ions was investigated by adding 1.5 g of durian leaf powder to 300 ml of 5 mg/L Fe(II) solution in a 500 ml beaker and mixed using jar test equipment over time periods of 5, 10, 20, 30, 60 and 120 minutes. The mixing rate was manipulated at 50, 100, and 150 rpm.

The effect of the particle size of adsorbent upon the rate of adsorption of durian leaf powder and Fe ions was investigated by adding 1.5 g of durian leaf powder to 300 ml of 5 mg/L Fe(II) solution in a 500 ml beaker and mixed using jar test equipment over a stirring speed of 100 rpm for 120 minutes. The above step was repeated for 5, 10, 20, 30, and 60 minutes and also by manipulating the particle size of the durian leaf powder by < 0.600 mm and > 0.600 mm. The size of the adsorbent particle was analysed using sieve analysis.

The influence of durian leaf powder on the adsorption of Fe (II) ions was studied in this study. Langmuir and Freundlich were the two isotherm models being used here in order to interpolate the graphical analysis of the adsorption equilibrium. The survey was directed from the result of the effect of contact time (5, 10, 20, 30, 60 and 120 minutes) and initial concentration of metal ion (3.0 mg/L, 5mg/L, 10 mg/L, 20 mg/L and 30 mg/L). The equation below was used to calculate the quantity of Fe ion adsorbed by the durian leaf powder.

$$q = (C_o - C_e)\, V/m. \qquad (2)$$

where, q_e = Amount of Fe(II) ions adsorbed at equilibrium (mg/g), C_o = Initial concentration of Fe(II) solution (mg/L), C_e = Concentration of Fe(II) at the equilibrium state (mg/L), V = Volume of metal solution (L), m = mass of adsorbent (g)

An adsorption isotherm model is a curve relating the equilibrium concentration of a solute to the surface of an adsorbent, qe, to the concentration of the solute in the liquid, Ce, with which it is in contact. It is also an equation relating the amount of solute adsorbed onto the solid and the equilibrium concentration of the solute in solution at a given temperature.

RESULT AND DISCUSSION

Effect of PH

The consequence of pH of the Fe (II) solution upon the adsorption efficiency was studied by altering the pH of the solution within a range of 2 – 8 (Figure 1). The result showed that the absorption rate increased at the beginning from pH 2 to 5. At pH 2 which has the highest acidity value, the concentration of Fe (II) ion removed was at least. This is because at low pH the concentration of H^+ ions is greater. Hydrogen ions tend to compete with metal ions for the adsorption site of the adsorbent. This ascribes that at higher concentration of H^+, the adsorbent becomes more positively charged. This hinders the electrostatic attraction between the metal and the adsorbent. The maximum metal uptake is around pH 6.0 by 81.0%. At this point, the concentration of hydrogen ions would be at least. Thus, more negatively charged adsorption site of adsorbent will be available for metal ion attraction.

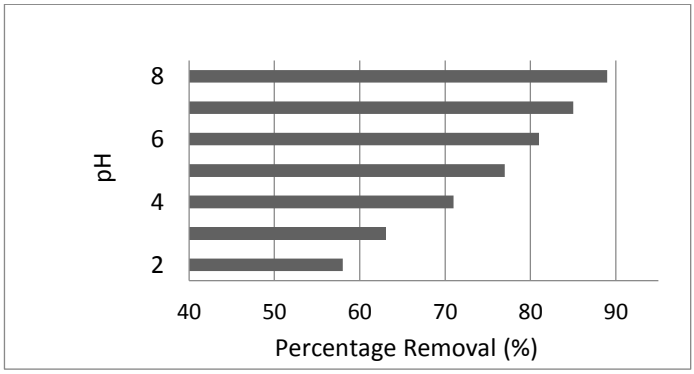


Figure 1: Effect of pH of Fe (II) solution on the uptake of Fe(II) ions by durian.

Effect Of Initial Concentration of Fe(II) ions and Contact Time

Equilibrium time is a crucial operational aspect to ensure an economical wastewater treatment process. During the initial few minutes, faster rate of absorption was observed at all different concentrations (53.0%, 71%, 60.5%, 49.5%, 42.3%)(Figure 1). Almost half of the concentration has been adsorbed within initial few minutes in regard of different concentrations. This is due to the availability of the larger surface area of the adsorbent for the adsorption of metals. With time, the removal efficiency rate becomes almost negligible. This is because of the swift depletion of the adsorption sites.

As the agitation time prolongs, the adsorption coherence increases until adsorption equilibrium is established. It is found that all concentrations attained equilibrium at the 60th minute of mixing (Figure 3). The rapid metal uptake was by 58.5%, 83%, 73.5%, 54.5%, and 46.3% of initial concentration of 3 mg/L, 5 mg/L, 10 mg/L, 20 mg/L and 30 mg/L respectively.

As per the initial concentration of Fe(II) ion factor, the removal mechanism is described as below. Initial removal is rapid with an inflating concentration of metal ion and slowed down with higher concentrations. The metal uptake was the highest when the initial concentration was 5 mg/L by 83.0%, whereas the metal uptake was only by 46.3% at an initial concentration of 30 mg/L. This is because of lower concentration the ratio of the metal ion number of the adsorption sites that are available is small.

At higher concentration, the adsorption specific sites become saturated and the exchange sites are filled. When the amount of adsorbent is fixed, the concentration of metal absorbed increases with increasing concentration of metal. However, the percentage of removal of metal ions decreases. Rapid metal uptake is found to be when the concentration of the metal solution is 5 mg/L.

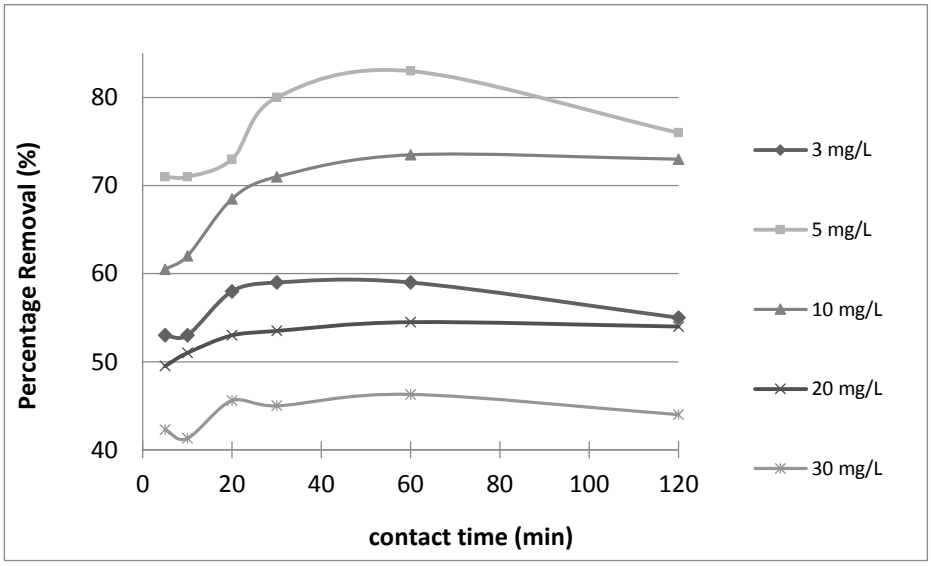


Figure 2: Effect of initial Fe(ll) ion concentration and contact time on the uptake of Fe(ll) ions by durian leaves

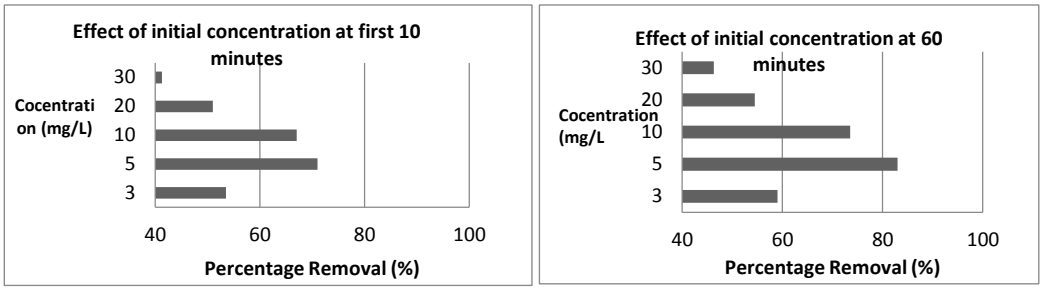


Figure 3: Effect of initial Fe(ll) ion concentration and contact time on the uptake of Fe(ll) ions by durian leaves in the first 10 minutes and 60th minutes

Effect of Mixing Time

It is the combination of both stirring speed and time taken to stir the sample. In this particular study, the adsorption capacity that is affected by the speed of mixing and time taken to mix resulted in the following:-

As the speed of the stirring increases, the adsorption capacity is increased in terms of boundary layer thickness. During the initial 5 minutes the metal uptake was by 49.0%, 61.0%, 66.0% for the mixing rate 50rpm, 100rpm and 150rpm respectively (Figure 4). By raising the speed of mixing, the thickness of the adsorbent particles' boundary layer is reduced. Hence, this made it available for more concentration of Fe ion to encounter with the adsorbent surface as shown in Figure 5. However, at a vigorous speed, the ferum ions desorbed from the adsorbent surfaces by breaking their newly formed unstable bond. Therefore, stirring speed should be maintained at an average rate.

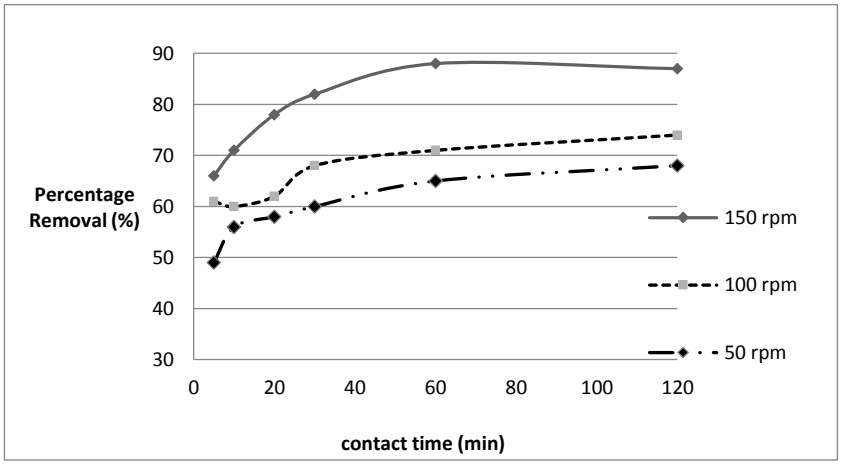


Figure 4: Effect of mixing time on the uptake of Fe(ll) ions by durian leaves

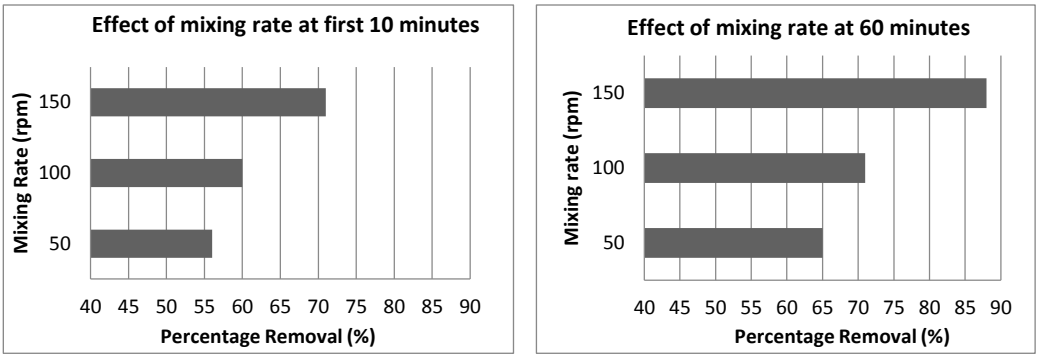


Figure 5: Effect of mixing time on the uptake of Fe (ll) ions by durian leaves at the first 10th minute and 60th minute

Effect of Particle Size of Adsorbent

Particle size of adsorbent has a significant influence on the adsorption capacity. The increase in the area per unit weight of the adsorbent has a limited effect on the metal adsorption rate. This experiment is conducted by using two different particle size, which were < 0.600 mm and > 0.600 mm and they were able to remove Fe (II) ions by 59.0% and 48.0 respectively during the initial 5 minutes. As per this study, the percentage of metal removal has increased with the decrease of particle size. This is due to the fact that smaller particles have larger surface areas. They tend to yield shorter time to reach equilibrium (Amuda, O. et.al., 2007).

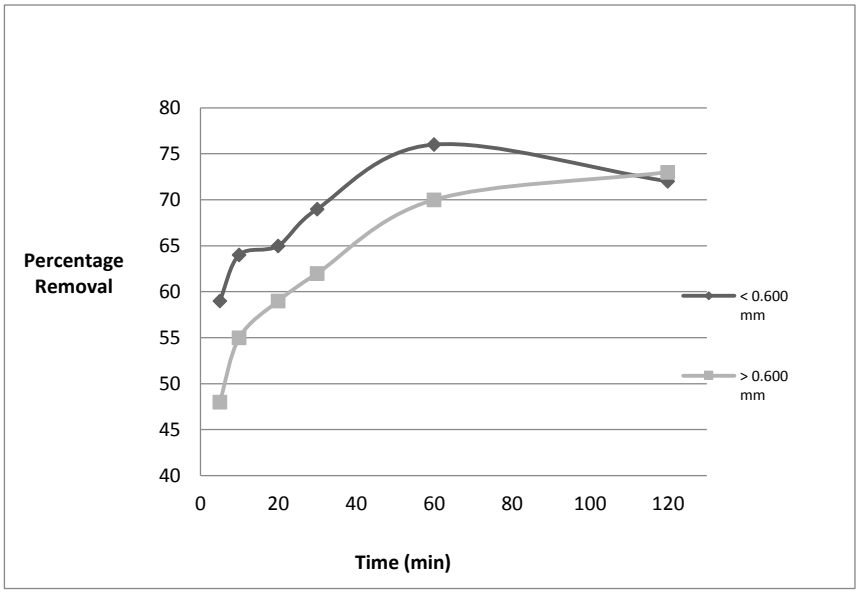


Figure 6: Effect of particle size of adsorbent on the uptake of Fe (ll) ions by durian leaves

BIOSORPTION EQUILIBRIUM ISOTHERMS

Freundlich Isotherm Model

The plot of log q_e vs log C_e is illustrated in Figure 7. This plot shows the Freundlich isotherm model that describes the adsorption relationship between Fe(II) ions and the durian leaves. The graph gives out a correlation coefficient of 0.7397 which is close to unity. This testifies that the data obtained can adjust well with Freundlich isotherm model. The plot gives out the values of K_F and n as 1.6203 and 1.788 respectively. The adsorption process carried out is considered affirmative as the value of n lies between the ranges of 1 to 10.

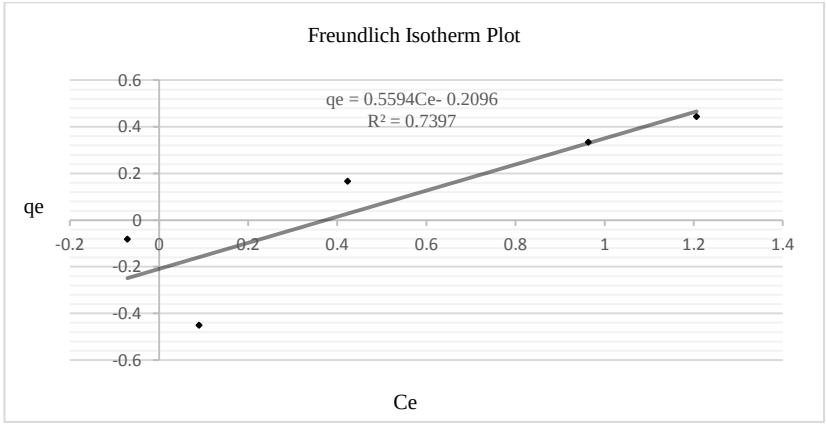


Figure7: Freundlich isotherm plot for the adsorption of Fe(II) ions onto durian leaves

Langmuir Isotherm Model

The plot of C_e/ q_e vs C_e is illustrated in Figure 8. This plot shows the Langmuir isotherm model that also describes the adsorption relationship between Fe(II) ions and the durian leaves. The graph gives out a correlation coefficient of 0.7736 which is close to unity. This testifies that the data obtained can also adjust well with the Langmuir isotherm model. According the Langmuir Equation, the maximum adsorption capacity for Fe(II) ions is 3.914 mg/g.

All the R_L values of each initial concentration of Fe solution studied were in the range of 0 and 1. This justifies that the adsorption of Fe(II) ions onto durian leaves is modelled in a favourable isotherm shape.

Table 1: Initial Fe (II) ion concentration and their R_L values

C_o (mg/L)	**R_L**
3.0	0.6937
5.0	0.5760
10.0	0.4045
20.0	0.2535
30.0	0.1846

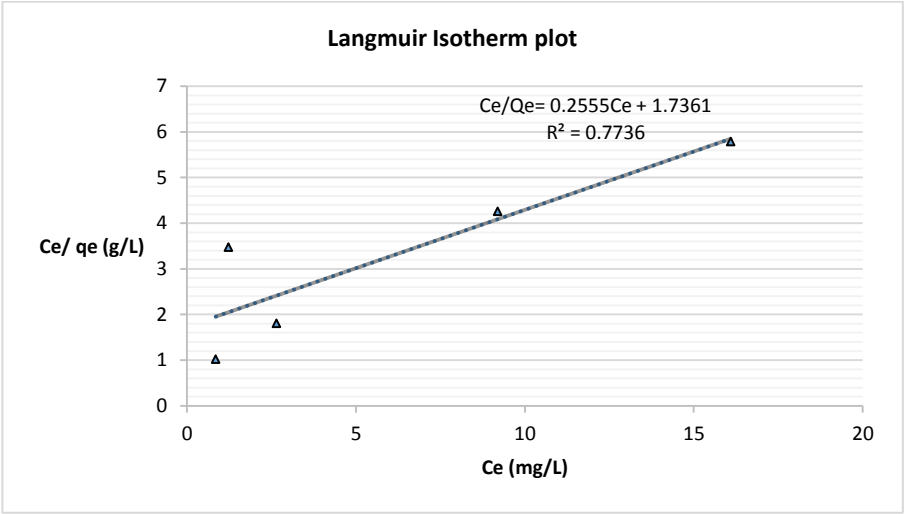


Figure 8: Langmuir isotherm plot for the adsorption of Fe (II) ions onto durian leaves

It is proved that the adsorption data obtained can confirm well to both Freundlich and Langmuir isotherm models. However, the data tend to fit better towards a Langmuir Isotherm model as the correlation coefficient plotted using this model (0.7736) is much closer towards unity.

Table 2: Isotherm parameters for Freundlich and Langmuir Isotherms

Freundlich isotherm			Langmuir isotherm		
q_m (mg/g)	K_L	R^2	K_F (mg/g)	n	R^2
3.914	0.1472	0.7736	1.6203	1.788	0.7397

Table 3 Comparison of Fe(II) ions removal by different adsorbents

Adsorbent	**q_m**	**Reference**
Durian leaves	3.9140 mg/g	Current study
Granular activated carbon	3.6010 mg/g	Josoh et.al., 2005
Cucumis Melo Rind	4.9800 mg/g	Othman, N. and Asharuddin, S.M. 2013

Josoh, et al. (2005) who studied the adsorption of iron onto granular activated carbon also obtained a similar type data. Cucumis melo rind is used by (Othman and Asharuddin 2013) to remove Fe(II) ion at a maximum capacity of 4.98 mg/g. All those above researches had come up with the suggestion of using the Langmuir model for graphical modulation of form removal process through adsorption.

CONCLUSION

The result obtained from this study showed that the removal of Fe (II) ions from solution is highly influenced and affected by pH of the solution, contact time and initial metal ion concentration, mixing rate and the particle size of adsorbent. Equilibrium is reached at the 60^{th} minute of batch mixing process and the optimum pH for adsorption is found to be pH 6. The increase in contact time and a decrease in Fe (II) ion concentration tends to increase the rate of removal of Fe (II) ion. The optimum concentration is thus considered to be 5 mg/L.

The equilibrium data adjusted well with the Langmuir isotherm model by giving out a correlation coefficient of 0.7736. This indicates that a monolayer pattern is followed by the adsorption mechanism of Fe (II) ion onto durian leaves. The maximum adsorption capacity determined using the Langmuir isotherm model is 3.914 mg/g. The characterization of this process proves that durian leave has high potential to be used as an alternative bio adsorbent for Fe (II) ion removal in aqueous solution through the adsorption mechanism since it is effective, cost saving, abundant in amount, and can be obtained easily.

REFERENCES

Ahluwalia, S., and Goya, D. (2005). Removal of Heavy Metals by Waste Tea Leaves from Aqueous Solution. *Engineering in in Life Sciences, 5*, 2

Ashtoukhy, E.S., Amin, N., and Abdelwahab, O. (2008). Removal of lead(II) and Copper(II) from Aqueous Solution using Pomogranate Peel as a New Adsorbent. *Desalination 223* 162-173.

Abdel-Ghani, N. Hefny, M. and El-Chaghaby, G. (2007). Removal of Lead from Aqueous Solution using Low Cost Abundantly available resources. *Int. J. Environ. Sci. Tech, 4 (1),* 67-73.

Amuda, O. Giwa, A. and Bello L.(2007). Removal of Heavy Metal from Industrial Wastewater Using Modified Activated Coconut Shell Carbon. *Biochemical Engineering journal,*Article in Press

Anusha, D.G., and RajaMurugadoss, D.J. (2014). Adsorption of Iron from Aqueous Solution Using Almond Shell as Adsorbent. *International Journal of Scientific Research, 3,* 10.

Benhima, H., Chiban, M., Sinan, F., Seta P., and Persin, M. (2008). Removal of lead and Cadmium ions from Aqueous Solution by Adsorption onto Micro-Particles of Dry Plants. *Colloids and Surfaces B: Biointerfaces 61*, 10-16.

Bhattacharyya, K.G., and Sharma, A. (2004). Adsorption of Pb(II) from Aqueous Solution by Azadirachta Indica (Neem) leaf Powder. *Journal of Hazardous Materials B113,* 97-109.

Chaturvedi, S., and Dave, O.N. (2012). Removal of Iron for Safe Drinking Water Desalination.*1st international journal of the science and technology of desalinating and water purification V 303.*

Goyal, P., Sharma, P., Srivastava S., and Srivastava M. (2008). Saraca Indica leaf Powder for Decontamination of Pb: Removal, Recovery, Adsorbent Characterization and Equilibrium Modelling. *Environmental Science Technology, 5(1),* 27-34.

Josoh, A., W. Cheng, W. Low, A., Nora'aini and Noor M. M. (2005). Study on the Removal of Iron and Manganese from Groundwater by Granular Activated Carbon. *Desalination 182,* 347-353.

Kadir, A.A. Abdullah, A. and Wai, L.K.(2013): Study on Ferum (Fe) and Zinc (Zn) Removal by Using Rice Bran at Sungai Pelepah, Kota Tinggi, Johor. *Universiti Hussein Onn.*

Li, W., Zhang, L., Peng, J., Li, N., Zhang, S. and Guo, S. (2008). Tobacco Stems As low Cost Adsorbent for the Removal of Pb(II) from Wastewater: *Equilibrium and Kinetic Studies. Industrial Crops and Products 28,* 295-302.

Othman N. and Asharuddin S.M.(2013). Cucumis Melo Rind as Biosorbent to Remove Fe(II) and mn(II) from Synthetic Groundwater Solution. *Advanced material research, 795*, 266-271.

Yasemin, B., and Zeki,T. (2007). Removal of Heavy Metals from Aqeous Solution by Sawdust Adsorption. *Journal of Environmental Sciences,* 160-166.

Zayadi, N. and Othman, N.(2013). Removal of Zinc and Ferum Ions Using Tilapia Mossambica Fish scale. *International Journal of Integrated Engineering, 5*., 23-29.

THE CHALLENGES IN IMPLEMENTING BUILDING INFORMATION MODEL (BIM) FOR SME'S CONTRACTOR IN THE CONSTRUCTION INDUSTRY

Khairul Firdaus Anuar[1] and Mohd Hezriq Idzuwan Zainal Abidin[2]
[1] Research Associate, I-Geo Disaster Research Centre
[1,2]Department of Civil Engineering, Faculty of Engineering and Technology Infrastructure, Infrastructure University Kuala Lumpur (IUKL)

ABSTRACT

Building Information Modelling (BIM) is a technology that is currently gaining momentum within the construction industry as interoperability issue is becoming more and more important in relative to the quality and productivity of the industry. BIM is defined as a modelling technology and associated set of processes to produce, communicate, and analyse building models throughout the entire project's lifecycle. Although there is bound of benefits that gained from the BIM application, the SME's contractor still reluctant to deploy the technology in delivering its services. The objectives set out in this research are to examine issues and challenges faced by SME's in adopting BIM in construction industry; to determine the potential solution in implementing BIM for SME's contractor; and to identify the advantages of how BIM can give a good impact on productivity in the construction industry. The methodology adopted for this research was quantitative method using the questionnaire survey. Convenience sampling was used where the respondents were recommended by experts and SME's contractor company/firm. The results concluded that: for the issues and challenges, the cost to implement BIM in a company where the highest rank scored, and for the potential solution, the government should provide awareness and motivation programme has been chosen by the respondents to be a top solution. And last for the advantages, the respondents agree that improved cost estimating at each project stage was the best advantages. It was found that BIM can be made an optional or a compulsory subject in the architecture, engineering and construction education curriculum for all undergraduate architecture, engineering and construction students before they go abroad into the world of the construction industry.

Keywords:
Building Information Model (BIM), Issues and Challenges, Potential Solution, Advantages, Construction Industry.

INTRODUCTION

Building Information Modelling (BIM) is one of the new technologies that in the developing process, it is applied to design, construction and management. It is like all the construction data will be in digital format. This technology is actually has been utilized in many advanced countries to guarantee their construction industries efficiently receive the utilization of the BIM as the construction work devices in the construction process. (Harris M. I, 2014). The important features of BIM are that it provides an object-oriented database that is made up of intelligent objects, the 3D representation of integrated information, and a relational database that is interconnected (CIDB, n.d). BIM is the practice of the methodology which conveys the principles to stand the view of accessibility in data about the cycle of the construction process. BIM has created to meet the client needs by view the visual of building design and building

estimation before the construction starts. The advancement of BIM in Malaysia only generated by private sectors since 2009 and the National cancer institute (NCI) is the first government project using BIM in the year of 2010. According to CIDB Malaysia (2014) stated that by knowing the importance of BIM in construction industry, that board will give and supply the knowledge about to manage the BIM so that it can survive and flourish. Early steps that CIDB was make is the provide awareness program and workshops to get the feedback and remark went to graphing path for big and bigger implementation of BIM.

LITERATURE REVIEW

The construction industry is one of the mainstays of a country's economic growth. It is not wrong to state that a country's construction zone can be used as an indicator to estimate that country's economic performance. Different people may hold different views, but when a country's economic statistics are heading downwards, the government's 'stimulus package' for the economy frequently comprises extensive allocation for the construction industry (Richard, 2003). As stated by Michel et. Al (2000), the role of IT in most industrial areas has changed impressively in the course of recent year. Building practitioners use IT to reproduce, break down and assess the expected execution of the luxury plan, the outline of the pleasantries' conveyance procedure and the configuration of associations in completing the procedures. Computer vision is a technology that spotlights on giving computers the qualities of the capacity of human vision. It can be utilized as a part of the definition of 3D objects from 2D images. An image is consequently checked and work in advancement can be measured. Case in point, it is conceivable to outwardly quantify the construction process of a superstructure, while some different parts of measuring advancement can't be completely mechanized. Along these lines, the utilization of a computer vision system is to help the task of project management to some degree (Zhang et al., 2009). This study characterizes SMEs uniquely in contrast to prior investigations of construction or different industries. Typically, researchers characterize SMEs by the quantity of workers or aggregate resources (Norris, 1984). In any case, this definition is not practical in the Malaysian construction industry. Therefore, construction companies once in a while have the quantity of workers and resources that match their task volume. As revealed by CIDB (n.d), BIM reduces risks of cost and time over-runs, enhances safety and improves competitiveness for contractors. Risk of rework is significantly reduced, thus resulting in increased profit.

METHODOLOGY

Methodology Flowchart

This study provides the essentials of what are the challenges in implementing building information modelling (BIM) for SME's contractor in the construction industry. The first chapter is the introduction of the research, which includes the problem statement, aim and objectives, scope of the study and research methodology used for this study. The second and third chapter is based on secondary data. A literature review was used and it focuses on the overview of BIM application, SME's classification and construction industry in Malaysia. The third chapter continues with the literature review, but this chapter focuses on efforts made to improve the participation of SME's contractor with the BIM. The Research Methodology lays down the methods used for this research.

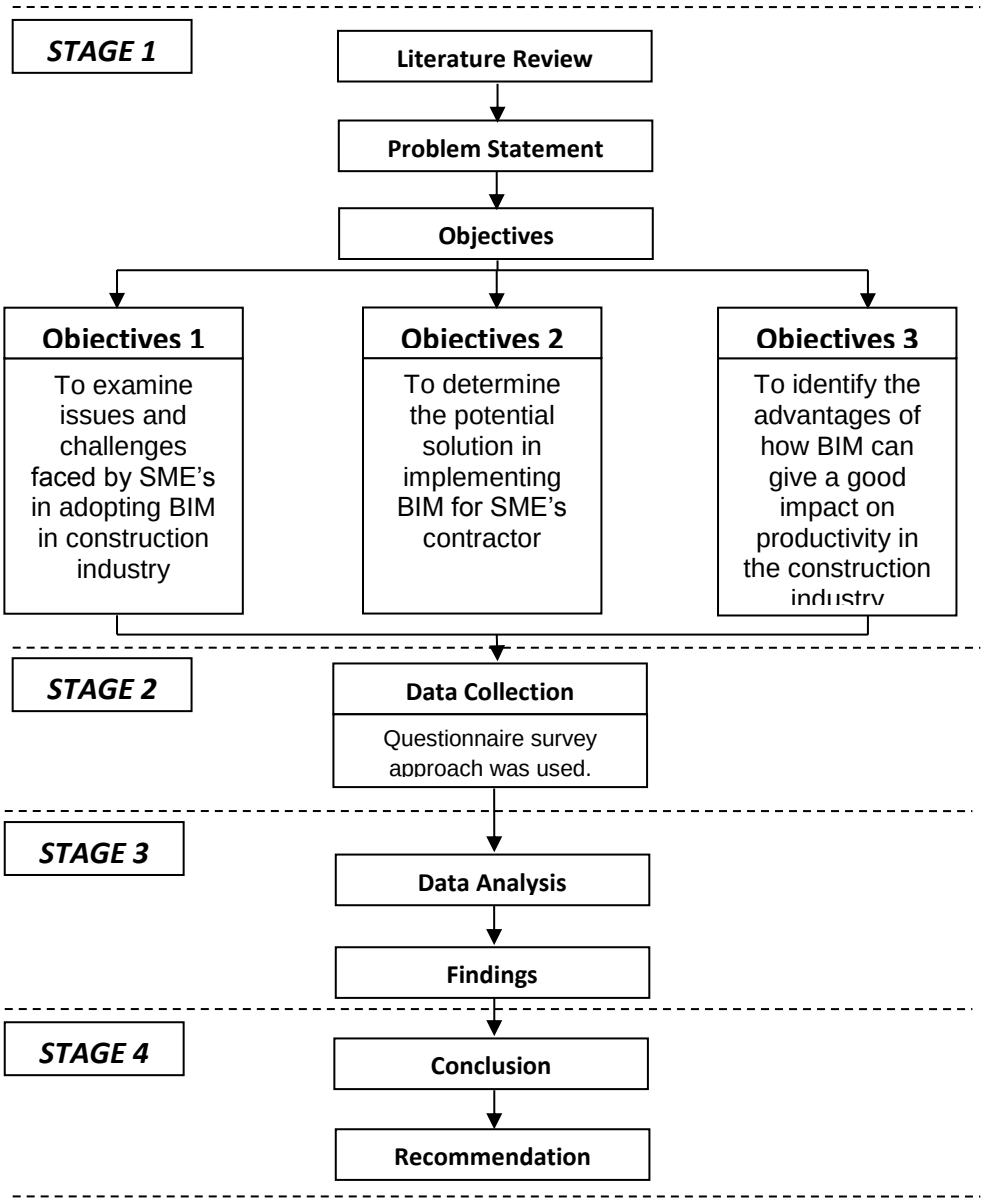


Figure 1: Research Process

Literature Review

The literature review is used as a secondary resource for gathering information about past research that has been done to identify what are the what are the challenges in implementing Building Information Modelling (BIM) for SME's contractor in the construction industry,

Questionnaires

The survey was conducted in December 2015 and convenience samplings were used due to limited time and sources of funding. In total 60 sets of questionnaires were distributed to the relevant party of construction project participants. The target respondents were based on recommendation from experts and industry players. In total 60 sets of questionnaire survey were distributed. Only 48 sets of replies and returned to complete questionnaire form by the respondents. From the survey, 48 responses were successfully obtained a giving rate of 80%.

4.0 RESULTS AND DISCUSSION

The first part of the analysis concentrates on analysing the data obtained by questionnaires. From the result of the questionnaires, the construction industry is dominated by male workers rather than female workers. This is a norm for the construction industry. The majority of the respondents has not more than 5 years' experience. The majority of the respondents work for a contractor firm and mostly involved in public projects. Sixty six (66%) of the respondent strongly agrees that the cost to implement BIM in the company is too high. Based on the percentage done on the first section that is to determine the cause of challenge in implementing BIM in company for SME's contractor. The remaining variables are rated neutral from the respondents. The highest ranked challenge is that the cost to implement BIM in the company is too high. And the lowest ranked challenge is readiness to change from traditional to BIM requires high cost of investment, clear Consensus as how to implement and use BIM. Moving on to the second objective that is to identify potential solution in implementing BIM for SME's contractor, the percentage shows that respondents agreed all the solutions are important. The highest ranked is important that the government should provide awareness and motivation programme. On the other hand the lowest ranked is the development of a CIDB portal to gain information about the BIM. Lastly, the third objective is to identify the advantages of how BIM can give a good impact on productivity in the construction industry the highest ranked for advantages of BIM is improved cost estimating at each project stage and the lowest ranked is increased speed of delivering projects.

4.1 Issues and Challenges Faced by SME's in Adopting BIM in Construction Industry

Tables 4.1 display the overall results of the survey on issues and challenges faced by SME's in adopting BIM in construction industry.

Table 4.1: Issues and Challenges faces with SME's (by ranking)

Issues and Challenges	**Frequency**						**Mean**	**Level of agree**	**Ranking**
	1	**2**	**3**	**4**	**5**	**Total**			
The cost to implement BIM in the company is too high.	0	0	2	14	32	48	4.63	Strongly Agree	1
The SME's contractors do not have the technology (hardware and software) and	0	0	4	18	26	48	4.46	Agree	2

capability to implement BIM.									
BIM is a new tool that many have little or no knowledge about it.	0	0	0	28	20	48	4.42	Agree	3
The in-house technical staff are not ready to be trained	0	0	4	20	24	48	4.42	Agree	4
Readiness to change from traditional to BIM requires high cost of investment, clear Consensus as how to implement and use BIM.	0	0	3	26	19	48	4.33	Agree	5

According to the table 4.1 above, shows the cost to implement BIM in the company is too high scored highest mean (4.63) followed by the SME's contractors do not have the technology (hardware and software) and capability to implement BIM scored second highest mean (4.46), BIM is a new tool or process that many have little or no knowledge about it and the in-house technical staff are not ready to be trained scored third highest mean (4.42). Readiness to change from traditional to BIM requires high cost of investment, and the clear consensus as how to implement and use BIM (mean 4.33) were found with a lower mean score.

Therefore, to implement BIM among SME's contractor, were found that, all issues and challenges listed based on strongly agree to strongly disagree it able to become the issues and challenges to against in implement BIM, to provide understanding for construction players regarding BIM knowledge and to explore the potential solution regarding the issues and challenges.

All results obtained, it able to describe that, the issues and challenges to implement BIM among SME's contractor indicated the government and CIDB should help and assist the SME's contractor to understand the BIM. Financial problem also was vital to become the biggest challenges to implement BIM. Therefore, all issues and challenges to implement BIM among SME's in the construction industry, it able to identify what are the solution to make. It also shows that all issues and challenges are important towards achieving aimed in order to improve and enhance implementation of BIM among SME's contractor in the construction industry.

However, it was believed that the data produce by respondents in line with the issues and challenges faces by the SME's contractor to implement BIM in construction industry where quality data that able to provide and grant indication on issues and challenges faces by SME's accordingly.

4.2 Potential Solution in Implementing BIM for SME's Contractor

Table 4.2 displays the results of the survey on the level of potential solution in implementing BIM for SME's contractor.

Table 4.2: Rank order of importance: Potential Solution in Implementing BIM

Potential Solution	Frequency						Mean	Level of Important	Ranking
	1	2	3	4	5	Total			
Is it important that the government should provide awareness and motivation programme?	0	0	5	15	28	48	4.48	Important	1
Provide additional training necessary to use BIM tools	0	2	4	12	30	48	4.46	Important	2
The system of certification and accreditation of qualified BIM contractors that have undertaken training.	0	0	6	20	22	48	4.33	Important	3
Providing initial support in the form of establishing 'One Stop BIM Technology Centre' for SMEs	2	1	7	14	24	48	4.13	Important	4
The development of the CIDB portal to gain information about the BIM.	0	3	5	25	15	48	4.08	Important	5
BIM should have a standard code of practices and guideline	0	8	5	17	18	48	3.94	Important	6

Based on this table above, the results indicate that the government should provide awareness and motivation programme scored highest mean (4.48). The government must play a role as a party that's responsible to make sure all the SME's contractors aware and motivated regarding BIM. Without this awareness and motivation, SME's contractors would ignore about the BIM, and this getting worse since the government itself wants all the projects in Malaysia have to use BIM by the year 2016.

Followed by providing additional training necessary to use BIM tools (mean 4.46), definitely, this approach is considered as important for SME's contractors to familiar with the

BIM. With the training SME's contractors easily to understand how to operate BIM, since BIM consists 5D systems, they're so many tools have to practice and study. It also indicated System of certification and accreditation of qualified BIM contractors that have undertaken training (mean 4.33); Providing initial support in the form of establishing 'One Stop BIM Technology Centre' for SMEs (mean 4.13); the development of a CIDB portal to gain information about the BIM (mean 4.08); and BIM should have a standard code of practices and guideline scored lowest mean (3.94). On the other hands, all the potential solutions are important to encouraging SME's contractors to use BIM for their projects.

4.3 The Advantages of How BIM Can Give a Good Impact on Productivity in the Construction Industry

Table 4.3 illustrates the overall results on the advantages of the advantages of how BIM can give a good impact on productivity in the construction industry.

Table 4.3: Advantages of BIM (by ranking)

The Advantages	Frequency						Mean	Level of Important	Ranking
	1	2	3	4	5	Total			
Improved cost estimating at each project stage	0	0	6	10	32	48	4.54	Agree	1
Improved productivity of the estimator in quantity take-off	0	2	6	17	25	48	4.48	Agree	2
Reduced overall project duration	0	0	4	18	26	48	4.46	Agree	3
Improved management of project schedule milestones	0	0	3	21	24	48	4.44	Agree	4
Reduced overall project cost	0	4	3	19	22	48	4.23	Agree	5
Improved design quality	0	0	9	20	19	48	4.21	Agree	6
Reduced redesign issues	0	3	5	25	15	48	4.08	Agree	7
Increased speed of delivering projects	2	3	5	19	19	48	4.04	Agree	8

According to table 4.3 above, result highlights, eight (8) variables on this advantage were classified in high level band (range mean value 4.04 to 4.54). Improved cost estimating at each project stage scored the highest mean (4.54), this followed by the second highest mean (4.48) which is improved productivity of the estimator in quantity take-off. While, reduced overall project duration scored the third highest mean (4.46). By using BIM overall project duration can be reduced when it has all in one system.

5.0 CONCLUSION

The research was conducted with the aim to identify what are the issues and challenges in implementing BIM for SME's contractor in the construction industry. Three objectives were outlined in order to achieve aim of the research.

5.1 To examine issues and challenges faced by SME's in adopting BIM in construction industry.

The following are the issues and challenges faced by SME's in adopting BIM in construction industry.

Issues and Challenges

a) The cost to implement BIM in the company is too high (4.63)
b) The SME's contractors do not have the technology (hardware and software) and capability to implement BIM (4.46)
c) BIM is a new tool that many have little or no knowledge about it. (4.42)
d) The in-house technical staff are not ready to be trained (4.42)
e) Readiness to change from traditional to BIM requires high cost of investment, clear Consensus as how to implement and use BIM (4.33)
f) Do you agree that BIM is the "future of project information management"? (4.08)

It is believed that the results from findings on issues and challenges were able to provide an indication and backbone on this research.

5.2 To determine the potential solution in implementing BIM for SME's contractor.

The potential solution is important to ensure SME's contractor do not leave behind from this new technology, with these solutions they can be guided and monitored how to use and implement BIM to their company without having issues. As a result, the government should play an important role to achieve what their wants for the construction industry in the future.

The following are the important solution in descending order:

Potential Solution

a) Government should provide awareness and motivation programme (4.48)
b) Provide additional training necessary to use BIM tools (4.46)
c) The system of certification and accreditation of qualified BIM contractors that have undertaken training (4.33)

d) Providing initial support in the form of establishing 'One Stop BIM Technology Centre' for SME's (4.13)
e) The development of the CIDB portal to gain information about the BIM (4.08)
f) BIM should have a standard code of practices and guideline (3.94)

5.3 To identify the advantages of how BIM can give a good impact on productivity in the construction industry.

Based on literature review, BIM is also known as an emerging technologies to be deployed in the planning, design and facility management and which can be used to improve performances and productivities of construction players, which are client, consultants, and contractor in designing projects, construction, operation and maintenance process. BIM has improved design management tools in the AEC industry from 2-dimensional (2D) to 3-dimensional (3D), 4-dimensional (4D) and 5-dimensional (5D) in order to increase accuracy of project design and detect design clashes. The ability of BIM in managing construction projects has reduced construction problems, project delay, construction cost overrun, and disputes among construction players. It believes there are the advantages in BIM that can change the traditional system of the construction process.

The following are the advantages of BIM in descending order:

a) Improved cost estimating at each project stage (4.54)
b) Improved productivity of the estimator in quantity take-off (4.48)
c) Reduced overall project duration (4.46)
d) Improved management of project schedule milestones (4.44)
e) Reduced overall project cost (4.23)
f) Improved design quality (4.21)
g) Reduced redesign issues (4.08)
h) Increased speed of delivering projects (4.04)

6.0 RECOMMENDATIONS

The research has identified recommendations to improve and enhance the participation of SME's contractor using BIM in construction industry. The following are recommendations to improve the participation of SME's contractor using BIM.

1. It is recommended BIM be made an optional or a compulsory subject in the architecture, engineering and construction, education curriculum for all undergraduate architecture, engineering and construction students before they go abroad into the world of the construction industry.
2. The biggest issues and challenges is the cost to implement BIM in company, because of that government should provide some funding to lend only for SME's to implement BIM in their company, with the terms and conditions for example SME's should provide the letter about their project, beside, government also may control and monitor all the SME's under the fund loan.
3. Provide conferences, forum and publish information relating the advantages of how BIM can give a good impact on productivity in the construction industry.

6.1 Recommendations for Future Research

The subject of Building Information Modelling (BIM) is continuously under study. Based on this study, the following could be possible area for further research that may also be beneficial to the industry:

1. To propose alternatives based on the identified benefits and advantages in promoting adoption of BIM.
2. To evaluate the differences between BIM based Project and Non BIM based project through some solid case studies.
3. To conduct a similar research towards the reason and perception of top and middle level management on BIM.
4. To develop a more appropriate system in solving interoperability issue in the context of the local construction industry.

As a final point, it is hoped that this research will advantageous to all parties involved in the construction industry and would stand as a good foundation for future research.

ACKNOWLEDGEMENT

The author of this research paper would like to thank the Department of Civil Engineering, Faculty of Engineering and Technology Infrastructure, Infrastructure University, Kuala Lumpur (IUKL) and the 48 numbers of relevant parties of construction project participants for the support and guidance in completing this research study.

REFERENCES

CIDB (2007). *Executive Summary Construction Industry Master Plan Malaysia 2006 – 2015*.Retrieved on September 28th, 2010 from http:// www.cream.com.my/publications/cimp.pdf

CIDB (n.d). *Building Information Modelling brochure*. Bahagian IT Pembinaan. Kuala Lumpur.

Michel C, Mieaust Ali J, Fieaust M, Asce (2000). *Collaboration and integration of project life cycle design information using IT system.* In: International Conference on Construction Information Technology (INCITE). Hong Kong.

Norris, K (1984). *Small Building firms: Their origins, characteristics and development needs*: Chartered Institute of Building.

Richard J.C. (2003). *Multistep Disputes Resolution in Design & Construction industry*. Journal of professional Issue in Engineering Education & Practice@ ASC.

Zhang X, Bakis N, Lukins TC, Ibrahim YM, W u S, Kagioglou M, Aouad G, Kaka AP, Trucco E (2009). *Automating progress measurement of construction projects. Autom. Constr. 18(3):294-30.*

PERFORMANCE ANALYSIS OF PID CONTROLLER FOR THREE-PHASE INVERTER FED INDUCTION MOTOR

Kuan Lee Choo[1] and Dianarita Devi Arthumunathan[2]
[1&2]*Faculty of Engineering & Technology Infrastructure, Infrastructure University Kuala Lumpur*

ABSTRACT
This paper presents the study of proportional integral derivative controller (PID controller) for three-phase inverter fed induction motor. The PID controller is proposed due to its simplicity in term of the control structure and it is easy to design. The simulation result shows that the PID controller is able to control the switching signals to the three-phase inverter so that the induction motor can track the reference speed. Then the characteristics of the induction motor response are compared with a PI controller done by Madhavi L. Mhaisgawali, 2013. The proposed PID controller for three-phase inverter fed induction motor is able to track the reference speed and achieve the steady-state value faster than the one using PI controller. The speed control is essential to maintain the performance and efficiency of an induction motor and therefore avoid damage of the induction motor.

Keywords:
Three-phase Induction Motor, PID Controller, Three-phase Inverter, Pulse Width Modulation.

INTRODUCTION

Currently, the three-phase induction motor has a vital role and also widely used in industrial application. The development of high performance induction motor is very important in industrial as well as other purpose application. For example when the speed of the rotor shaft inside the generator is high and it has to be controlled within a certain period of time, so then the speed controller is able to control the switching signals to the three-phase inverter to control the speed of the rotor shaft. Two types of control methods used in motor control system such as the proportional integral (PI) controller and also the Proportional, integral and derivative (PID) controller. However, PI controller is unable to provide the desired control performance for more complex system such as induction motor where there exist of variable-frequency, harmonically optimum converter power supplies and the presence of harmonic. The disadvantage of adjusting the proportional and integral gains is very costly and it consumes a lot of time for a high speed control system. In addition it also cannot predict the error in future time. The error can only be solved by introducing the derivative gain.

This paper proposes the PID controller to control the velocity of the three-phase induction motor. PID controller consists of all the necessary dynamics such as the derivative, integral and proportional. The (P) Proportional gain eliminates oscillations which improve the rise time. The integral (I) gain increases the control signal which leads to zero error in the system or eliminates steady state error. The derivative (D) gain gives a fast reaction change of the controller input and also improves overshoot.

SYSTEM DESCRIPTION OF THE PROPOSED DESIGN

Overall Block Diagram of the Proposed Design

Figure 1 show the overall block diagram of the proposed design, where the DC voltage source is supplying a DC voltage of 400V to the three-phase inverter. Pulse-width modulation (PWM) technique is used to generate switching signal to the insulated gate bipolar transistors (IGBTs) of the three-phase inverter. The six number of IGBTs in the three-phase inverter are all of same rating and they are two complementary switch pairs in each phase in which only one of the switches in a pair will turn on each time while the other will be turned off. The PWM switching technique generates the inverter switching command to achieve desired torque at the motor shaft. Three-phase inverters are commonly used to supply three-phase loads; applications such as uninterruptible ac power supplies and ac motor drives. Each phase of the proposed three-phase inverter circuit consists of three legs, each for one phase. Basic one leg inverter is described with the similarity of each inverter leg. Therefore the output voltage from the inverter is independent from the direction of the load current. (Mohan, et al., 1989)

The three-phase stator current Is_a, Is_b and Is_c is measured and feed to the direct current, Id and quadrature current, Iq in stationary reference frame. The motor speed is compared with reference speed and the error produced is sent to the PID controller. (Pedro, N, 2010). The output of the PID controller is the electromagnetic torque. The quadrature stator current component and direct stator current component are converted into current references in stationary reference frame. The current references in stationary frame is converted to the phase current references and fed into the current regulator. The current regulator then processes the output and reference currents to produce the switching gate signals. The DC voltage source supplies voltage around 400V to the IGBTs and the pulse generator sends signal as pulse for the switching to take place and rotate the rotor.

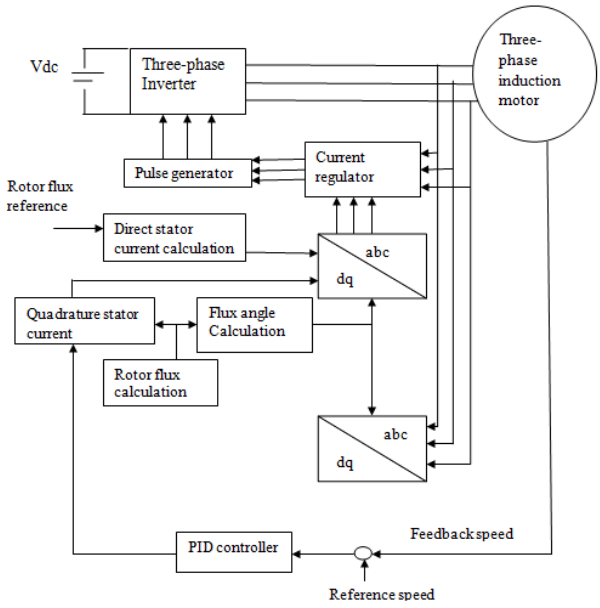


Figure 1: Overall Block Diagram of the Proposed Design

The proposed PID controller uses the same approach by Mhaisgawali, M, 2013 as shown in Figure 2. The mathematical equation for the control signal is as shown in equation 1,

$$u(t) = K_p e(t) + K_i \int e(t)dt + K_d \frac{de(t)}{dt} \quad (1)$$

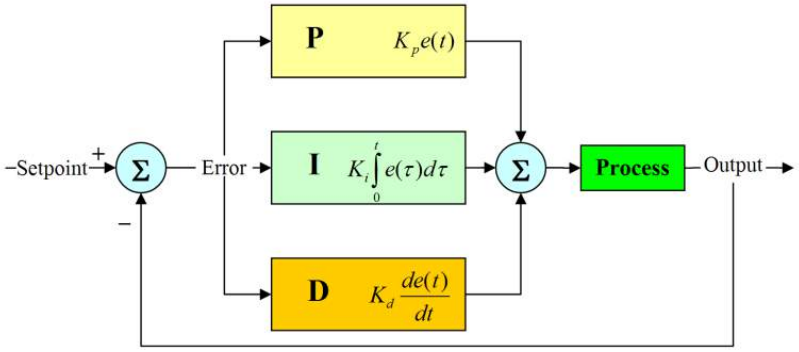


Figure 2: PID Overview (Mhaisgawali, M, 2013)

From equation 1 the error signal, *e* is a variable which tracks the error, and can be obtained by finding the difference between the reference value and the actual output. The error signal is then sent to the PID controller to compute integral and the derivative of the error signal. The control signal, *u* of the plant is the summation of the proportional gain, K_p multiplying with the magnitude of the error, the integral gain, K_i multiply with the integral of the error signal and the derivative gain, K_d multiply with the derivative of the error signal.

METHODOLOGY

SIMULINK Model of the PID controller for Three-Phase Inverter Fed Induction Motor

A complete SIMULINK diagram of the proposed PID controller for three-phase inverter fed induction motor is shown in Figure 3.

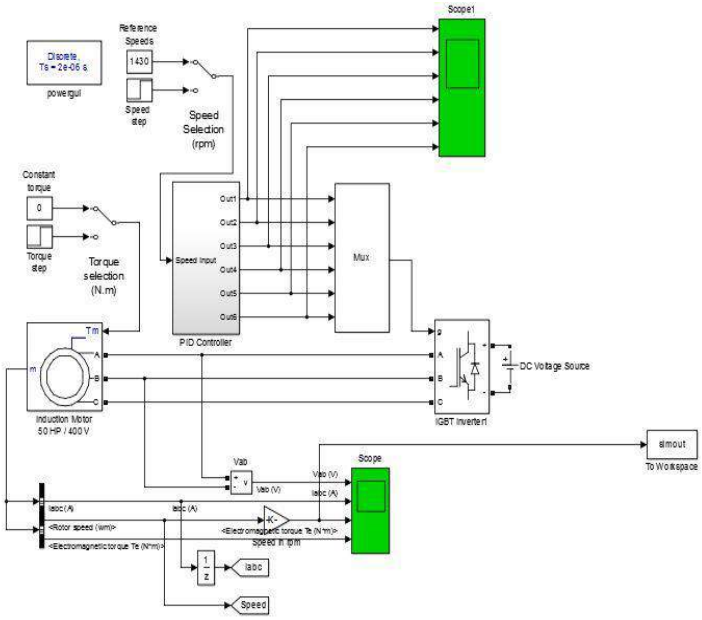


Figure 3: Developed SIMULINK model for the proposed PID controller of Three-Phase Induction Motor

The induction motor stator is fed by the current control of the three-phase IGBT inverter. Hysteris regulator regulates the stator currents and generates the inverter drive signals for the inverter switches to control the induction motor. Quadrature axis current component and the direct axis current component control the motor torque and the motor flux. The three-phase current is converted to into quadrature and direct current. Then, the stator currents were added into multiplexer by applying the mathematical operation using the functional block parameters provided in MATLAB SIMULINK to run the simulation.

The knowledge of the rotor flux magnitude and the rotor flux angle is the key information for the field oriented control of three-phase induction motor.

$$\psi_r = \frac{l_m i_d}{1+\tau_r} \qquad (2)$$

where

ψ_r = rotor flux

i_d = direct current

τ_r = rotor torque

l_m = magnetizing inductance

Equation (2) shows the rotor flux magnitude calculation. The induction motor stator is fed by the present control of the three-phase IGBT inverter. Hysteris controller manages the stator currents and creates the inverter drive signals for the inverter switches to control the induction motor. The stator currents were added into multiplexer by applying the mathematical operation using the functional block parameters provided in MATLAB SIMULINK to run the simulation.

SIMULATION RESULTS AND DISCUSSION

The proposed design is simulated using MATLAB SIMULINK. The velocity reaction of the three-phase induction motor is checked by utilizing the PID controller and compared with the response of the speed for three-phase induction motor utilizing the PI controller by Madhavi L. Mhaisgawali, 2013. Figure 4 shows the results obtained by Madhavi L. Mhaigaswali 2013 where PI controller is used as a speed controller for three-phase inverter fed induction motor.

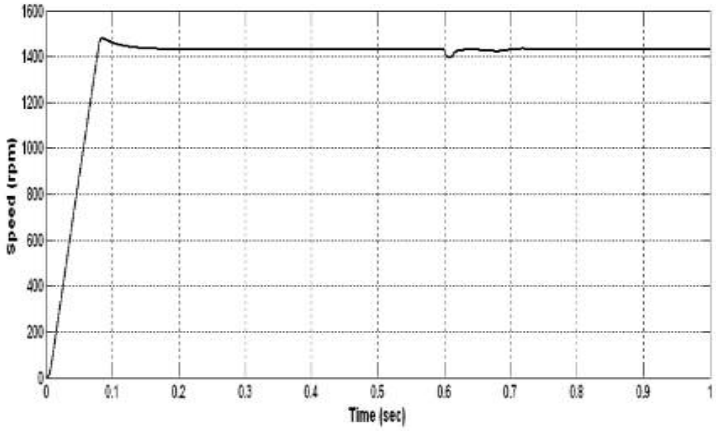


Figure 4: Speed Response of Three-Phase Induction Motor with PI Controller

As can be seen from Figure 4, the speed obtained from the simulation is 1430 rpm and the settling time is 0.269 s with the rise time 0.083 s. The PI controller disposes of the steady-state error and enhances the rise time however it requires longer time to settle to its consistent state value. In addition, the overshoot in the speed response can rapidly damage a motor system. The PID controller contains the derivative which is able to decrease the overshoot in the speed response of the rotor as can be seen in Figure 5.

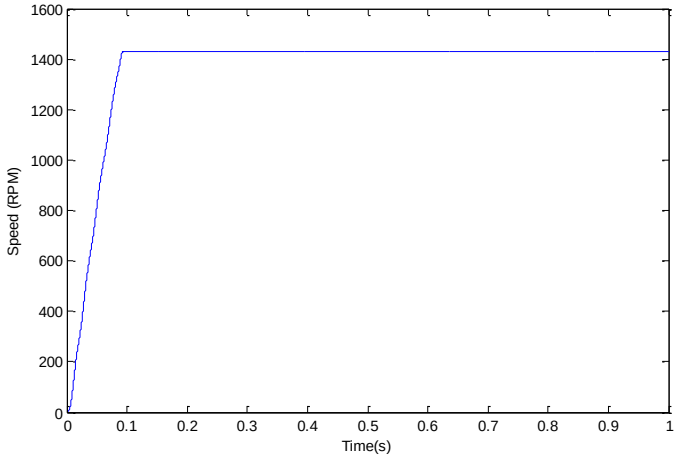


Figure 5: Speed Response of Three-Phase Induction Motor using the PID controller

The speed reaction of the three-phase induction motor utilizing the PID controller gives decrease in rise time, decrease in overshoot and the steady-state error is eliminated. The voltage given for the induction motor is 400V. The Table 1 below demonstrates the comparison of rise time and settling time of three-phase induction motor utilizing PID controller and PI controller.

Table 1: Comparison between PI Controller and PID Controller

Parameters	PI Controller	PID controller
Speed (RPM)	1430	1430
Rise Time(s)	0.083	0.0679
Settling time(s)	0.269	0.0897
Overshoot	Increase	Eliminate

It is observed from Table 1 that the proposed PID controller has better speed response as compared with the PI controller for the three-phase induction motor. The speed of the three-phase induction motor utilizing PID controller has lesser rise time, settling time and overshoot is eliminated.

The feedback of the rotor speed from the three-phase induction motor is given to the PID controller. The output from the PID controller is associated with the current regulator where the motor current tracks the reference current and the genuine motor current inside the hysteresis band. Therefore six pulses are produced to control the switches of three-phase inverter to give three-phase induction motor with its desired magnitude and frequency. In addition to the speed response, the three-phase output voltage from the three-phase inverter is also verified using MATLAB SIMULINK simulation. As can be seen from Figure 6, the three-phase output voltage, i.e., V_{ab}, V_{bc} and V_{ca} have the same magnitude of 400V and are displaced by 120° phase angle. The voltage can be controlled by changing the magnitude of the supply voltages to the stator. The magnitude of the three-phase output voltages are essential to guarantee the induction motor can work under desired condition.

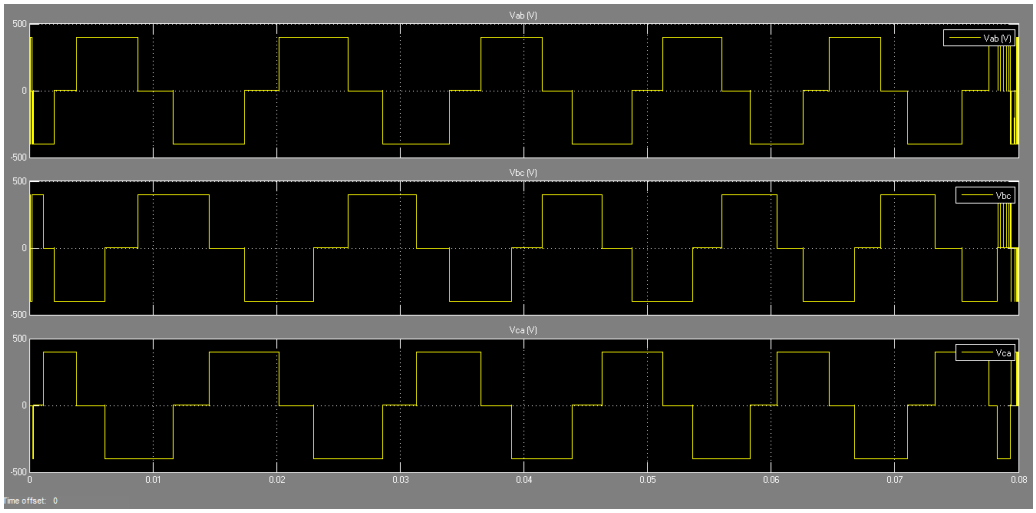


Figure 6: Simulation of voltage for three-phase induction motor

CONCLUSION

The paper proposes a PID controller for three-phase inverter fed induction motor by using MATLAB SIMULINK simulation. The simulation results reveal that the PID controller is able to control the switching signals to the IGBTs of inverter and track the reference speed of the induction motor. The PID controller has better effects compared to the PI controller as a speed controller for the three-phase inverter fed induction motor such that the PID controller has the ability to improve the transient response, eliminate the overshoot and decrease the settling time.

The proposed design is able to enhance the performance and efficiency of the three-phase induction motor. The motor can be damaged if the engine moves in a rapid over the rated speed by the engine itself.

REFERENCES

Mhaisgawali, M. (2013). Induction Motor Speed Control using PID Controller. *International Journal of Technology and Engineering Science*, *1*(2), 151-155.

Mhaisgawali, M. (2013). Speed Control of Induction Motor using PI and PID Controller. *IOSR Journal of Engineering*, *3*(5), 25-30.

Mohan, N., Tore, M., & William, P. (1989). *Power Electronics Converters, Applications and Design* (3rd ed.). USA.

Pedro, N., & Joao, L. (2010, September 4). Development of a Variable Frequency Power Electronics Inverter to Control the Speed of a Three-Phase Induction Motor. *Science Education and Sustainable Development*, *3*(7), 989-995. Retrieved from https://repositorium.sdum.uminho.pt/bitstream/1822/13472/1/7_3_31.pdf

Mohammed, J. (2011). Modelling, Analysis and Speed Control Design Methods of a DC Motor. *English and Technology Journal*, *29*(1), 141-155

ACCURACY OF AUTOMATED GRAIN SIZING (AGS) AT DIFFERENT GROUND SAMPLING DISTANCE

Sulaiman, M.S.[1], Azhari, N.N.[2] and Zainal Abidin, R.[3]
[1,2,3]*I-Geo Disaster Research Centre, Faculty of Engineering and Technology Infrastructure, Infrastructure University Kuala Lumpur*

ABSTRACT
Automated grain sizing technique (AGS) has been widely used to characterize the grain size distribution of particles at channel bed. Although a number of techniques were available as described in the literature, the accuracy of this technique was subject to further validation and verification. The accuracy of AGS technique is hindered due to over-segmentation and pixel resolution of the imaging samples. Another disadvantage / drawback is the distance between pixel centers measured on the ground. This paper discusses the grain size distribution (GSD) using AGS technique taken at different ground sampling distances. The GSD curve from AGS technique was fitted to the conventional curve obtained by sieving and correction factors were proposed to reduce errors between these two techniques. It was observed that different ground sampling distance did not affect the GSD. However, GSD using AGS and conventional sieving showed some variation due to over-segmentation. The use of correction factors gave better results and it was nearly unity between two techniques.

Keywords:
Automated Grain Sizing, Grain Size Distribution, Sieving, River Bed, Bed Material, Correction Factor

INTRODUCTION

Grain size analysis is a common test in geotechnical engineering to determine the relative proportions of the various particle sizes in a given soil sample in the laboratory or in the field. Generally, researchers or practitioners use mechanical sieving or pebble count to determine the grain size distribution (GSD). Although advanced laboratory equipment is being used in the technique it is still time consuming. Fluvial environment research often requires river bed material information for the purposes of obtaining roughness length-scale estimates, sediment transport calculations, geomorphic or aquatic habitat classification and general monitoring (Strom et al., 2010). Nowadays, the process can be expedited by using image-analysis to automatically extract grain-size information from digital images of soil samples at the river bed. Generally, AGS technique can be divided into two; either by extracting grain-size information from digital images of bed samples using the statistical properties of the total image grain texture (e.g: Rubin 2004; Barnard et al., 2007; Buscombe 2008; Buscombe and Masselink 2009) or by locating individual grain boundaries (McEwan et al., 2000; Butler et al., 2001; Sime and Ferguson 2003; Graham et al., 2005a; 2005b; Strom et al., 2010; Graham et al., 2012; Chang and Chung 2012; 2013; Sulaiman et al., 2014). The former assumed that grains within an image are not treated as an individual object, but as a group of textures (Buscombe and Masselink 2009) while the latter implies the use of edge detection and image segmentation principles (Sulaiman et al., 2014).

Critical Remarks

Although AGS technique provides ease to the researcher, the accuracy and reliability of AGS technique is subject to further verification (Sulaiman et al., 2014). There are many factors that hinder the accuracy of AGS technique; over-segmentation, pixel quality, tilting and pixel unit. Pixel unit and over-segmentation were given special attention in this paper and numbers of repetition were made (capturing the image) to elucidate the effect of these drawbacks to the accuracy of AGS technique. The results on GSD for AGS technique is fitted to the conventional mechanical sieving in order to observe the accuracy of AGS technique. GSD from the sieving method was taken as the true value since percentage frequency by weight alleviates the bias towards operator's error. Furthermore, sieving technique is a recommended method and widely used in the field of civil engineering. British Standard BS 1377-2: 1990 Section 9: "Determination of particle size distribution" clearly depicts the use of opening size of sieving pan which is similarly the same with the Wentworth scale. The sieve size (d_s), typically advance of a logarithmic series based on 2 (Bunte and Abt 2002) such that

$$d_s = 2^x \tag{1}$$

where x is usually the bin size in increment of 0.5. The pan size of 20 mm, 14 mm, 10 mm, 6.3 mm, 5 mm, 3.35 mm, 2 mm, 1.18 mm, 0.6 mm, 0.425 mm, 0.3 mm, 0.212 mm, 0.15 mm, 0.063 mm and appropriate receiver were used in accordance with BS 1377-2 to obtain the actual GSD. The aims of this paper are: 1) to test the accuracy of AGS technique compared to conventional sieving; 2) to correct the AGS distribution curve by implementing correction factor.

AUTOMATED GRAIN SIZING TECHNIQUE (AGS)

The analysis of grain size distribution can be divided into two types of approach; mass-based technique and 'counting-based technique. In the mass-based technique the full use of sample weight and the fraction weight of the retaining mass on the sieve pan was considered. However, in the counting-based technique the percentage of frequency of the counted material as previously suggested by Wolman (1954) was calculated. The latter technique of AGS (locating individual grain boundaries) uses the counting-based technique where the intermediate axis of each identified particle are counted. Strom et al. (2010) postulated that imaging technique should encompass 4 major steps, namely 1) obtaining images; 2) image processing; 3) image analysis from available software; 4) obtaining GSD from image analysis. Step-by step application of AGS techniques is shown in Table 1.

Table 1: Execution steps of Automated Grain Sizing (AGS)

Step	Process	Theme	Software / Tool
1.	Image captures using a digital camera (inclusive of physical meter)	Obtaining image	Digital camera
2.	Cropping the preselected image	Image processing	Image J
3.	8-bit image conversion	Image processing	Image J

4.	Median filtering	Image processing	Image J
5.	Binary threshold	Image processing	Image J
6.	Morphological close and watershed	Image processing	Image J
7.	Measure grain; fit ellipse	Image analysis	Image J
8.	Numerical sieving	GSD	Built in program-Igor Pro

Figure 1 shows step-by step execution of AGS graphically using the public domain Image J and Igor Pro software. Previously, practitioners from medicine use the Image J software to count the number of nuclei in a substance and some astrophysicists use Image J to count the stars in the sky. The capability of Image J to identify the edge of an object is crucial as AGS technique acquire the detection of image boundary, thus automatically identify the boundary dimension. The resulting GSD emulates the use of an area-by-number distribution. Thus, it is not comparable to distributions obtained by sieve analysis (Sulaiman et al., 2014). Thus, GSD from AGS technique must be converted using the following equation.

$$n_{ai} = \chi n_i \tag{2}$$

where n_{ai} is the adjusted number of grains in size fraction i after transformation, n_i is the original number of grains in size fraction i, and χ is a transformation function:

$$\chi = e^{\beta' \overline{\Psi_i}} \tag{3}$$

where $\overline{\Psi_i} = (\Psi_i + \Psi_{i+1})/2$ is the mean size in psi units of size fraction i, and $\beta' = \beta ln2$ with β being the transformation coefficient. Using Kellerhals and Bray (1971) (see Table 2), the conversion from area-by-number to a volume-by-weight distribution (sieving) can be obtained by letting $\beta = 2$. This conversion assumes that the cube model is appropriate and that the sieve aperture sizes correspond to the intermediate axis of the measured particles (Sulaiman et al., 2014).

Table 2: Conversion Factor for Particle Size Distribution

Conversion from	Conversion to				
	Volume-by weight	Grid-by number	Grid-by weight	Area-by number	Area-by weight
Volume-by weight	1 0	1 0	D^3 3	$1/D^2$ -2	D 1
Grid-by number	1 0	1 0	D^3 3	$1/D^2$ -2	D 1
Grid-by weight	$1/D^3$ -3	$1/D^3$ -3	1 0	$1/D^5$ -5	$1/D^2$ -2
Area-by number	D^2 2	D^2 2	D^5 5	1 0	D^3 3
Area-by weight	$1/D$ -1	$1/D$ -1	D^2 2	$1/D^3$ -3	1 0

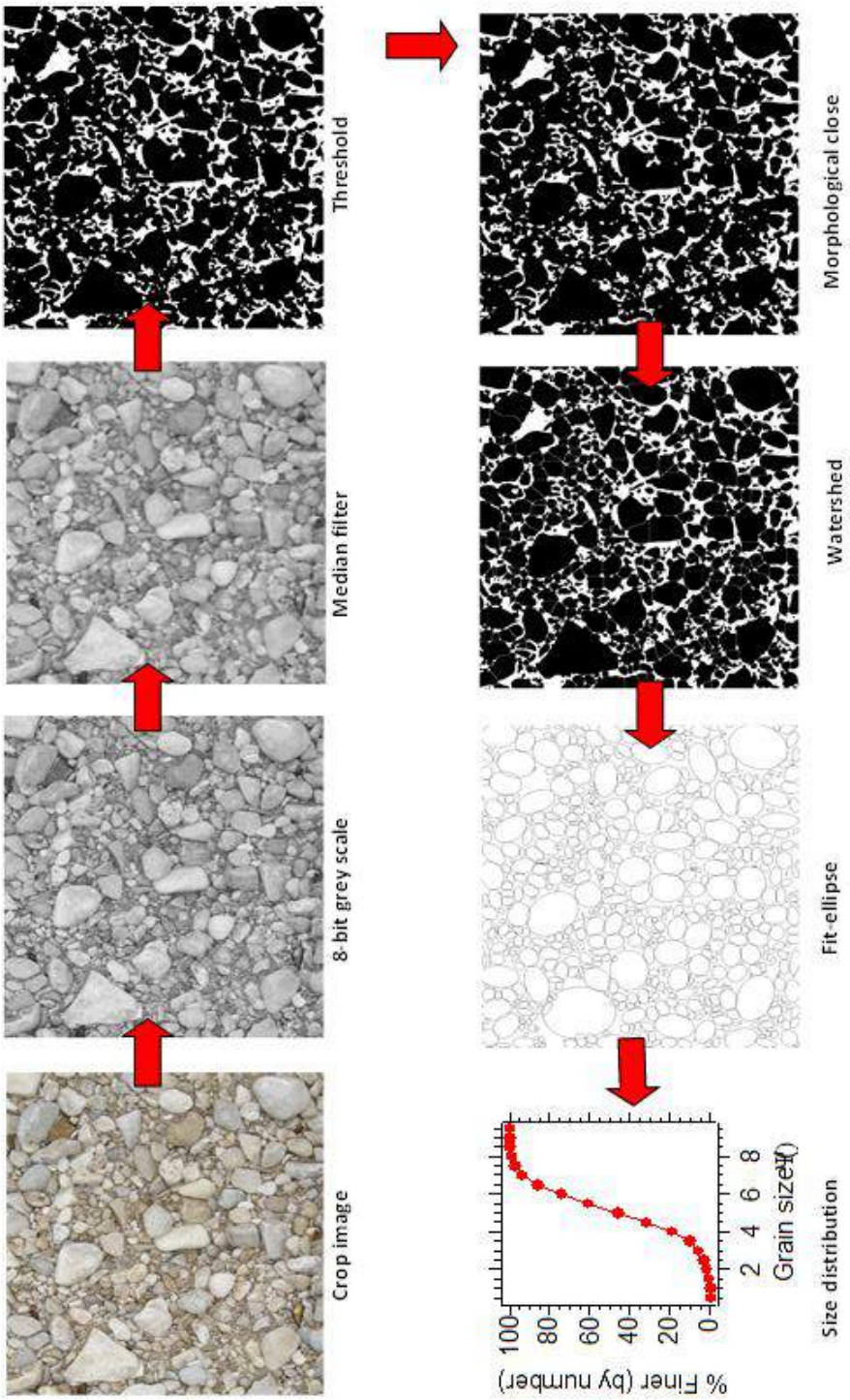


Figure 1: Basic principle of image processing technique

METHODS

The One-to-one plot for GSD by Automated Grain Sizing (AGS) has been found to show the accuracy of the technique as opposed to widely using mechanical sieving. Prior to the development of the GSD, few samples were collected at Sungai Inki, Selangor (see Figure 3), to represent the whole river transect. The samples were taken at 6 different locations from the river transect namely Downstream Left, Downstream Middle, Downstream Right, Upstream Left, Upstream Middle, and Upstream Right. The distances between the upstream and downstream are roughly 100m. Six samples of dates were grabbed to illustrate the variation of GSD across the transect.

Figure 2: Distribution of samples at Sungai Inki, Selangor

The samples were brought to the laboratory for drying at 104 (C for 24 hours, the samples were spread on aluminium trays placed on a level ground and images were captured at a different ground sample distance in the vertical direction (see Figure 3). A meter ruler was placed on the tray to capture the physical scale of image. The digital camera axis were maintained perpendicular to the tray plane to avoid inclination. At each point, the image was taken at 3 different distances in the vertical direction between the camera lens and the sample area, i.e. 2cm, 5cm, and 7 cm (see Figure 4). Each area produced 3 images and each image was processed accordingly.

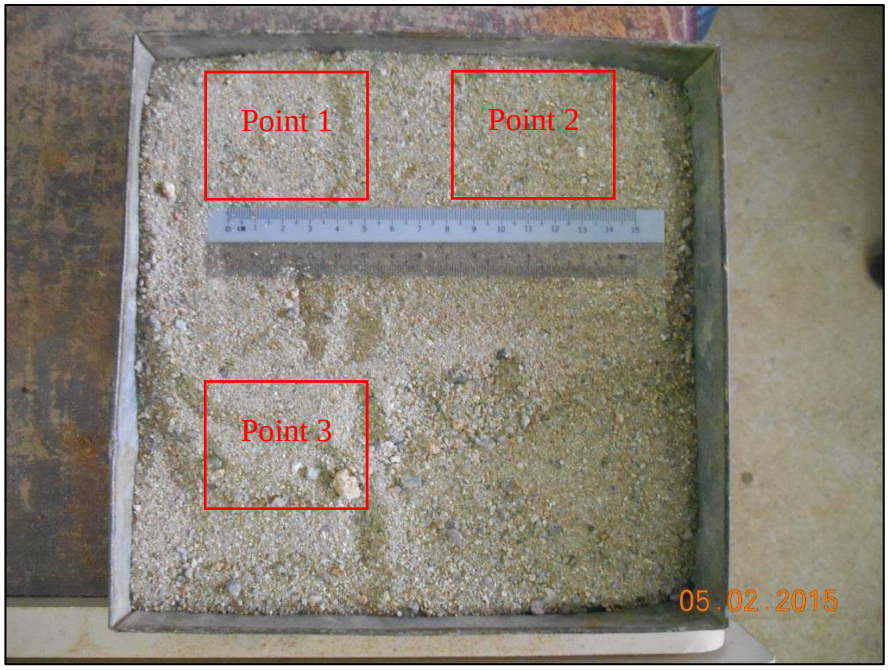
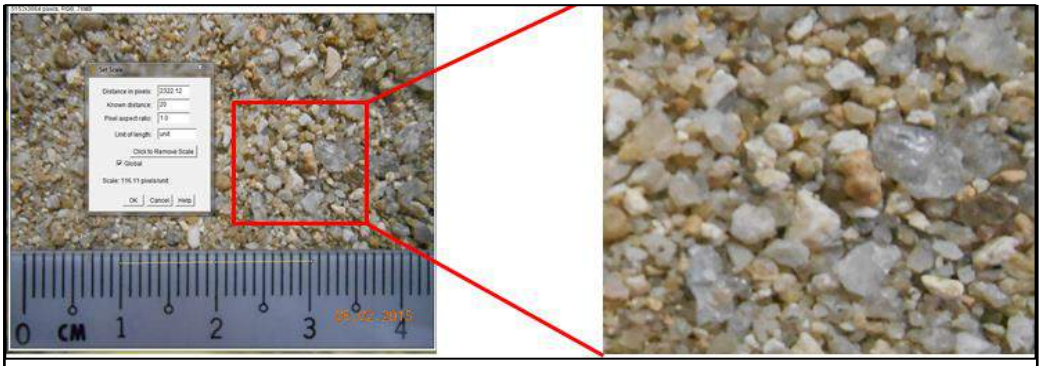


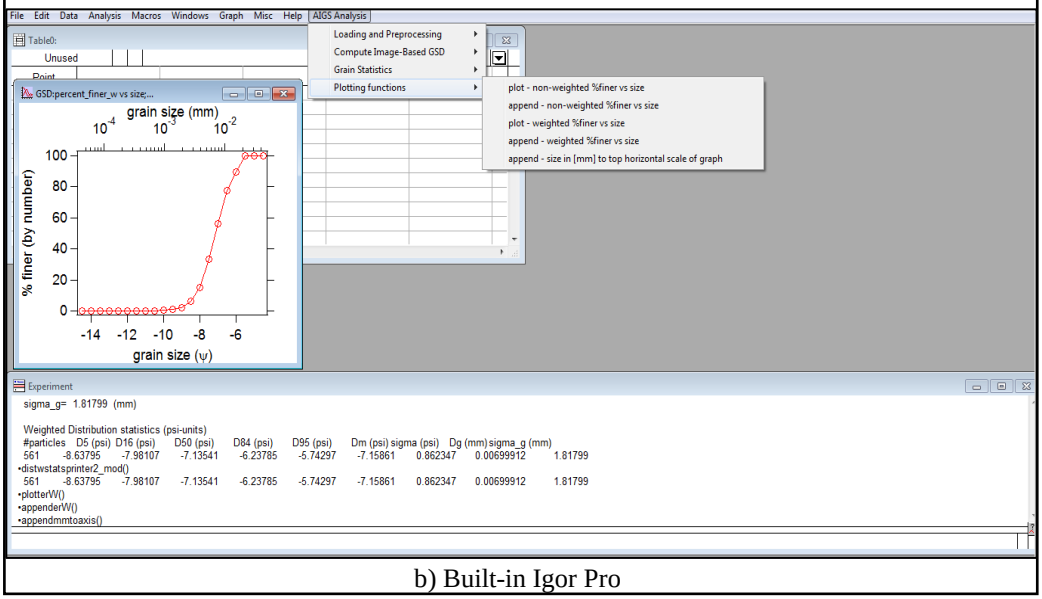
Figure 3: Areal photo of samples

Figure 4: Distance between camera lens and sample

Image J software is used for image processing technique and extracting grain information while the built-in Image J software is used for numerical sieving and creating grain size plot (Figure 5).



a) Image J processing



b) Built-in Igor Pro

Figure 5: Software Modelling and analysis tools

The root mean square error method and also standard deviation will be applied to check the error of GSD graph plotted between AGS and mechanical sieving. The root mean square error or also known as the average of the square of all of the errors can be calculated by (Amaral 2014):

$$RMSE = \sqrt{\frac{\sum (AGS - Conventional)^2}{n}} \tag{4}$$

where *n* is the number of sample data.

RESULTS AND DISCUSSION

The percentage distribution of soil particles from manual sieving and AGS techniques were compared to observe the discrepancy between these two techniques. However, AGS technique is plotted for three different ground sample distance, namely 2 cm, 5cm and 7 cm. These 4 plots of GSD are shown in Figure 6.

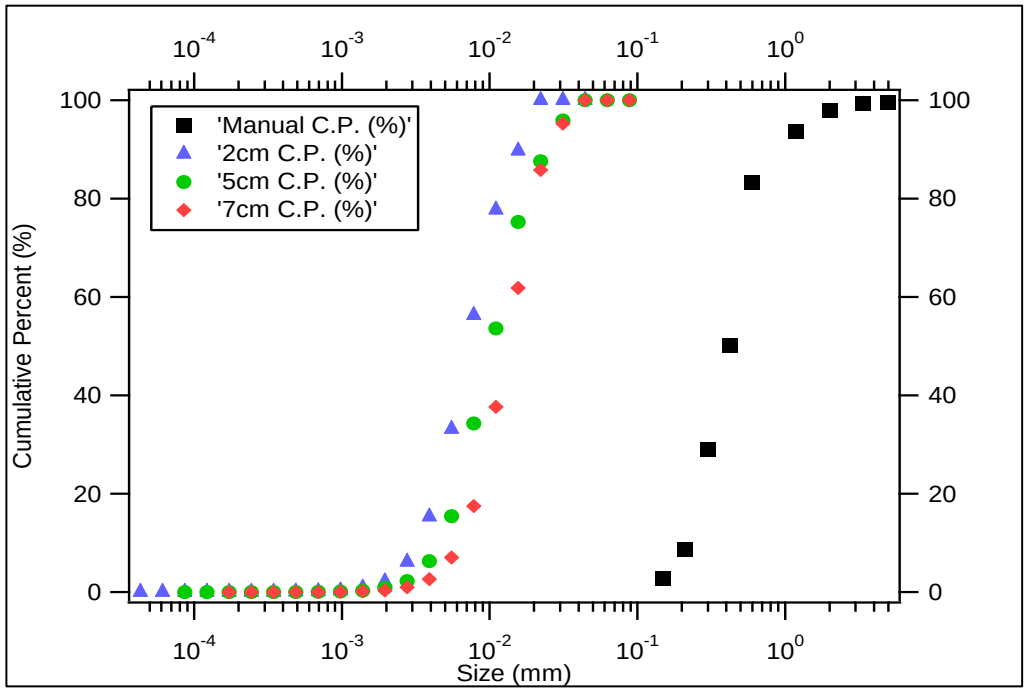


Figure 6: Grain Size Distribution (GSD) for Different Techniques

It can be observed that the discrepancy between different ground sample distances is small. However, AGS technique and mechanical sieving pose a large discrepancy between them. These differences can be perused in Table 3 where standard deviation and root mean square error (RMS) between imaging and mechanical sieving is quite large (>1). Thus, a simple empirical correction factor is introduced to correct these discrepancies so that the RMS and standard deviation is close to 0.

Table 3: Calculated Standard Deviation and RMSE for Downstream Left Point 1

	Manual / AGS			**AGS / AGS**		
	Manual: 2cm	Manual: 5cm	Manual: 7cm	2cm : 5cm	2cm : 7cm	5cm : 7cm
Standard Deviation	9.59	6.26	5.94	0.03	0.04	0.10
Root Mean Square Error	7.93	6.51	5.99	0.82	0.75	0.92

The least square method was employed to find the empirical correction equation for different ground sample distance. The sample of least square technique for ground sample 2 cm is shown below.

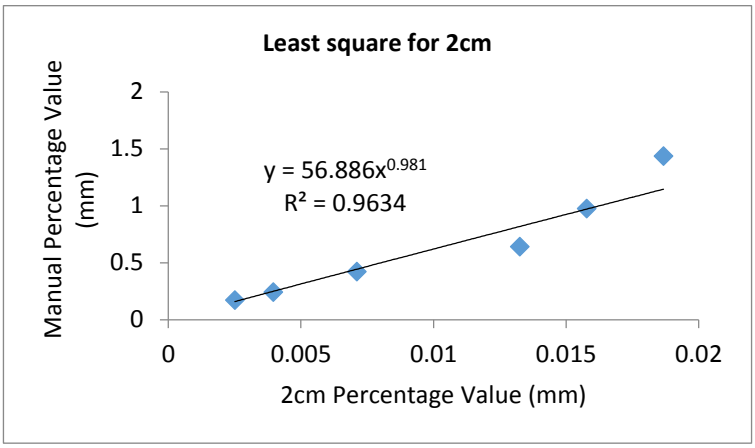


Figure 7: Least Square Technique for Ground Sample 2 cm

Different ground sample distance will have a different correction factor as shown in equation 5-7.

$$y = 56.886x^{0.981} \quad (5)$$

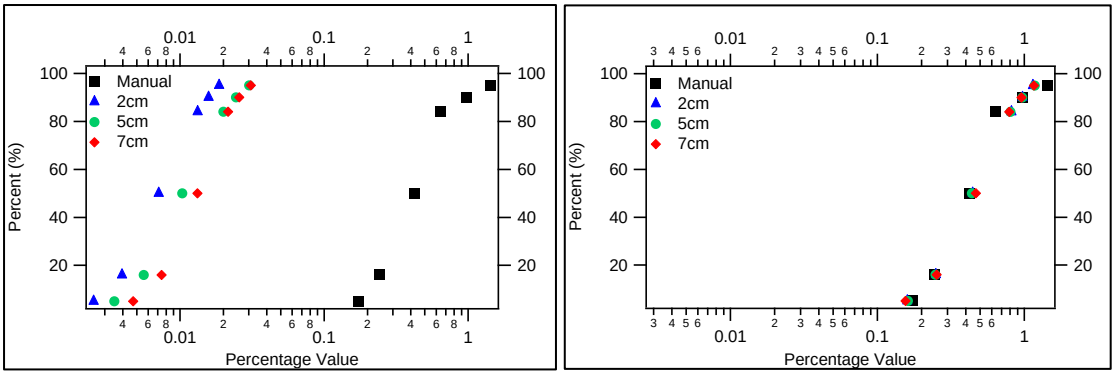
$$y = 29.836x^{0.923} \quad (6)$$

$$y = 47.9866x^{1.07} \quad (7)$$

where y=after corrected value and x=before corrected value. Deploying these empirical correction formulations to AGS technique improved the GSD significantly as the standard deviation close to 1 and RMS close to zero.

Table 4: Improvement after Employing Correction Function

	Before		After	
	Standard Deviation	Root Mean Square Error	Standard Deviation	Root Mean Square Error
Manual: 2cm	9.59	7.93	0.40	0.79
Manual: 5cm	6.261	6.50	0.15	1.00
Manual: 6cm	5.944	5.99	0.41	0.79
2cm : 5cm	0.038	0.82	0.13	1.00
2cm : 7cm	0.04	0.75	0.40	0.79
2cm : 5cm	0.11	0.92	0.15	1.00



a) Before Correction b) After Correction

Figure 8: Improvement of GSD after Correction

CONCLUSIONS

An experimental investigation on the use of AGS for grain size distribution of material at a river bed has been performed. Various correction factors at various particle sizes were applied to the curves thus obtained and it was found that the method was comparable to the conventional mechanical sieving. From the preceding section the following conclusions were made;

i) Obtaining the sample image at a different sampling distance will not give significant difference on the GSD curve should AGS technique is used for analysis.
ii) GSD curve and AGS curve showed a significant discrepancy between them.
iii) A correction factor should be employed to correct those discrepancies and the ratio between them is almost close to unity.

There are a few factors that could influence the result of AGS to become inaccurate. The error could be caused by: the quality of the capturing the image; blurring due to shaky hand when taking the images; too much noise in the picture which caused by the lighting and over-segmentation by the imaging software. It is suggested that the camera be mounted on a rigid frame to avoid man made errors. The correction functions produced by the least square method are capable to correct those discrepancies. A single and uniform correction factor is very much helpful and practical to be developed and used in the future.

REFERENCES

Amaral, F. T. (2014, March 17). Root Mean Squared Error. Retrieved from kaggle: https://www.kaggle.com/wiki/RootMeanSquaredError.

Barnard, P. L., Rubin, D. M., Harney, J., and Mustain, N. (2007). The field test comparison of an autocorrelation technique for determining grain size using a digital 'Beachball' camera versus traditional methods, *Sediment. Geol.*, 201, 180–195.

Bunte, K. and Abt, S.R. (2001). Sampling surface and subsurface particle size-distribution in wadable gravel and cobble-bed streams for analysis in sediment transport. *General Technical Report RMRS-GTR-74*, Rocky Mountain Research Station p. 428.

Buscombe, D. (2008). Estimation of grain-size distributions and associated parameters from digital images of sediment, *Sediment. Geol.*, 210(1–2), 1–10.

Buscombe, D., and Masselink, G. (2009). Grain-size information from the statistical properties of digital images of sediment, *Sedimentology*, 56(2), 421–438.

Butler, J. B., Lane, S. N., and Chandler, J. H. (2001). Automated extraction of grain-size data from gravel surfaces using digital image processing, *J. Hydraul. Res.*, 39(5), 519–529.

Chang, F.J. and Chung, C.H. (2012). Estimation of riverbed grain-size distribution using image-processing techniques. *Journal of Hydrology*, 440-441, 102-112.

Chang, F.J. and Chung, C.H. (2013). A refined automated grain sizing method for estimating river bed grain-size distribution of digital images, *Journal of Hydrology*, 486, 224-233.

Graham, D. J., Reid, I., and Rice, S. P. (2005a). Automated Sizing of Coarse-Grained Sediments: Image-Processing Procedures, *Mathematical Geology*, 37(1), 1-28.

Graham, D. J., Rice, S. P., and Reid, I. (2005b). A transferable method for the automated grain sizing of river gravels. *Water Resour. Research*, 41, W07020.

Graham, D., Rollet, A., Rice, S., & Piégay, H. (2012). Conversions of Surface Grain-Size Samples Collected and Recorded Using Different Procedures, *Journal of Hydraulic Engineering*, 138(10), 839-849.

Kellerhals, R. And Bray, D.I. (1971). Sampling procedure for coarse alluvial sediments. *Journal of the Hydraulic division ASCE*, 97, 1165-1179.

McEwan, I. K., Sheen, T. M., Cunningham, G. J., and Allen, A. R. (2000). Estimating the size composition of sediment surfaces through image analysis. *Proc. Inst. Civ. Eng., Waters. Maritime Energ.*, 142, 189–195.

Rubin, D. M. (2004). A simple autocorrelation algorithm for determining grain size from digital images of sediment. *J. Sediment Res.*,74(1), 160–165.

Sime, L. C., and Ferguson, R. I. (2003). Information on grain sizes in gravel-bed rivers by automated image analysis, *J. Sediment Res.*, 73(4), 630–636.

Strom, K.B, Kuhns, R. D. and Lucas, H.J. (2010). Comparison of automated image-based grain sizing to standard pebble-count methods, *Journal of Hydraulic Engineering*, 136(8), 461-473.

Sulaiman, M.S; Sinnakaudan, S.K.; Ng, S.F. and Strom, K. (2014). Application of Automated Grain Sizing Technique (AGS) for Bed Load Samples at Rasil River: A case study for Supply Limited Channel, CATENA 121, 330-342.

Wolman, M.G. (1954). A method of sampling coarse river-bed material. *Transactions American Geophysical Union*, 35 (6), 951-956

Infrastructure University Kuala Lumpur Research Journal **IUKLRJ**
Vol. 3 No. 1 2015

RMC Research Management Centre
Accelerating Excellence through Research and Innovation

Research Management Centre
Infrastructure University Kuala Lumpur
Corporate Block, Unipark Suria,
Jalan Ikram-Uniten, 43000 kajang,
Selangor Darul Ehsan.
Tel : (603) 8926 6993
Fax : (603) 87341021

www.IUKL.edu.my

ISSN 2289-4144
9 772289 414007