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

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

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

INTRODUCTION

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

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

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

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

LITERATURE REVIEW

Current Concrete Waste Issues in Construction Industries

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

Ready-mixed Concrete Waste

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

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

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

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

Precast Concrete Waste

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

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

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

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

Demolition Concrete Waste

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

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

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

Current Common Practice of Concrete Waste Management in Malaysia

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

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

Landfill Disposal Method

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

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

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

3R concept - Recycle, Reduce, Reuse

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

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

Illegal Construction and Demolition Waste Disposal

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

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

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

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

Policies, Law and Enforcement in Malaysia

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

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

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

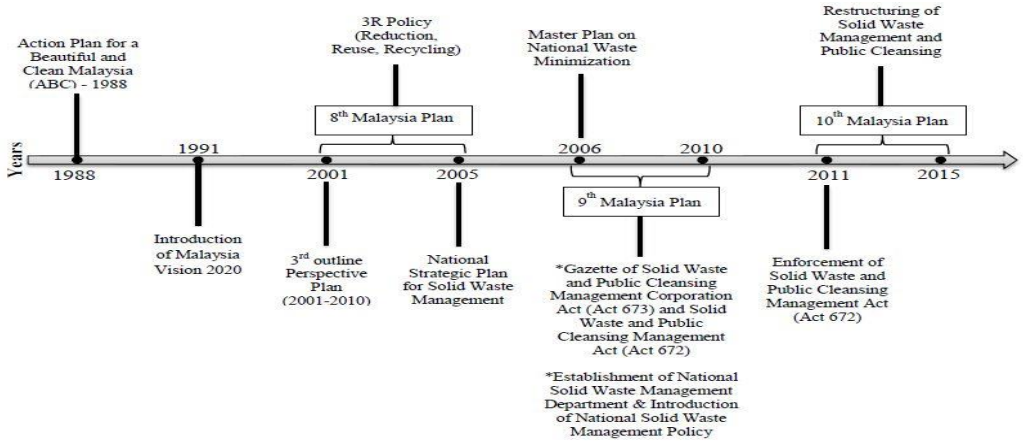

Figure 1: Timeline of Solid Waste Transition in Malaysia (CIDB 2015) (Saadi N. 2016).

METHODOLOGY

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

The questionnaire items were classified in to five sections:

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

DATA ANALYSIS AND FINDINGS

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

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

Data analysis for Section 1 – Participants' Demographic Analysis

Table 1: Participants Demographic Summary

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

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

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

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

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

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

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

Table 3: Familiarity on Various Construction and Demolition Waste Aspects

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

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

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

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

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

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

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

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

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

Table 5: Types of Projects Contributed to Concrete Waste Generation

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

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

Table 6: Agreement on Various Factors

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

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

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

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

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

Data analysis for Section 4 – Concrete Waste Management Practices

Table 7: Satisfaction on Various Construction and Demolition Management Practices

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

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

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

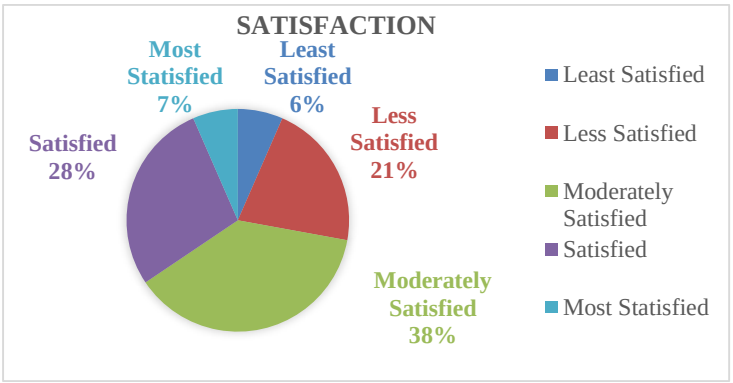

Figure 2: Satisfaction on Current Concrete Waste Management

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

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

Table 8: Summary result of recommendations

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

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

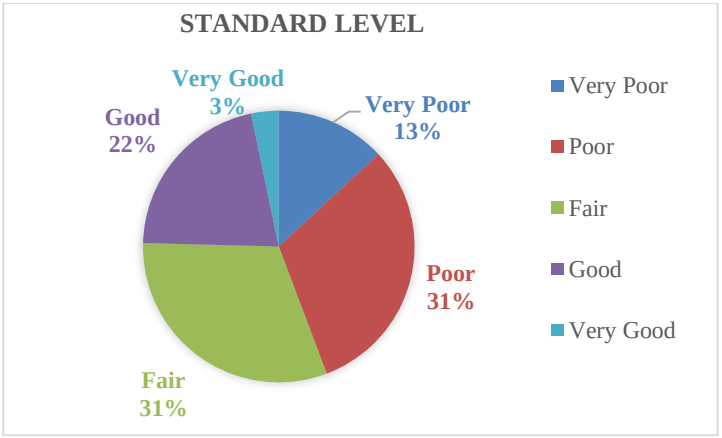

Figure 3: Standard of Current Malaysian Construction and Demolition Waste Legislation and Policies.

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

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

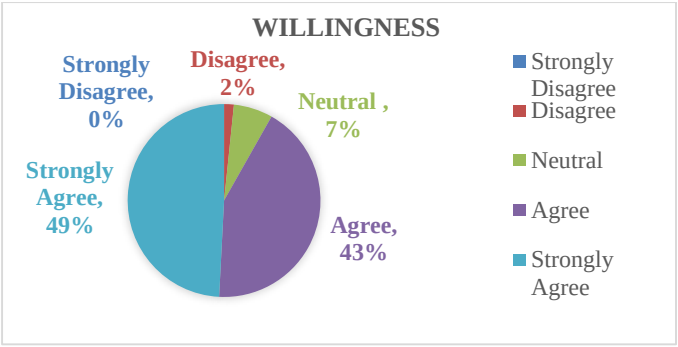

Figure 4: Result of Participants's Willingness

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

CONCLUSION AND RECOMMENDATION

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

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

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

FUTURE WORK

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

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