

# Issues on Construction Waste: The Need for Sustainable Waste Management

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**Abstract**—Construction wastes have become a pressing issue in many developing countries and have adverse effects on environment, economy and social aspects. Illegal dumping is a common issue created from the physical construction waste and besides that non physical waste like cost and time overruns are not properly addressed among the construction players. This paper explores the impacts of construction on sustainable construction and contributing causes which will help the practitioners to formulate ways in avoiding or reducing the waste. It also highlights the sustainable approach in managing the construction waste as practice.

**Keywords**—construction waste; illegal dumping; cost overrun; time overrun; construction waste causes; sustainable waste management

## I. INTRODUCTION

Construction industry plays a key role in socio-economic development of any country. Nowadays construction industry is rapidly growing because of increase in standard of living, demands of infrastructure projects, changes in consumption habits, as well as natural increase in population. This growth has contributed significantly in waste generation [1] [2] [3], which has become serious problem for every nation. Several researchers and practitioners indicate that waste emanates during planning, design, procurement, and construction stage [4] [5] [6]. The waste also influences economical dynamics of society and also has an important effect on the environment and surroundings [7].

Construction waste can be clustered into two groups namely; physical and non physical waste as shown in Fig. 1. In common, physical waste is generated in the form of material loss. It contributes to a significant part of landfill. Studies show that construction industry produces large amount of waste and more than 50% of waste material is deposited in landfill [8]. Reference [5] reported that almost 26% of landfill occupied with construction waste. In another recent study as in [9], pointed out the waste generated in China are around 40% and 39.27 million tons in Spain [10]. On the other hand, non physical construction wastes mainly are time and cost overrun for construction projects [11] [12]. These problems will become more critical when a stoppage of a particular construction work and this cause the abandoning of the project.

There are numerous research works carried out on construction waste and the findings show several negative impacts to the environment, social and economy of a country [13] [14] [15] [16]. These impacts also contribute to a reduction in construction productivity and thus reduce the performance of the overall construction project [11]. These negative impacts are pushing the construction industry to integrate with sustainable approach in moving toward sustainability [17]. It is timely to adopt sustainable construction waste management to avoid its potential negative impacts. Hence, this paper discusses the issues created from physical and non physical construction waste and also the factors that generated construction waste. It also provides different dimension of handling construction waste which leads to sustainable construction waste management.

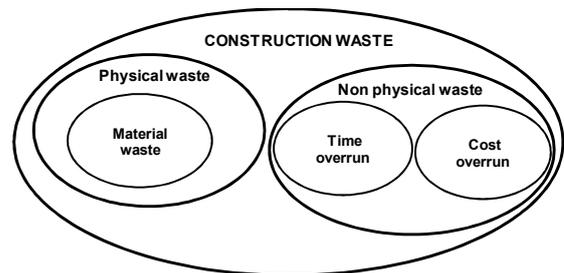


Figure 1. Classification of construction waste [18]

## II. ISSUES RELATED TO CONSTRUCTION WASTE

Construction waste is a prominent issue globally and has adverse effect on overall performance of a project as well as the society and nature. Waste can be generated in various forms. As indicated in Fig. 1, the waste occurs in the form of material, time and cost losses.

### A. Materials waste as a physical construction waste

The major physical waste generated from construction activity is identified in the form of material waste like concrete leftover, demolished debris, steel scrap and others [3]. Studies show that material waste has significant impact to the cost of the project as well as an adverse impact on environment. One of the implications created from huge quantities of material waste is illegal dumping. Illegal dumping is the unlawful deposit activity of waste onto land [19]. This unethical activity always causes problems to the

public in general and to the environment in many places around the world. Wrongly disposal of physical wastes are increasing and this contributes to pollution globally [4][20]. Various countries are bogged down by this issue of illegal dumping and it is very important to understand the current situation as discussed below:

### Malaysia

Malaysia is facing the problem of illegal dumping and the issue has become more serious recently throughout the country as in [21], along roadsides and tropical mangrove swamp [22] [23]. This has disturbed the ecology of the mangrove swamp. This implies lack in practice of waste management practices in construction industry. Though there are regulatory policies in Malaysia for handling waste generation including Solid Waste and Public Cleansing Management Act 2007 (PPSPPA) governed by Ministry of Housing and Local Government; Standard Specifications for Buildings Works (SBW) governed by Ministry of Works; Environmental Quality Act 1974 (EQA) governed by Ministry of Natural Resources and Environment; and *Pembinaan* Malaysia Act 1994 (PMA) governed by Construction Industry Development Board (CIDB) [23]. However, these policies do not fully cover all aspects of construction waste management. PPSPPA is have to focus more on domestic waste rather than construction waste, SBW is solely for contractors who handles projects with Public Work Department (JKR) under Clearing, Cleaning, and Making Good on Completion Clause, requires garbage and construction waste clearance to be done twice a week and contractors are needed to dispose the construction waste in landfills or approved sites. PMA scopes to prevent, to reduce, to control pollution and to enhance environment. The wastes are interpreted as liquid, solid, gasses and radioactive. The wastes are either normal waste or schedule waste. The drawback of the law is that it considers waste when it is deposited and causes pollution to environment. PMA act is to provide functions relating to the construction works in the country. It gives power to investigation officers for entering construction site at any time for the purpose of inspection. This enforcement law gives the authority to act upon construction waste left on site through the term of site clearance. According to the Malaysian government report as in [24], about 39.3% construction waste was found in Hulu Selangor District from a total of 87 illegal dumping grounds. Hence, recently Ministry of Housing and Local Government has signed concession agreement with private waste management companies for 22 years [25]. However, the private companies mainly focus on domestic waste, but disregard or little attention is given to construction waste. Further, to monitor contractors' works and activity, CIDB and Solid Waste Management and Public Cleansing Corporation plan to produce a guideline on the management of construction waste in the future [25] [26]. This shows the seriousness of Malaysian government in handling the waste and is still struggling to overcome the problem.

### Singapore

In Singapore, National Environment Agency (NEA) has overall responsibility of construction waste and enforcement of illegal dumping problem [27]. In addition, the government

of Singapore is giving the utmost importance to matters pertaining to the protection of environment. Moreover, Singapore legislation has tightened their rules and regulations with penalties to put up with the problem of illegal dumping. Nevertheless, the construction waste and the problem of illegal dumping are still rampant in the country [6] [28].

The problem is prevalent in remote areas of Lim Chu Kang, Jalan Buroh, Mandai and Neo Tiew Road [6] [29]. Hence, government policies have recognized this issue as important indicator in construction industry. Furthermore, the Singapore Green Building Council (SGBC) was established to improve the Singapore building and construction industry to achieve sustainability [30]. In addition, local construction industries in Singapore adopted ISO 14000 EMS for upgrading the performance of environmental construction [31]. These noble initiatives will enable the country to manage the problem of illegal dumping in a sustainable manner.

### Hong Kong

The government of Hong Kong has introduced several initiatives for implementing waste management. The initiatives are Waste Disposal Ordinance, 10-year Plan to Reduce Waste and Pollution, Green Manager Scheme, Waste Reduction Framework Plan (WRFP), Pay for Safety and Environment Scheme and a Waste Disposal Charging Scheme [32]. Moreover, the public sector has incorporated sustainable construction principles into standard specifications. Architectural Services Department (ASD) and the Local Housing Department have also revised their standard specifications with environmental element [33].

However, all of these initiatives are still not reaching the aim for sustainability because issues on illegal dumping are still in an alarming stage in the country. The construction waste has been illegally dumped at Long Keng, Sai Kung [34] and other sites [35]. Tai Lam Country Park was used as dumping ground for construction waste such as rocks, concrete and other construction debris [36]. In this case, the sustainable effort and action need to be carried out immediately to protect the country.

#### B. Cost and time overrun as non physical waste

Construction industries are extremely concerned about time and costs of the project. Most of these projects are having dilemma in cost and time overrun globally. The non-physical waste normally occurs during the construction process. In contrast to the material waste, non-physical waste occurs when materials are not physically lost but money and time overrun [3] [18] can lead to failure for the majority projects.

Currently, the issue of time and cost overrun in construction projects is becoming epidemic in Malaysia as in [18] [44] [47] and has led to abandonment of many projects. As reported by the Ministry of Housing and Local Government through the national newspaper earlier this year as in [37], 35 projects involving 12,000 units house in Malaysia have been abandoned abandonment. These problems are caused by poor financial management by the developers, wrong construction specification, construction delays, lack of supervision and lack of enforcement on existing rules. This has caused dissatisfaction of the buyers of abandoned homes and social

relationship among developers and buyers has become tensed. Indirectly, this situation has resulted into unhealthy conditions and declining purchasing power of new houses. In other words, non-physical waste has an impact on economic growth and social development of countries.

Table I tabulates a summary of various research of non physical waste in different countries.

TABLE I. SUMMARY OF STUDIES ON NON PHYSICAL WASTE

Researcher	Country	Non physical waste	
		Time	Cost
B.G. Hwang, and Z. B. Yeo [8]	Singapore	x	
S. Alwi, [11]	Indonesia	x	
C. T. Formoso [12]	Brazil		x
R. Ndiokubwayo, and T. Haupt [16]	Africa	x	x
G. Polat and G. Ballard [38]	Turkey	x	
L. Koskela [39]	Finland	x	x
S. Nagapan [52]	Malaysia	x	x

### III. CAUSATIVE FACTORS FOR THE GENERATION OF CONSTRUCTION WASTES

Construction waste is generated throughout the project from the pre-construction stage, rough construction stage and finishing stage. Generation of construction wastes can be caused by various factors. It is very important to identify and understand those causes for controlling waste generation at source. Hence, this study explores the causes and effects of construction waste. Extensive literature review was conducted to identify causes of construction waste and interviews were conducted with 15 experts involved in construction industry. These results identify 81 factors categorized in seven groups. They are design, workers, management, procurement, site condition, handling and external factor groups. Identification of the causative factors can help in increasing awareness of construction practitioners to control construction waste. Summary of the identified causes of construction waste was compressed in fishbone diagram as shown in Fig. 2.

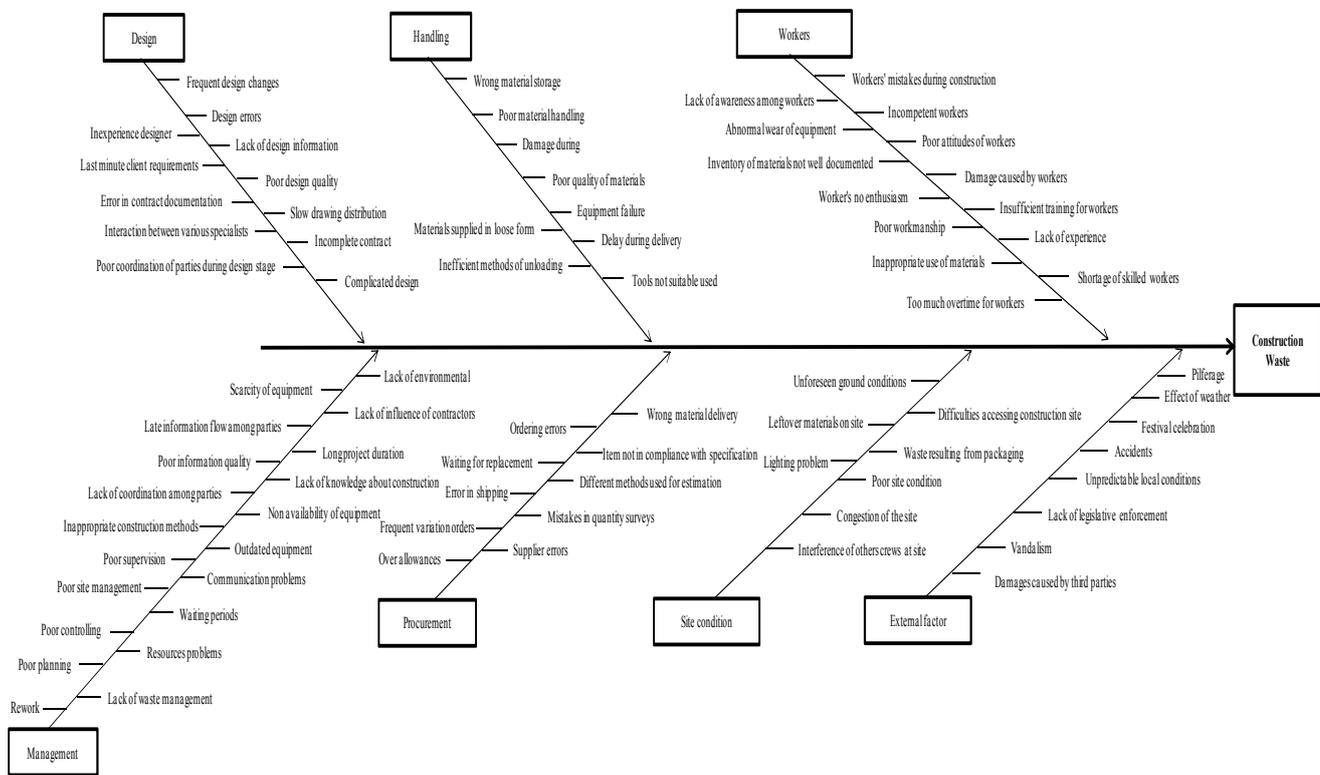


Figure 2. Causative factors of construction waste

### IV. SUSTAINABLE CONSTRUCTION WASTE MANAGEMENT

Construction waste is a global issue which needs serious attention. One of the effective ways to control construction waste is adoption of sustainable construction

principles as sustainable construction does not focus on only environmental issues but also on economic and social aspects. Hence, it is important to adopt sustainable waste management to encounter the effects of construction on overall sustainable criteria rather than cost alone. Various studies have been carried out to outline the effects of construction waste on

sustainable construction as tabulated in Table II. Sustainability in construction waste can be seen as stepwise strategy to achieve desirable and most suited process depending on the conditions and type of waste generation. This process can be translated into the waste management hierarchy, as shown in Fig. 3, which includes prevention, minimization, reuse, recycling, recovery and disposal of construction wastes. Although waste management hierarchy consists 6 steps, it is most recommended that waste management should be considered to apply from highest desirability step i.e. prevention to lower priority step. Various steps of sustainable waste management are discussed in the following section.

TABLE II. EFFECTS OF CONSTRUCTION WASTE ON SUSTAINABLE CONSTRUCTION CRITERIA

Effects	References								Aspects of Sustainable
	[4]	[16]	[17]	[23]	[41]	[40]	[42]	[43]	
Environmental pollutions	x	x		x	x	x			Environmental
Shortage of land				x			x		
Increasing of Illegal dumping							x		
Severe ecological damage	x								
Increase in transportation charges of construction waste				x	x				Economic
Increase cost of projects			x						
Increase in landfill fee		x	x				x		
Increase price of raw materials					x				
Delay of projects			x						Social
Economic losses								x	
Dangerous to the people's health				x					
Negative effects to the society	x	x							

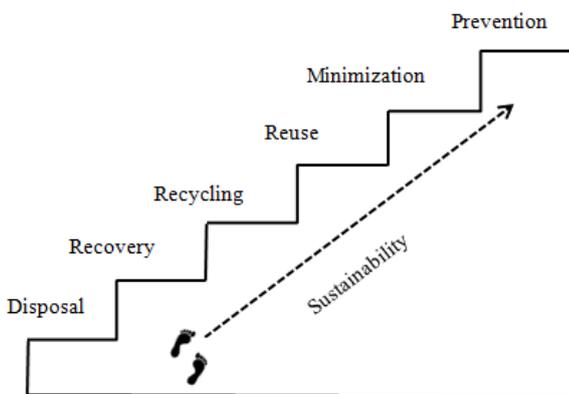


Figure 3. Sustainable waste management hierarchy

A. Prevention

Prevention is also referred as to avoid, which is the best way to manage waste [6]. This is the highest levels in the need for sustainability.

Nevertheless, there are a few challenges which have to be tackled by practitioners mainly during pre construction stage. Designers need to take into account of the technical information about construction process during the design stage to avoid construction waste [45]. It can help in preventing construction waste, as studies show that error and frequent change in design will always be the waste generating factors [4] [41] [42].

In Hong Kong and Malaysia the prefabrication technique has been used as a solution to prevent waste generation during design phase [2][46]. However, prevention of wastes, requires a fine coordination among all those involved in construction process. Thus it is paramount to have a very good rapport and communication with and within the construction community i.e the contractors, consultants and clients, to avoid any miscommunication or untoward happenings. Lack of communication and discussion could lead to misunderstanding and the generation of more waste. Therefore, various improvement methods should be implemented frequently to experience the benefits of the approach on excellent management toward sustainability in construction waste.

B. Minimization

Minimization or reduction was ranked in the second most preferable way in managing the construction waste. Thus, reducing factors of waste generation could help out in the construction industry. These steps reduce destruction on environment and reduce construction cost. Moreover, minimize from beginning of projects will be reduce resources usage and reduce transportation works [9]. Hence, minimization talent needs to embark and practice for reducing the waste at source of generation.

Due to the running out of reclamation sites and landfill space in Hong Kong, researchers urge to have site inspection regularly and a waste management plan for the reduction of waste [20]. Therefore, waste minimization is obviously important for a sustainable practice. Another similar scenario due to scarcity of land happens in Singapore. The authorities in the country's construction field, taking minimization manner for achieving sustainability and lessen the usage of land [6]. However the need is for the contractors to support and play their utmost role for the enhancement of this sustainable step.

C. Reuse

In spite of the two steps lower than prevention and minimization, most countries used this approach to reduce construction waste at site before disposing them to landfills. In Germany, a very advanced waste handling technology was developed to reuse construction materials. The technology used by Siemens Company is a three step process which includes drying, distillation and burning of waste technique to enable the waste material to be reused [48]. In Hong Kong, the construction practitioners are practicing on-site sorting of inert and non-inert waste materials at site in promoting the reuse approach in waste management. Therefore, these sorting actions enable the reuse of some of the generated waste [20]. Similarly, another study stated that a trip-ticket scheme in Hong Kong encouraged separating inert waste for possible reuse [49]. Consequently, there are many types of reuse technique in constructions. Some of the contractors used broken bricks and stones as a sub-grade of access road to the construction site [9]. They also used construction materials such as timber or plywood to build their temporary shed at site.

D. Recycle

Recycling of waste is placed fourth in the waste management hierarchy. Some developed countries such as Germany and Hong Kong obtain these steps to reduce disposal waste in landfills. In Germany, the government supported the recycle activity very well. Study on raw material of light

weight concrete shows commitment of the country in sustainability. Moreover the country is committed to collect a million tons of glass every year for recycling purpose. This shows the country is fully geared to become a green nation [7].

Meanwhile, in the case of Hong Kong, recycle aggregates for concrete and paving blocks has been promoted by the government [49]. Wang and Li have reported that Holland government has utilized legislative power and forcing construction players in recycling process [9]. This is in accordance with the findings as in [17], which states that waste land filling charge is an effective instrument for forcing contractors and developers to reduce waste.

Another commendable practice conducted by Alex Fraser Group is by using recycled waste materials in Western Ring road projects. However, argument from construction companies to use the recycle products remained high even after obtained formal accreditation. Besides that, policies in Korean government mandate the use of recycled aggregates in construction. Benefits of the government regulations stipulate minimum requirements for the use of recycled aggregates in construction projects [50].

#### E. Recovery

In the hierarchy of construction waste management, recovery ranked fifth in its priority. Recovery which is defined as the removal of materials or components from the waste stream in a manner to keep its original form for reuse in the similar form as it was produced [51]. With recovery, the volume of waste ending up in a landfill can be reduced. In Germany, the incineration technology has assisted the recovery of metal waste. This recovery tools, will cut off until 2 to 3 kilogram harmful heavy metal in 1 ton waste after distillation and burning process. Thus, this method resolved the problem effectively from taken space to the landfill. Moreover, gas produced during the handling process is used to generate electricity [48]. The recovery steps also have been practiced in many countries. However government has to support this process because the setting up of the recovery factory may cause a sum of money.

#### F. Disposal

Disposal is the last option and can be labeled as the lowest criterion towards achieving sustainability in waste management. However many countries dispose their construction waste in landfills. For example in Malaysia, the Department of National Solid Waste Management revealed that about 289 landfills are exists in the country [18]. Furthermore, the study also stated that contactors' perception on direct disposal of construction waste to landfills has become a culture. Despite strong influence in the disposal of waste to landfill, Solid Waste Management and Public Cleansing Corporation (PPSPPA) and Construction Industry Development Board (CIDB) keep promoting recycling and Industrialized Building Systems (IBS) to reduce the amount of waste in landfills. Disposal method however is not a favorable choice because the role of sustainable waste management is to reduce the amount of waste that is discharged into the environment.

### V. CONCLUSION

The paper has discussed the issues on construction waste and challenges which has become a growing concern in many countries. At present, illegal dumping has become a dominant problem in tackling physical construction waste. For non

physical waste, the problems are time and cost overruns [52][53]. The paper has also highlighted cause factors which can be mitigated for managing construction waste in a sustainable manner. To incorporate sustainability in managing the construction waste, the waste management hierarchy should be adopted as a way forward in making the construction industry look greener. Besides that, legislation/policy can be a supportive tool in handling construction waste. Lastly, this ongoing research will develop a Construction Waste Guidelines in collaboration with Solid Waste Management and Public Cleansing Corporation for construction project in-order to sustain the environment, economy, and social development for Malaysia.

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