

Preliminary Survey on the Crucial Root Causes of Material Waste Generation in Malaysian Construction Industry

Sasitharan Nagapan
Department of Civil
Engineering Technology,
University Tun Hussein Onn
Malaysia,
Johor, Malaysia

Suaathi Kaliannan
Department of Civil
Engineering Technology,
University Tun Hussein Onn
Malaysia,
Johor, Malaysia

Abd Halid Abdullah
Department of Civil
Engineering Technology,
University Tun Hussein Onn
Malaysia,
Johor, Malaysia

Samiullah Sohu
Department of Civil
Engineering, Quaid-e-Awam
University of Engineering,
Science & Technology,
Nawabshah, Pakistan

Rafikullah Deraman
Department of Civil Engineering
Technology,
University Tun Hussein Onn Malaysia,
Johor, Malaysia

Muhammad Fikri Hasmori
Department of Civil Engineering
Technology,
University Tun Hussein Onn
Malaysia, Johor, Malaysia

Nor Haslinda Abas
Department of Civil Engineering
Technology,
University Tun Hussein Onn Malaysia,
Johor, Malaysia

Abstract—Construction waste generation has been perceived as a crucial issue that has critical consequences on the project effectiveness and ecological effect of the construction industry. The key objective of the current research is to identify the root causes of material construction waste generation in Malaysia. A well-structured questionnaire was designed based on the 52 identified root causes of material waste generation. The developed questionnaire was distributed to 35 highly experienced in Malaysian construction industry experts. The collected data was analyzed by the use of mean score analysis. The top identified root causes are poor supervision during the construction stage, lack of efficient site management, last minute changes, cutting uneconomical sizes of materials, and constant design changes during the construction period. The initial findings will aid construction practitioners to focus on these root causes in order to reduce the material construction waste generation at construction sites.

Keywords-preliminary survey; material waste; root causes; environment; Malaysia

I. INTRODUCTION

Construction industry is considered a key part in any nation's socio-economy growth. Nowadays, construction industry is developing rapidly [1-2] but is generally considered environmental unfriendly [3]. This industry enhances considerably environmental problems such as exploration of the natural resources, ir retrievable conversion of the environment, and increase of contaminants in the atmosphere [4]. Construction waste is produced throughout site clearance, material utilization, overabundance acquirement of materials and human errors at construction site. 10-30% of the waste

starts from construction works [5, 6]. Therefore, initial identification of the root causes is essential in order to reduce material waste generation rate.

II. CONSTRUCTION WASTE

Material waste can be generated throughout construction works. It may occur in preliminary design stage, during construction and with poor human behavior [7-9]. Construction waste is considered as any material that is damaged, unnecessary and extra purchased, or noncompliant to specifications [2, 10]. According to [11, 12], annual construction waste generation has been increasing in Malaysia. Construction waste is being created through the entire construction time frame, from the earliest starting point of the outline arranged until the last stage. There are numerous root causes that prompt construction waste generation. It is essential to distinguish those causes in order to control waste generation. According to [1], there are several root causes of construction waste generation such as design, workers, management, procurement, site condition, handling and external factors. It is stated that poor site management is one of the major root causes in producing waste. Absence of awareness or knowledge in construction waste, procurement of materials differing to specification, unsuitable storage causing damage and rework are among the key causes identified in contributing to waste generation rate [13]. It has been discovered that waste produced in Malaysian construction projects are mainly initiated by employee and management problems [14]. These root causes should be controlled to reduce the quantity of generated waste. There are other aspects that are considered as sources of construction waste such as incomplete information,

weak material management, unskilled labor, and damage during transportation [15]. The root causes were categorized under common characteristics like material management on site, material handling, transportation and storage and site management and practices in [16].

III. RESEARCH METHODOLOGY

This study adopts quantitative technique in order to comprehend the viewpoint of construction experts towards the root causes of construction waste generation in Malaysian construction industry. The exploration of this research is divided into 2 phases. The first phase includes extensive literature review after which 52 root causes contributing to material construction waste generation were identified. In the second phase, a questionnaire was developed. The questionnaire comprises of two parts, demography of the respondents and root causes of waste generation rate in Malaysian construction industry. Each respondent was asked to verify the crucial root causes for the environment of Malaysian construction industry.

IV. DATA COLLECTION AND ANALYSIS

The questionnaire was designed based on a five-point Likert [17] scale ranging from 1 for Disagree to 5 for Strongly Agree. The developed questionnaire was distributed to 35 experts in Malaysian construction industry. The received questionnaires were analysed and reliability test was conducted. The Cronbach's alpha value was 0.970 which indicates a high level of consistency. According to [18, 19], if Cronbach's alpha value is higher than 0.7, the inner consistency of data is highly acceptable. Figure 1 indicates the number of respondents and their corresponding working experience. The majority (12 out of 35, 34.3%) of the respondents have 16-20 years of experience in the construction industry. The total percentage of respondents with more than 10 years of experience in the industry is about 88.5%. This shows that the majority of the respondents are eminently experienced and vastly knowledgeable regarding Malaysian construction industry.

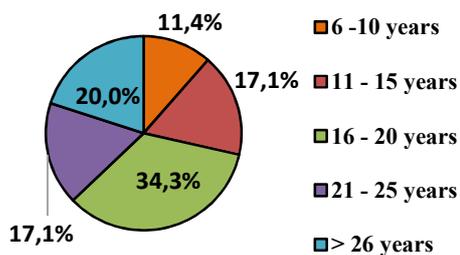


Fig. 1. Respondents' working experience

Figure 2 exhibits the respondents' organization/enterprise. Most of the respondents are contractors with 62.9% (22 out of 35). The opinions of contractors are considered important as they are the ones who are stated at the site and have better understanding about the root causes of construction waste generation. Clients' and consultants' inputs are crucial as well

because they are also having good involvement in construction industry field.

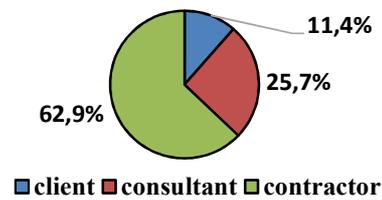


Fig. 2. Respondents' enterprise type

V. RESULTS AND DISCUSSION

The mean value of each root cause of material waste generation is presented in Table I. Result analysis showed that the root causes with the higher mean value for generation of waste in Malaysian construction industry are "supervision during construction stage is poor", "efficient site management is lacking", "last minute changes due to client requirements", "cutting uneconomical sizes of materials", "constant design changes during construction period", "unsuitable tools used during construction", and "unsatisfactory attitude of workers". The ranking of the root causes of construction waste generation is shown in Table II. There are 46 root causes which scored more than 4.00, however for this paper only the top root causes are elaborated.

A. Supervision During Construction Stage is Poor

Supervision and coordination is clearly expected to guarantee great task conveyance. Satisfactory supervision prompts quality employment yet accompanies extra cost for the successful supervision [19-21]. Good project supervision is imperative as it might give important pointers to different elements that may cause problems [22, 23, 27]. Therefore, poor supervision at site leads to more material waste generation.

B. Lack of Efficient Site Management

Site management should have a work task flow according to the project's needs [24-26]. Teamwork should be incorporated for an efficient site management plan [27, 28]. This includes managing scope, issues, risks, communication and the work plan. If the site management is not systematic the work will be faulty and will cause reworks. If basic management is lacking, the construction waste generated will not be coordinated efficiently, thus a huge sum of waste such as concrete, metal, sand, timber will be generated. This root cause is one of the main contributors to construction waste generation.

C. Last Minute Changes due to Client Requirements

Changes in design occurring while construction has begun is one of the root causes of generating waste [23, 29, 30]. Clients should be clear with their vision of the project from the beginning.

D. Cutting Uneconomical Sizes of Materials

Cutting materials into different sizes and uneconomical shapes generates waste [23]. When timber or metal are being cut without considering the next usage, the excess becomes

waste. This factor is one of the highest regarding the volume of waste in waste production [31, 32].

TABLE I. ROOT CAUSES OF CONSTRUCTION WASTE GENERATION AND THEIR MEAN VALUES

Code	Root Causes of Material Waste Generation	Mean	Code	Root Causes of Material Waste Generation	Mean
RC22	Supervision during construction stage is poor	4.611	RC27	Abandonments of materials on site without proper waste control	4.278
RC21	Lack of efficient site management	4.528	RC44	Supplier errors due to carelessness	4.278
RC1	Last minute changes due to client requirements	4.472	RC31	Ordering errors by the workers	4.250
RC35	Cutting uneconomical sizes of materials	4.472	RC36	Inadequate storage place at project site	4.250
RC4	Constant design changes during construction period	4.444	RC43	Miscalculation in quantity surveys	4.250
RC12	Unsuitable tools used during construction stage	4.444	RC25	Language problems among foreign and native workers	4.222
RC15	Unsatisfactory attitude of workers	4.444	RC26	Lack of environmental awareness by the site team	4.222
RC2	Slow information flow among all parties involved in the project causing redundant work	4.417	RC42	Error in shipping of materials	4.222
RC11	Improper material handling by the workers	4.417	RC8	Incomplete information provided in the drawing	4.194
RC24	Rework due to miscommunication among engineers and workers	4.417	RC18	Inappropriate use of materials	4.194
RC46	Lack of possibility of ordering small quantities of materials	4.417	RC48	Effect of weather conditions	4.194
RC3	Lack of coordination among parties involved in the project	4.389	RC16	Insufficient worker training by the employer	4.167
RC23	Improper construction methods applied by the workers	4.389	RC28	Inventory of materials not according to site conditions	4.139
RC34	Usage of wrong materials	4.389	RC49	Occurrence of accidents at site	4.139
RC38	Poor quality of supplied materials	4.389	RC6	Improper design quality produced by consultant	4.111
RC47	Inefficient methods of unloading supplied materials	4.389	RC17	Management and technical team are less experienced	4.083
RC10	Inappropriate material storage at site	4.361	RC32	Frequent variation orders due to carelessness	4.056
RC20	Planning of technical team at site is weak	4.361	RC33	Inadequate security and pilferage at site	4.056
RC7	Design produced by consultant is complex	4.333	RC39	Materials supplied in loose form	4.055
RC13	Faults of workers during construction process	4.333	RC5	Design errors due to inexperienced designer	4.002
RC14	Workers at construction site are less skilful	4.333	RC50	Vandalisms	3.833
RC45	Inaccurate material delivery procedures	4.333	RC51	Damages caused by third parties	3.806
RC19	Poor workmanship	4.306	RC29	Inadequate lights provided at night	3.750
RC30	Unforeseen geological conditions	4.306	RC9	Designing without considering wastage	3.667
RC37	Damage of materials during transportation	4.306	RC40	Packaging waste generated	3.556
RC41	Items ordered are not in compliance with specifications	4.306	RC52	Unpredictable local conditions	3.278

TABLE II. CONSTRUCTION WASTE ROOT CAUSES RANKING

Root Causes	Mean	Rank
Supervision during construction stage is poor	4.611	1
Lack of efficient site management	4.528	2
Last minute changes due to client requirements	4.472	3
Cutting uneconomical sizes of materials	4.472	3
Constant design changes during construction period	4.444	4
Unsuitable tools used during construction stage	4.444	4
Unsatisfactory attitude of workers	4.444	4
Slow information flow among all parties involved in the project causing redundant work	4.417	5
Improper material handling by the workers	4.417	5
Rework due to miscommunication among engineers and workers	4.417	5
Lack of possibility of ordering small quantities of materials	4.417	5

E. Constant Design Changes During Construction Period

Sudden drawing changes can lead to higher waste generation [25, 26, 33]. This is an issue among contractors, designers and clients during design work stage [23, 30, 31, 34]. When the design is not confirmed during the initial stage, frequent changes may occur in construction period generating material wastages. This could be avoided if all the parties involved could have frequent productive meetings during the design stage to confirm the design prior to the construction.

F. Unsuitable Tools Used During Construction Stage

Tools used during construction may not be appropriate or suitable [25, 27, 35] leading to augmented generation of

construction waste.

G. Unsatisfactory Attitude of Workers

In a construction site, poor behavior can distress everyone and cause conflicts among workers [36, 37]. Laziness of workers can cause reworks in the project [26, 27]. Hence bad attitude may have crucial effects on work, causing workers to become dispirited and unhappy which would cause mistakes to occur more often and output would likely be poor [38].

H. Slow Information Flow Among All Parties Involved in the Project Causing Redundant Work

Communication and effective information flow are a pivotal part in construction procedures [36, 39]. Having an efficient information flow among all parties can give a focused favorable advantage to a construction project [19, 29]. Bad information flow will cause redundant work.

I. Improper Material Handling by the Workers

All materials received at site should be unpacked and arranged properly to avoid any damage [23, 31-33]. If the materials are not handled with care, damage can occur generating construction waste [36, 38].

J. Rework due to Miscommunication Among Engineers and Workers

Failure to communicate can ultimately lead to serious accidents at site, project rework, and employee problems [31]. When there is miscommunication among the team, rework will

occur often and more material waste will be produced. Effective communication is critical for collaborative work [23, 32]. Clear communication not only reduces rework, it can also significantly increase the efficiency of the construction process [1, 34].

K. Lack of Possibility of Ordering Small Quantities of Materials

Lack of possibility of ordering small quantities of materials is one of the common causes of construction waste generation [30]. Usually, only bulk orders can be ordered from a supplier [7, 10, 33]. There would be a minimum ordering amount to be fulfilled even though the amount required is less than the minimum order. Therefore, material waste such as cement, timber, etc. will occur if there is excess of unused material.

VI. PRELIMINARY SURVEY OUTCOME

While conducting the preliminary survey, the construction practitioners suggested six major root causes which contribute to waste generation of Malaysia construction industry. They are “human mindset of ignorance”, “political involvement”, “errors during installation”, “less usage of prefabricated materials”, “breakdown of equipment during concreting work” and “lack of BIM usage for design”. Regarding the first, human nature is to be of no concern on the waste and environment and the actions that must be taken. For “political involvement”, we should note that there has been a change in recent government, thus, many construction projects have faced design changes, kept on hold or stopped [40], “Errors during installation” occur during improper installation of scaffolding which may cause damage to the materials used [4], “Less usage of prefabricated materials” shows that material wastage compared to conventional construction can be reduced, “Breakdown of equipment during concreting work” may occur during malfunction of concrete pump where the leftover concrete in the pump will turn into waste. Lastly, “lack of BIM (Building Information Modeling) usage” for design purpose shows that BIM can help minimize double handling of work from the design stages.

VII. CONCLUSIONS

This research found that construction waste generation is a major issue in the Malaysian construction industry, thus it is crucial to identify the root causes which contribute to construction waste generation in order to minimize the generated waste. After analysis, 46 root causes with mean value more than 4.00 were considered as crucial root causes. The acquired root causes will aid the construction practitioners to curb the construction waste generation from the initial stages of construction. The outcome of this research will not only be valuable in minimizing material waste generation but it will also support cultivating environmental awareness in construction industry of Malaysia.

ACKNOWLEDGMENT

We would like to thank the Ministry of Education, Malaysia for funding this study under the Fundamental Research Grant Scheme (FRGS) Vot 1624 which is headed by Ts. Dr. Sasitharan Nagapan.

REFERENCES

- [1] S. Nagapan, I. A. Rahman, A. Asmi, “Construction waste management: Malaysian perspective”, International Conference on Civil and Environmental Engineering Sustainability, Johor Bahru, Malaysia, April 3-5, 2012
- [2] S. Ulubeyli, A. Kazaz, V. Arslan, “Construction and demolition waste recycling plants revisited: Management issues”, Procedia Engineering, Vol. 172, pp. 1190-1197, 2017
- [3] S. Lockrey, H. Nguyen, E. Crossin, K. Verghese, “Recycling the construction and demolition waste in Vietnam: Opportunities and challenges in practice”, Journal of Cleaner Production, Vol. 133, pp. 757-766, 2016
- [4] A. P. Kern, F. M. Dias, P. M. Kulakowski, “Waste generated in high-rise buildings construction: A quantification model based on statistical multiple regression”, Waste Management, Vol. 39, pp. 35-44, 2015
- [5] M. Jain, “Economic aspects of construction waste materials in terms of cost savings – A case of Indian construction”, International Journal of Scientific and Research Publications, Vol. 2, No. 10, pp. 1-7, 2012
- [6] S. O. Ajayi, L. O. Oyedele, M. Bilal, O. O. Akinade, H. A. Alaka, H. A. Owolabi, K. O. Kadiri, “Waste effectiveness of the construction industry: understanding the impediments and requisites for improvements”, Resources, Conservation and Recycling, Vol. 102, pp. 101-112, 2015
- [7] D. Kulatunga, R. Amaratunga, R. Haigh, R. Rameezdeen, “Attitudes and perceptions of construction workforce on construction waste in Sri Lanka”, Management of Environmental Quality, Vol. 17, No. 1, pp. 57-72, 2006
- [8] A. Bakshan, I. Srour, G. Chehab, M. El-Fadel, “A field based methodology for estimating waste generation rates at various stages of construction projects”, Resources, Conservation and Recycling, Vol. 100, pp. 70-80, 2015
- [9] S. O. Ajayi, L. O. Oyedele, K. O. Kadiri, O. O. Akinade, M. Bilal, H. A. Owolabi, H. A. Alaka, “Competency-based measures for designing out construction waste: task and contextual attributes”, Engineering, Construction and Architectural Management, Vol. 23, No. 4, pp. 464-490, 2016
- [10] L. Muhwezi, L. M. Chamuriho, N. M. Lema, “An investigation into materials wastes on building construction projects in Kampala-Uganda”, Journal of Engineering Research, Vol. 1, No. 1, pp. 11-18, 2012
- [11] R. A. Begum, S. K. Satari, J. J. Pereira, “Waste generation and recycling: Comparison of conventional and industrialized building systems”, American Journal of Environmental Sciences, Vol. 6, No. 4, pp. 383-388, 2010
- [12] M. I. A. Rahim, N. Kasim, I. Mohamed, R. Zainal, N. Sarpin, M. Saikah, “Construction waste generation in Malaysian construction industry: illegal dumping activities”, IOP Conf. Series: Materials Science and Engineering, Vol. 271, No. 1, pp. 1-8, 2017
- [13] R. Ikau, C. Joseph, T. Tawie, “Factors influencing waste generation in the construction industry in Malaysia”, Procedia - Social and Behavioral Sciences, Vol. 234, pp. 11-18, 2016
- [14] S. H. Hassan, H. A. Aziz, M. N. Adlan, I. Johari, “The causes of waste generated in Malaysian housing construction sites using site observations and interviews”, International Journal of Environment and Waste Management, Vol. 15, No. 4, 295-308, 2015
- [15] S. A. Dajadian, D. C. Koch, “Waste management models and their applications on construction sites”, International Journal of Construction Engineering and Management, Vol. 3, No. 3, pp. 91-98, 2014
- [16] T. Khaleel, A. Al-Zubaidy, “Major factors contributing to the construction waste generation in building projects of Iraq”, The 3rd International Conference on Buildings, Construction and Environmental Engineering, Egypt, October 23-25, 2017
- [17] J. D. Owolabi, L. M. Amusan, C. O. Oloke, O. Olusanya, P. Tunji-Olayeni, D. Owolabi, P. Joy, I. Omuh, “Causes and effect of delay on project construction delivery time”, International Journal of Education and Research, Vol. 2, No. 4, pp. 197-208, 2014

- [18] W. Yuan, C. Deng, H. Zhu, J. Li, "The statistical analysis and evaluation of examination results of materials research methods course", *Creative Education*, Vol. 3, pp. 162-164, 2013
- [19] S. Alwi, K. Hampson, S. Mohamed, "Non value-adding activities in Australian construction projects", *International Conference on Advancement in Design, Construction, Construction Management and Maintenance of Building Structure*, Bali, Indonesia, March 27-28, 2002
- [20] E. M. Nazech, D. Zaldi, B. Trigunaryah, "Identification of construction waste in road and highway construction projects", *The 11th East Asia-Pacific Conference on Engineering and Construction*, Taipei, Taiwan, November 19-21, 2008
- [21] S. G. Dalibi, "Resultant effects of poor supervision in construction projects in Nigeria", *6th Building and Construction Economic Round Table*, Abuja FCT, Nigeria, July 14-15, 2016
- [22] C. T. Formoso, L. Soibelman, C. De Cesare, E. L. Isatto, "Material waste in building industry: Main causes and prevention", *Journal of Construction Engineering and Management*, Vol. 128, No. 4, pp. 316-325, 2002
- [23] G. Polat, A. Damci, H. Turkoglu, A. P. Gurgun, "Identification of root causes of construction and demolition waste: The case of Turkey", *Procedia Engineering*, Vol. 196, pp. 948-955, 2017
- [24] A. B. Wahab, A. F. Lawal, "An evaluation of waste control measures in construction industry in Nigeria", *African Journal of Environmental Science and Technology*, Vol. 5, No. 3, pp. 246-254, 2011
- [25] Y. Zhao, D. K. H. Chua, "Relationship between productivity and non value-adding activities", *11th Annual Conference of the International Group for Lean Construction*, Blacksburg, Virginia, USA, 2003
- [26] W. Lu, H. Yuan, "A framework for understanding waste management studies in construction", *Waste Management*, Vol. 31, No. 6, pp. 1252-1260, 2011
- [27] X. Wang, P. Kang, V. W. Y. Tam, "An investigation of construction wastes: an empirical study in Shenzhen", *Journal of Engineering, Design and Technology*, Vol. 6 No. 3, pp. 227-236, 2008
- [28] A. F. Urio, A. C. Brent, "Solid waste management strategy in Botswana: The reduction of construction waste", *Journal of the South African Institution of Civil Engineering*, Vol. 48, pp. 18-22, 2006
- [29] M. Osmani, J. Glassand A. D. Price, "Architects perspectives on construction waste minimisation by design", *Waste Management*, Vol. 28, No. 7, pp. 1147-1158, 2008
- [30] C. S. Poon, A. T. W. Yu, S. W. Wong, E. Cheung "Management of construction waste in public housing projects in Hong Kong", *Construction Management and Economics*, Vol. 22, No. 7, pp. 675-689, 2004
- [31] G. A. Bekr, "Study of the causes and magnitude of wastage of materials on construction sites in Jordan", *Journal of Construction Engineering*, Vol. 2014, ArticleID 283298, 2014
- [32] B. Nikmehr, M. R. Hosseini, M. Oraee, N. Chileshe, "Major factors affecting waste generation on construction sites in Iran", *6th International Conference on Engineering, Project, and Production Management*, Gold Coast, Australia, September 1-4, 2015
- [33] T. O. Adewuyi, I. A. Odesola, "Factors affecting material waste on construction sites in Nigeria", *Journal of Engineering and Technology*, Vol. 6, No. 1, pp. 82-99, 2015
- [34] O. O. Fadiya, P. Georgakis, E. Chinyio, "Quantitative analysis of the sources of construction waste", *Journal of Construction Engineering*, Vol. 2014, ArticleID 651060, 2014
- [35] L. Y. Tam, I. W. Shen, H. Fung, J. Y. Wang, "Controlling construction waste by implementing govern-mental ordinances in Hong Kong", *Journal of Construction Innovation*, Vol. 7, No. 2, pp. 149-166, 2007
- [36] L. Ekanayake, G. Ofori, "Construction material waste source evaluation, proceedings: Strategies for a sustainable built environment", *Strategies for a Sustainable Built Environment*, Pretoria, South Afrika, August, 2000
- [37] R. A. Garas, Anis, E. A. Gammal, "Material waste in the Egyptian construction industry", *9th Annual Conference of the International Group for Lean Construction*, National University of Singapore, Singapore, 2001
- [38] M. S. Pakhare, A. B. More, N. V. Bhalerao, "To Identify the root causes for wastages of construction materials", *International Journal of Advance Research and Innovative Ideas in Education*, Vol. 3, No. 4, pp. 2137-2139, 2017
- [39] S. Senaratne, D. Wijesiri, "Lean Construction as a strategic option: testing its suitability and acceptability in Sri Langka", *Lean Construction Journal*, Vol. 2008, pp. 34-48, 2008
- [40] The Star Online, "Govt Scraps MRT 3 Project", available at <https://www.thestar.com.my/news/nation/2018/05/31/govt-scraps-mrt-3-project-pm-we-must-reduce-our-borrowings>, 2018