International Journal of Management (IJM)
Volume 11, Issue 7, July 2020, pp. 1099-1106, Article ID: IJM_11_07_097
Available online at http://www.iaeme.com/IJM/issues.asp?JType=IJM&VType=11&IType=7
ISSN Print: 0976-6502 and ISSN Online: 0976-6510
DOI: 10.34218/IJM.11.7.2020.097

CONSTRUCTION SOLID WASTE MANAGEMENT ON THE BUILDING SITE: A LITERATURE REVIEW

Abdulrazak H. Almaliki
Department of Civil Engineering,
Ph.D., CE. Assistant Professor, Faculty of Engineering,
Taif University, Saudi Arabia
razak.791@gmail.com

ABSTRACT

Building construction is a key aspect of infrastructure development and urban growth in both developing and developed countries. However, the construction sector generates too much waste that pollutes the environment. Waste reduction is becoming a major research topic in the field of construction and building-site management. Solid waste management at the construction site is the act of reducing, reusing, and recycling the generated waste to minimise the quantity of solid waste deposited on the landfills. Contractors maximize profits by minimizing the generation of waste on-site. Waste reduction not only saves the environment from pollution but also reduces the deposition costs and the purchasing expenses of some raw materials. Today, construction solid waste management is a global concern for sustainable construction sector and on-site construction management. Owing to such a significant concern, this research is a critical literature review of the published research on construction solid waste management. It has focused on the factors leading the accumulation of solid waste, its effects, the best practices for on-site solid waste management, and the factors behind failures in many adopted waste management initiatives.

Key words: Construction solid waste, Waste control, Waste management, environment.

Cite this Article: Abdulrazak H. Almaliki, Construction Solid Waste Management on the Building Site: A Literature Review, *International Journal of Management*, 11(7), 2020, pp. 1099-1106.
http://www.iaeme.com/IJM/issues.asp?JType=IJM&VType=11&IType=7

1. INTRODUCTION

By definition, construction solid waste is the unused solid materials or products generated because of various construction activities taking place at the site during preconstruction, post-construction, and construction phase (Rahim, 2017). Some scholars such as Saadi, Ismail, and

Alias (2016); Hasmori et al., (2020), have defined construction solid waste as unwanted materials from the renovation, construction, and demolition activities taking place at the building site. Such unwanted materials include timber pieces, steel, concrete materials, and other unnecessary building materials. Today, there is a high rate of solid waste increase at the construction site. Construction projects generate millions of tonnes of solid waste that may cause environmental degradation if not well managed (Saadi, Ismail, and Alias, 2016). According to Marzouk and Azab (2014), the rise in the amount of construction waste generated at the building sites is due to inefficient waste management practices at the site. Not only will such waste harm the surrounding environment but also it will create an undesirable effect on the construction time, project productivity, production costs, economic and social impacts. On the industrial scale, construction waste contributes to a reduction in the value of productivity and performance for all construction projects. The only way to overcome the aforementioned issues is to promote effective construction waste management practices. Yuan (2013) indicates that solid waste management is the sustainable approach to reduce on-site waste and mitigate its negative effects on the society, surroundings, and industry at large. This research reviews the existing research on the various solid waste management practices that can reduce on-site solid waste and provide mutual benefits to the economy, society, and the environment. Such practices to minimize solid waste on the building sites can be traced from existing research publications of 2010 up to 2020.

2. CRITICAL LITERATURE REVIEW

Recent studies and research developments have sufficient knowledge on environmental effects of on-site solid waste. This has furthered research developments on waste management as a sustainable approach to construction management. The construction sector needs to be sustained through effective management practices. Effective waste management practices will significantly contribute to a reduction in environmental pollution. Several scholars have indicated that unwanted debris from demolition and construction processes and activities contribute to pollution of the environment and damage the ecosystem (Nagapan et al. 2013; Yuan, 2013; Wahi et al, 2016; Hasmori et al., 2020).

Several reasons have been put forward to explain the cause and the impact of construction waste. Hassan et al (2012) found that on-site solid waste accumulates due to insufficient/inefficient utilization of construction materials. At every phase of building, solid waste causes an environmental impact. For the last three decades, the world has been grappling with environmental pollution, some of which are caused by such unwanted materials. This impact will harm the future generation if there are no sustainable measures are adopted to combat the challenge (Hossain et al., 2011). According to Njoroge (2012), unsuccessful waste management in most construction projects is attributed to improper waste disposal facilities and ineffective waste regulations. Besides, some issues, such as illegal waste dumping and maintenance of waste disposal facilities also need significant attention.

Several scholars have also highlighted various effects of construction solid waste. The research conducted by Njoroge (2012) indicated that poor waste management of construction solid waste in terms of handling and disposal destroy the entire ecosystem and cause several public health challenges such as lead poisoning and asbestosis. In the same accord, Nor et al. (2013) noted that construction solid waste depletes natural resources, block the potential sewer systems, change the living environment, increase energy consumption and lead into unbalanced ecology. In contrast, against Njoroge (2012), Nagapan et al. (2012) indicated that illegal dumping and creation of unlawful dumping sites are caused by financial constraints and the unfavorable location of the building site. Sometimes, the landfill site is too far from the building site; hence, contractors try to minimize costs and decide to refuse the disposal of

wastes into the allocated landfills. Besides, Nagapan et al., (2012) found that some contractors try to dodge payments for transportation and landfill charges to maximize profits from the construction project. Therefore, the construction sector has a significant role to play to ensure that contractors engage in sustainable development practices. This can be done by introducing new enforcement regimes and enacting new legislation to enforce the best solid waste management practices at the building sites.

Sustainable waste management in construction sites is defined as a culture or a discipline that addresses issues to do with generation solid waste, collection, storage, disposal and processing of such unused materials while bearing-in-mind the public health, economic, aesthetics, and environmental concerns (Fauziah and Agamuthu, 2012). In other words, waste management involves the collection, monitoring, processing, transportation, and dumping of waste materials. Despite the initiatives adopted by several contractors across the world to reduce the generation of on-site waste, good management of the unused materials and construction debris remains a great challenge (Tey et al., 2013). This means contractors on many construction sites mismanage most of the waste. However, there has been an increase in research developments and innovations to advance on-site waste management. Several scholars have indicated various approaches to effective and sustainable solid waste management. According to Nagapan, Rahman, and Asmi (2012), the solid waste management process goes beyond mere waste disposal. It should encompass strategies to sustainably utilize available construction resources to reduce the generated waste per project. Therefore, on-site waste management also includes the efficient utilization of generated waste. Unfortunately, many contractors dispose of the waste directly to the landfills as the only way to manage such large amounts of the generated waste. Contractors prefer this method because solid waste materials are presumed to be having less premium value. According to Saadi, Ismail, and Alias (2016), direct waste disposal practices are likely to be prohibited in the future because the construction sector has generated a large amount of waste in the environment due to the increasing amount of waste generated by construction projects by year. Most of the existing landfills are already overflowing, while others have reached the maximum level of acceptable pollution. The study conducted by Nagapan, Rahman, and Asmi (2012) found that out-of-the 289 landfills in Malaysia, 113 landfills are not working because they have either reached their full capacities or the protests from the residents in the nearby places have led to their closure. Therefore, there is a need for alternative mechanisms of preventing waste accumulation and initiatives from reusing, reducing, and recycling the already-generated solid waste. These initiatives are called the 3Rs of waste management at the building site. Dania, Kehinde, and Bala (2007) emphasize that the construction of solid waste must go through the pre-treatment processes before its disposal into the gazetted landfill. Before getting into the landfills, construction waste should pass through the 3R concept, i.e., reduction, reuse, and recycle in the same order. At the end of these criteria, the waste management process will end in the landfills. Waste reduction aims at reducing the amount of the generated waste materials out of the ongoing construction activities. The aim is to ensure that the resources are efficiently utilized to produce less waste before it becomes a bigger problem. According to Esa (2017), Waste reduction in construction management is achieved by avoiding or reducing processes and activities that can cause waste accumulation. Nevertheless, the waste reduction should begin at the planning stage by including the reduction strategies in the management plan and implementing the reduction strategy throughout the entire construction cycle. Besides, Wahi et al. (2016) noted that waste reduction is the most efficient and effective approach to waste management because it does not deplete a lot of resources. Before adopting any waste reduction strategy, it would be important to first recognize the various factors that influence waste generation in building sites. Nagapan et al. (2012b) found that waste generation is caused by poor site conditions,

weather factors, procurement errors, poor management planning, poor human resource capacity, poor material handling, and design challenges/changes. Fortunately, all these factors, as mentioned earlier, can be addressed with effective waste reduction strategies. Waste reduction strategies not only reduce waste generation but also simplify the task of waste recycling, reduce waste disposal, and the associated transportation costs (Wang et al., 2014). Certainly, it is not possible to eliminate waste at the building site. Each building site will generate various types of waste irrespective of the measures adopted to avoid waste. However, effective waste reduction strategies will minimize the accumulation of waste and enhance the optimum utilization of building materials. Because contractors cannot eliminate waste, the next stage of consideration in construction solid waste management is waste reuse. Nagapan et al. (2012) found that some of the unused constituents and supplies such as concrete and broken bricks can be used as sub-grading material for the construction of footpaths and access roads to the building site. By definition, waste reuse is the use of unused materials such as timber formwork and broken bricks to perform other functions or do the same function they were intended to do. Therefore, not all the unused materials are useless, and they can be put to other uses to minimize resource wastages and reduce construction costs. This makes the project more profitable hence boost the revenue growth. Past the reuse stage, the next phase to consider is solid waste recycling, which is the process of gathering all the utilized and the reused materials and turn them into other usable items (Wahi et al., 2016). According to Hasmori et al. (2020), all the unused items at the building site should be sorted and sent to the processing machinery for conversion into other raw-materials or for being remanufactured into other usable products. The sorting process for waste recycling can be conducted as the off-site or on-site technique for waste management (Gaurav, Varma, and Khan, 2019). In the same accord, on-site recycling involves isolation of various materials designated to produce a new product where such a product can be used as a raw-material to support other construction processes and activities while off-site recycling involves separation and transportation of the used construction materials to other construction organizations to be used as raw materials. Waste recycling strategies require a high level of investment in research and development to yield sustainable raw-materials and products. This would require a high level of government participation, regulation, and law enforcement to ensure that the construction industry is engaged in successful recycling programs in the construction sector. Recycling sustains the future construction industry by ensuring raw-material availability and reducing the negative impact of solid waste on the environment. Recycling is also part of sustainable environmental management. According to Abu-Eusuf et al. (2012), construction waste at the building site is generated by mistakes in quantity surveys, wrong material storage, ordering errors, poor conditions at the site, lack of proper storage and material handling practices, poor supervision, poor quality of materials, poor material handling, and storage at the building site. Several scholars agree with Abu-Eusuf et al. about the cause of solid waste at the building site (Jaillon et al., 2009; Nagapan et al. 2013; Yuan, 2013; Hasmori et al., 2020). To bridge these gaps, there should be sustainable waste streams and ensuring good practices to reduce the rates of the generated waste. Like other construction management disciplines, waste management is the process cycle that should be adopted by the organization to plan, control, and evaluate the volume of waste produced by the ongoing project. There are various activities involved in achieving sustainable solid waste management at the building site. These include waste collection, storage, transportation, recycling/processing, and disposal. The landfills should be closer to the construction site to minimize transportation costs. The processing activities should be environmentally friendly, while the waste collection phase should be less costly and economical to minimize revenue outflows. Before disposal, all the generated waste should pass through the various pre-treatment processes so that the amount of solid waste sent into the landfill is minimal.

The 3R criteria (reduce, reuse, and recycle) has been proposed by several scholars as to the best approach to solid waste construction (Giusti, 2009; Fauziah & Agamuthu, 2012; Hasmori et al., 2020). The approach of dumping waste in the landfills should not be used before all other possible measures have been exhausted. Besides, the issue of illegal dumping should be addressed through industrial-self regulation and policy implementation. According to Gentil et al. (2011), it was found that illegal dumping is the result of the limited state for the existing landfills. Therefore, the government should have the upper hand in ensuring the adoption of sustainable waste control practices via guidelines, technology, policy, and regulations. Constructors and society enjoy mutual benefits from the adoption of sustainable waste control practices at the building sites. Such benefits include efficient utilization of the resources, maximization of the product design, elimination of the environmental impact, and reduction of the cost of transporting and disposing of huge amounts of solid waste to the landfill (Ismam and Ismail, 2014).

The disposal method pollutes the environment and reduces the size of the available land for urban production, yet it is one of the common methods applied in many countries across the world (Fauziah & Agamuthu, 2012; Abolore, 2012). Therefore, construction firms must engage in research and innovations to come up with sustainable methods, tools, and techniques to facilitate the collection, processing, monitoring, and transportation of solid waste. According to Mallak & Ishak (2012), waste management in many construction firms fails due to financial constraints, unfavorable government policies, packaging problems, technology inefficiency, and information and awareness problems. It is now the time for contractors to recover from these hardware and software challenges before the reputation of the building sector gets eroded. In the same accord, Cheng & Ma (2013) indicated that the survival of the future construction industry entirely depends on the capacity of contractors to adopt sustainable waste management practices. Because of the increasing urban expansion into rural areas, contractors must implement sustainable construction waste management practices. The study conducted by Mallak & Ishak (2012) indicates that United Kingdom contractors have adopted the 3R hierarchy of reducing, reuse, recycle, and disposal strategy to promote sustainable construction solid waste management. The knowledge and awareness development about the waste reduction practices was facilitated by the introduction of policies and guidelines on sustainable waste management practices. In the same accord, Yu et al. (2013) found that the government of Hong Kong has introduced a waste disposal scheme aimed at reducing construction solid waste and combat the problem over 37,690 tonnes of waste produced per day. The guidelines and action should back the initiative plans to promote sustainable waste reduction, reuse, and recycling rather than promoting direct waste disposal.

The study conducted by Mallak & Ishak (2012) found that waste management is affected by several obstacles, including poor government cooperation, lack of adequate finances, packaging problems, poor technology use, and lack of knowledge on best practices to manage solid waste at the building sites. Therefore, it would be imperative for contractors to invest in knowledge and awareness development to increase the human resource capacity to develop effective construction solid waste management interventions. Besides, it would be imperative to revise the common waste management practices adopted by contractors to come up with a comprehensive and sustainable construction waste management strategy.

Some studies have suggested the adoption of the Construction and Demolition waste management (CDWM) approach. The study conducted by Bosch-Sijtsema & Buser (2017) focused on the systematic review of the existing research on the CDWM approach to solid waste management. The focus was on those articles that directly refer to the monitoring, evaluation, processing, and transportation of the demolition and construction waste at the building sites. The authors found that LCA assessment and performance, large material

production analyses, economic comparison and optimization of process models drive the adoption of construction and demolition waste management practices at the building sites. Scholars highlight the need for advanced technology to improve designs, minimize waste generation, and support CDW management. Some scholars such as Akinade et al. (2015); Alwan et al. (2017) highlight the importance of adopting the Building Information Modeling/BIM technology to design for the demolition or to support sustainable waste management. The benefits of BIM technology are significant for the future growth of the construction sector. Although the study was focused on CDW management, the authors did not give a comprehensive analysis of the applicability of BIM technology in real building settings. Because of the growing urbanization across the world and the increasing focus on the renovation of the ancient buildings in the urban areas, it necessary to further research developments on how the construction industry can align their waste control strategies with CDW practices to ensure sustainable waste management in urban areas.

Similarly, the study conducted by Markandeya Raju Ponnada and Kameswari (2017) aimed at compiling the existing literature on CDW management practices adopted by contractors in different countries and how regulatory authorities promote sustainable waste management. The aim was to explore the properties & causes of waste generation, its harmful impact, and how the 3R criteria can improve waste management. The authors indicate that all on-site waste is recyclable despite the large waste stream in the environment. The authors also noted that solid construction waste is more than domestic waste gathers in two years of building occupancy. It is imperative to recycle such waste and make it more useful to the contractor and the society. It is less costly to recycle the generated was than transporting and disposing of it into the landfill. Secondly, Demolition and construction waste because large waste streams which will damage the sector. The CDW stream is complex because it is largely composed of various materials such as unwanted concrete, rubble, construction debris, timber, steel, concrete, clearance materials, threads and other materials produced by different activities such as building renovations, roadwork, site preparation, land formation and excavations, and construction/renovation (Gaurav, Varma, and Khan, 2019). Construction/demolition waste also includes cases of wastage in fuel and labor used in construction activities. Such unwanted debris is a great concern for the future construction sector because it has an environmental effect on the approval of the ongoing construction projects and the future efficiency of the construction sector. Even some of the construction wastes that have been regarded as less harmful are currently proven to generate harmful products/substances that pollute the environment. Therefore, the construction sector should adopt the two construction management practices and ecologically sound planning practices to create a sustainable environment.

3. CONCLUSION

This critical literature review has been conducted to explore the causes of solid waste and the best management practices that should be adopted to combat the challenge of large amounts of cumulative solid waste from building sites. Scholars have indicated that waste generation is caused by poor site conditions, weather factors, procurement errors, poor management planning, poor human resource capacity, poor material handling, and design challenges/change. Research has shown that many contractors are still using direct disposition of solid waste on landfills, which is reducing landfill space, polluting the environment, and causing community tension. The 3R strategy has been recommended as an ecological approach to on-site solid waste management. This means that all contractors have to first reduce the quantity of the generated waste, then embark on its reuse and proceed to the recycling phase before depositing such waste into the landfill. However, it has been noted that adoption 3R strategy requires heavy investment in research and development as well as

technology innovations to sustain the process of monitoring, processing, collecting, and evaluating the generated solid waste. We have reviewed 25 research papers, but the 3R strategy has been ranked as the most sustainable approach to construction management. It has been noted that illegal landfilling and poor waste management practices are derailing the future of the construction sector. Failure to adopt the best construction management practices is caused by financial constraints, unfavorable government policies, packaging problems, technology inefficiency, and information and awareness problems. Therefore, education of the workforce and the creation of awareness about modern construction waste management practices are crucial to sustainable on-site waste reduction. Besides, scholars suggest the need for contractors to adopt proper material handling practices, standardization of materials and designs, waste segregation for various building materials, and adoption of low waste construction technology to promote on-site waste reduction. These soft measures can be easily applied to the building site as the basic waste management practices despite the technology and techniques of constructing the building.

REFERENCES

[1] Abolore, A. A. 2012. Comparative Study of Environmental Sustainability in Building Construction in Nigeria and Malaysia. *Journal of Emerging Trends in Economics and Management Sciences, 3: 951-961*

[2] Ab- Eusuf, M., Ibrahim, M., & Islam, R. (2012). The Construction and Demolition Waste in Klang Valley, Malaysia. *Journal of the Malaysian Institute of Planner, 99-124*

[3] Akinade, O, Oyedele, L O, Bilal, M, Ajayi, S O, Owolabi, H A, Alaska, H A and Bello, S A 2015. Waste minimization through deconstruction: A BIM-based Deconstructability Assessment Score (BIM-DAS). *Resources, Conservation and Recycling, 105(Part A), 167-176.*

[4] Alwan, Z, Jones, P and Holgate, P 2017. Strategic sustainable development in the U.K. construction industry, through the framework for strategic sustainable development using Building Information Modelling. *Journal of Cleaner Production, 140(1), 349-358.*

[5] Bosch-Sijtsema, P., & Buser, M., 2017, September. Construction and Demolition Waste Management on the Building Site: A. In *Proceeding of the 33rd Annual ARCOM Conference* (Vol. 4, p. 6).

[6] Dania, A.A., Kehinde, J.O., and Bala, K., 2007, November. A study of construction material waste management practices by construction firms in Nigeria. In *Proceedings of the 3rd Scottish Conference for Postgraduate Researchers of the Built and Natural Environment, Glasgow* (pp. 121-129).

[7] Cheng, J. C. P., & Ma, L. Y. H. 2013. A BIM-based System for Demolition and Renovation Waste Estimation and Planning. *International Journal of Integrated Waste Management, Science, and Technology, 33(6): 1539-1551.*

[8] Esa M R 2017. Moving towards sustainable construction in Malaysia: a holistic model for construction and demolition (C&D) waste management Master Degree Thesis (Brisbance: University of Queensland)

[9] Fauziah S H and Agamuthu P 2012. Trends in sustainable landfilling in Malaysia, a developing country Waste Management and Research 30 656-663

[10] Gaurav, A., Varma, A.A., and Khan, A.U., 2019. Overview of Construction and Demolition waste and challenges identified to tackle the issue.

[11] Gentil, E. C., Gallo, D., & Christensen, T. H. (2011). Environmental Evaluation of Municipal Waste Prevention. *International Journal of Integrated Waste Management, Science and Technology, 31(12): 2371- 2379.*

[12] Hassan, S. H., Ahzahar, N., Fauzi, M. A., & Eman, J. 2012. Waste Management Issues in the Northern Region of Malaysia. Procedia - Social and Behavioral Sciences, 42: 175-181.

[13] Hasmori, M.F., Zin, A.F.M., Nagapan, S., Deraman, R., Abas, N., Yunus, R., and Klufallah, M., 2020, January. The on-site waste minimization practices for construction waste. In *IOP Conference Series: Materials Science and Engineering* (Vol. 713, No. 1, p. 012038). IOP Publishing.

[14] Hossain, M. S., Santhanam, A., Nik Norulaini, N. A., & Omar, A. K. M. 2011. Clinical Solid Waste Management Practices and its Impact on Human Health and Environment - A Review. *International Journal of Integrated Waste Management, Science and Technology, 754-766.*

[15] Ismam, J. N., & Ismail, Z. 2014. Sustainable Construction Waste Management Strategic Implementation Model. *Journal of WSEAS Transactions on Environment and Development, 10: 48-59*

[16] Nagapan S, Rahman I A and Asmi A 2012b. Factors contributing to physical and non-physical waste generation in the construction industry. *International Journal of Advancement in Applied Sciences 1 1-10*

[17] Marzouk M and Azab S 2014. Environmental and economic impact assessment of construction and demolition waste disposal using system dynamics. *Resources, Conservation, and Recycling 82 41-49*

[18] Nagapan, S., Rahman, I. A., & Asmi, A. (2012). Factors Contributing to Physical and Nonphysical Waste Generation in the Construction Industry. *International Journal of Advances in Applied Sciences (IJAAS), 1(1): 1-10.*

[19] Nagapan, S., Rahman, I. A., Asmi, A., Hameed, A., & Zin, R. M. (2012). Identifying Causes of Construction Waste - Case of Central Region of Peninsula Malaysia. *International Journal of Integrated Engineering, 4(2): 22-28*

[20] Njoroge. G. Kimani. (2012). Environmental Pollution and Impacts on Public Health: environmental pollution and impacts on public health. Retrieved from http:// www.unep.org/urban_environment/PDFs/ DandoraWasteDump-ReportSummary.pdf

[21] Nor, R., Raja, H., Noor, M., Ruslan, A., Ridzuan, M., Endut, I. R., Noordin, B., et al. (2013). The Quantification of Local Construction Waste for the Current Construction Waste Management Practices: A Case Study in Klang Valley. *Business Engineering and Industrial Applications Colloquium (BEIAC), 2013 IEEE, 183-188.*

[22] Rahim M H I A, Kasim N, Mohamed I, Zaina R, Sarin N, and Saikah M 2017. Construction waste generation in Malaysia construction industry*: illegal dumping activities GCoMSE2017 (Johor Bahru) vol 271* (Bristol: IOP Publishing) pp 1-8

[23] Saadi N, Ismail Z, and Alias Z 2016. A review of construction waste management and initiatives in Malaysia. *Journal of Sustainability Science and Management 11 101-114*

[24] Tam V W Y, Tam C M, Zeng S X, and Ng W C Y 2007. Towards adoption of prefabrication in construction *International Journal of Build. Science and Its Applications 42 3642-3654.*

[25] Tey J, Goh K, Kek S L, and Goh H. 2013. The current practice of waste management system in Malaysia: Towards sustainable waste management 1st FPTP Postgraduate Seminar 'Towards Sustainable Management' (Batu Pahat) (Batu Pahat: Universiti Tun Hussein Onn Malaysia) pp 1-5

[26] Wang, J, Li, Z, and Tam, V W (2014). Critical factors in effective construction waste minimization at the design stage: A *Shenzhen case study, China. Resources, Conservation and Recycling, 82, 1-7.*

[27] Wahi, N., Joseph, C., Tawie, R., and Ikau, R., 2016. A critical review of construction waste control practices: legislative and waste management perspective. *Procedia-Social and Behavioral Sciences*, *224*(11), pp.276-283.

[28] Yuan H 2013. A SWOT analysis of successful construction waste management. *Journal of Cleaner Production 39 1-8*