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BIM Competencies for Minimizing the Construction Remnant of Project Moving Forward from Linear to Circular Economy

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ABSTRACT

A modern lifestyle, alongside the advancement of technology has led to an increase in the type of waste and its amount and being generated, leading to a waste disposal catastrophe. Therefore in the past decades, construction and demolition (C&D) waste issues have received increasing attention from both practitioners and as well as from researchers around the world. An affordable waste management action to reduce waste at all phases of design and construction with special consideration to the long-term environmental and economic impacts of continuous waste generation. Therefore, many studies on coherent C&D waste minimization and management have been conducted. Although 21 process-related and 8 technology-related limitations in C&D waste management and minimization have not yet been resolved. Building information modeling (BIM) helps project participants improve the processes involved and technologies in the planning, design, construction, and demolition phases, thereby managing and minimizing C&D waste efficiently. Therefore, this paper identifies for coherent C&D waste management and minimization, such as phase planning, site utilization planning, 3D coordination, design review, quantity take-off, construction system design, digital fabrication, and 3D control and planning BIM has the potential opportunities. The BIM based approaches would C&D waste management and minimization processes and technologies by addressing existing limitations through in-depth literature review.

KEYWORDS: *Construction waste management, classification of CW, source of CW, sustainable waste management, BIM*

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INTRODUCTION

Construction industry provides one of basic requirement i.e. shelter of the civilized population. On another hand with increased living standard, infrastructure demand projects, changes in consumption habits, as well as natural increase in population has become serious problem for every nation in terms of acceptable amount waste generation.

To overcome these gaps and to enable better management level guidance over construction waste, during entire phase of project, a new modeling technique is proposed in this paper

Circular Economy Concept

Increased global attention towards the concept\ of the circular economy owing to the need for managing the finite resources efficiently. The concept of circular economy was widely accepted and promoted by business and governments because it is regarded as the solution for reconciling the seemingly conflicting objectives of businesses and environmental sustainability These include waste-to-energy, supply chain, waste-to- resource supply chain, eco-industrial park, cradle-to- cradle, industrial ecology, regenerative design product- service-system, blue economy, design-for-deconstruction All these concepts form the basis for what is known as today‘s Circular Economy and the common feature among them is the need to manage resources, minimize waste and to protect the environment.

Construction Waste

Construction industry plays a key role in socio-economic development of the country. Nowadays with rapid growth construction industry has contributed significantly towards waste generation which has become serious problem for every nation. The grievous problem is the significant amount of construction activities on one hand and also the poor construction waste management (CWM) on the other. Several researchers and practitioners indicate that waste emanates that occur during planning, design, procurement, and also in construction stage. The waste also influences economical dynamics of society and also has an unenviable effect on the environment and surrounding.

Construction waste is one among the most harmful wastes that has been generated. Further there is no lack of management level guidance in construction industry to manage wastage during construction execution level puts an additional pressure.

It is a common practice for construction waste to be used for landfill, leads to extensive amounts of soil, water, and air pollution due to production of CO_2 and methane from anaerobic degradation of the waste. It also brings tremendous pressure on valuable landfill space, particularly in compact urban spaces like as those in Hong Kong, Singapore, and Japan. Researchers and practitioners of the industry have thus endeavored to manage construction waste by devising engineering, economical, policy and managerial approaches.

Globally Existing Condition of Construction Waste

Debris from construction and demolition projects constitutes about 35% of solid waste in the world; the majority ends up in landfills, in uncontrolled sites or in other inappropriate places.

A construction and demolition activity generates about 32% landfill waste and 25% of all used raw materials in the United Kingdom (UK). The consumption increased from 420 million tons in 2003 to 470 million tons in2013. Currently, the UK construction industry produces about 120 million tons of waste, of which 13million tons are materials that have been delivered to the site but are never used.

In U.S., the estimated amount of building-related waste generated in 2003 was about 170 million tons. It has been reported that the amount of CW in China had reached 1.5 billion tons in 2014, with most of the waste disposed of through land filling and illegal dumping, a decline from peak C & D activity in the early 2010s.

Construction and demolition activities generate about 44% of all waste generated within England.

The EC (European Commission) reported that construction waste is responsible for 25–30% of total waste generated in the European Union.

Indian Scenario of Construction Waste

In India the annual investment in construction activities is around 70 billion dollars and an additional investment of 50 billion dollars is expected for an annual growth rate of 15%. It is estimated that 163 billion dollars are needed for supporting infrastructure in the next 10 years. It stated that there is a shortage of about 41 million housing units to sustain the needs of the current population.

Estimated the material requirement for the housing sector require 55,000 million m^3 whereas the road sector requires an additional quantity of 750 million m^3.The rapid increase in construction activities pollute the environment due to waste generation. According to the global statistical reports, it is stated that the construction industry is considered as one of the bulk generators of waste. Annually of about 10–12 million tons of waste is being generated in the Indian construction industry. However, this number is misleading since this only includes the waste that is properly disposed and accounted for; there is also the practice of dumping construction waste by the roadside or on an empty plot of land and these activities are never been documented.

These kinds of waste disposal practices are quite prevalent and make the waste estimation process impossible and challenging in Indian context.

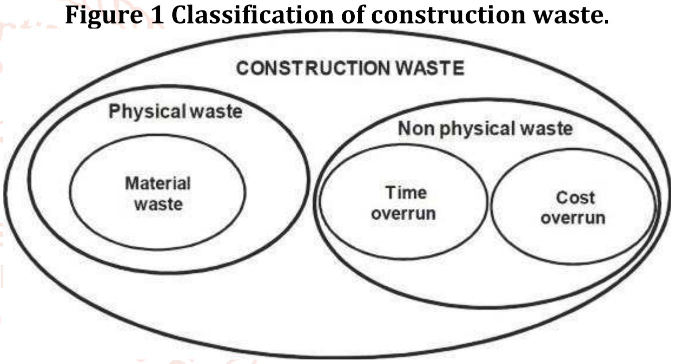
India has the relevant regulations for waste management but owing to their weak enforcement, construction firms place enforcement of waste management and reduction at the bottom of their agenda due to the complexity of incorporating them within the existing system. India is one of the top ten countries utilizing natural resources to satisfy the construction needs. Recycled materials such as aggregate originated from demolition reduce the demand for aggregates in the construction industry nearly about 12.3 million tons of raw materials can be conserved with proper recycling. There is considerable resistance to usage of recycled aggregates instead of virgin materials amongst the various management and workforce in construction firms of India.

Data collection on construction waste management in India is challenging and tedious due to lack of documentation on waste generation at construction sites. The Indian construction industry can be fragmented into small, medium and large constructions. Smaller construction sites do not indent to employ waste management at their sites. The practices encountered for handling waste at construction sites include: dump onto the sides of the roads; disposal into water bodies and low lying areas making data collection difficult. Large construction sites clear up the waste through conducting—pep talks‖ that addresses issues associated with housekeeping and adapting procedures such as implementing —wall of fame‖ and wall of shame‖ at their construction sites. These companies reuse waste generated at site as the land filling and market waste through local vendors. It is stated by Hansen that the number of disposal sites is being considerably decreased worldwide and thus need for alternative solutions are to be investigated.

Classification of Waste

Construction waste can be clustered into two categories namely; physical and non-physical waste as shown in Fig. 1

Figure 1 Classification of construction waste.



Physical wastes are generated in the form of material loss; contribute to a significant part of landfill. On the other hand, non-physical construction wastes mainly are nothing but time and cost overrun for construction projects; these problems would become more critical when a stoppage of a particular construction work and this cause the abandoning of the project.

A. Materials Waste in form of Physical Construction Waste

The major physical waste generated from construction activity is identified in the form of material waste like concrete leftover, steel scrap, demolished debris and others. Studies show that material waste has significant impact to the project cost as well as an adverse environment impact. One of the implications created from huge material quantities of waste is being illegal dumped. Illegal dumping is the unlawful deposit activity of waste onto land area and this unethical activity always cause problems to the public in general and to the environment in many places around the world. Wrongly disposal of are increasing and this contributes to pollution globally. Various countries are bogged down by this issue of illegal dumping of their waste.

Material waste significantly contributes additional cost to construction because it usually involves new purchases to replace wasted materials; rework costs, delays, and disposal cause financial losses.

B. Cost and Time Overrun in form of Non-Physical Waste

Construction industries are extremely concerned about projects time and costs. Globally most of these projects are having dilemma in cost and time overruns which 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 can lead to majority projects failure i.e. the issue of time and cost overrun in construction. Projects are becoming epidemic and have led to abandonment of many projects across the world. These problems are caused by poor financial management by the developers, wrong construction specification, lack of supervision, construction delays and lack of enforcement on existing rules. This has caused dissatisfaction of the buyers of abandoned homes and a tensed social relationship among developers and buyers have become prevalent which indirectly resulted into unhealthy conditions and also in declining purchasing power of new houses. In other words, non-physical waste has its impact on economic growth and social development of countries.

Sources of Waste Generation

Construction material waste arises from varied sources such as design, logistics, and physical construction processes. According to Sir Egan‘s Rethinking Construction report on the state of UK construction industry, up to 30% of all construction rework occurs, labour is used to half of its potential efficiency, and at least 10% of building materials for every construction project is wasted.

CW (Construction waste) generation occurs throughout the project from the pre- construction stage, rough construction stage and finishing stage. Generation of CW can be caused by various factors and it also very important to identify and understand those causes for controlling waste generation at source.

Extensive literature review was conducted to identify causes of construction waste in terms of their contributions and impacts. These results identified 81 factors categorized broadly into seven groups of construction waste into six categories: Procurement, Design, Material handling, Operations, External factor, Residual and Others as indicated in following table. Identification of the causative factors can help in awareness increment in construction practitioners to control construction waste.

Table 1 Table of Classification of Waste based on source

Sources of waste	Causes
Procurement	Ordering error, supplier‘s error resulting in excessive materials on site
Design	Changes to design, documentation error
Material handling	Transportation, off-loading, and in appropriate storage
Operations	Tradesperson‘s error, for example, Installing wrong materials and having to remove such materials
External factor	Weather -Humidity, temperature, vandalism- Inadequate security, Inadequate security
Residual	Cutting materials to sizes
Others	Lack of waste management plan, Festival celebration, Difficulties accessing construction site.

Sustainable Construction Waste Management

The numerous research works carried out on construction waste and the findings show several negative impacts to the social, environment and economy of a country. These impacts also contribute to reduced construction productivity and thus reduce the performance of the overall construction project. These negative impacts are pushing the construction industry to move toward sustainability by integration with sustainable approach. One of the effective ways to control CW is to adopt sustainable construction principles as sustainable construction is not only focused on environmental issues but also on economic and social aspects. Sustainability in CW can be seen as stepwise strategy to achieve desirable and most suited process depending on the conditions and waste generated type. This process can be converted into the waste management hierarchy, as shown in Fig. 2, which includes prevention, minimization, reuse, recycling, recovery and disposal of construction wastes.

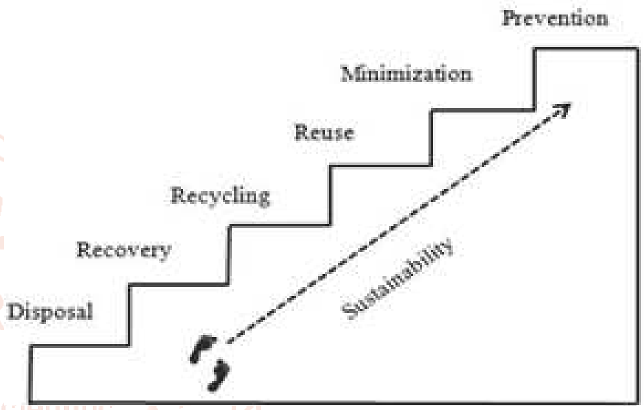


Figure 2 Hierarchy of Sustainable waste management

1. Prevention - best way to manage waste
2. Minimization /reduction - second most preferable way
3. Prevention & minimization- most used approach by many countries
4. Recycling of waste – but has good potential
5. Recovery - ranked fifth priority.
6. Disposal -last option, lowest criterion

Most recommended waste management principle is which should be considered to apply from highest desirability step i.e. prevention to lower priority steps.

Strategy Framework for waste-efficient projects

The strategies for delivering waste-efficient projects could be categorized under six different groups, as shown in Figure 3 as per the literature review

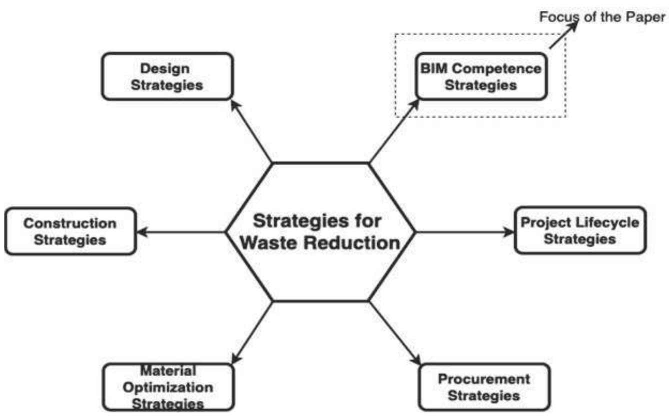


Figure 3 six different Strategy Framework for waste-efficient projects

BIM- Building information modeling

Building information modeling (BIM) can be utilized as a less expensive, virtual, and also as the computational environment to enable designers to ponder different design options, or contractors to evaluate different construction scheme with a view to minimizing construction waste generation.

BIM helps participants of the project to improve the processes and technologies in the planning, design, construction, and demolition phases, thereby managing and minimizing C&D waste efficiently. For coherent C&D waste management and minimization, such as design review, phase planning, 3D coordination, quantity take-off, site utilization planning, construction system design, digital fabrication, and 3D control and planning BIM has the potential opportunities. The BIM-based approaches would able to support C&D waste management and minimization processes and technologies by addressing existing limitations through in-depth literature review.

A. BIM Assistance in CWM

BIM is likely to impinge on the complete process of building documentation to shift from architectural drawings into a computerized model. BIM can already demonstrate all of the individual elements as in below description. However it cannot yet achieve all of these benefits incrementally without separate dedicated interface.

1. Provide project visualization.
2. Build fundamental intelligence into 2D (drawings)
3. Provide a single database of information that meets the needs of all stakeholders involved.
4. A beneficial project management tool
5. Enhance issue tracking process
6. Provide seamless information flow
7. Yields automated bills of material (Reduce the bidding time and effort)
8. Provision of shop drawings automatically
9. Off-site prefabrication Facility
10. Simplified material ordering and also ease site management
11. Improve field coordination and there by significantly reducing interferences
12. Change orders have been reduced
13. Cost saving and time reduction at every phase of design and construction
14. Provide owner with live and also intelligent file records (Provide electronic links for service) and maintenance Facilitate peak building performance throughout a life cycle
15. Faster and also more effective processes
16. Better design models can be rigorously analyzed; simulations can be performed quickly and benchmarking can be performed. Better communication and understanding from 3D visualization by using BIM.
17. Reducing Rework, problems are fixed early in the design and hence resulting in fewer issues in the plans and hence fewer hassles. Any design changes entered to the building model gets automatically updated. Resulting in less rework that can occurs due to possible drawing errors or omissions. There by reducing rework is very important and BIM helps in achieving it.
18. Better Collaboration BIM facilitates early participation of all the stakeholders and simultaneous work carried out by them and there by shortening the design time and reducing errors and omissions. Thus helps to reduce cost by doing simultaneous value engineering and not at the end of design process.
19. Generation of accurate and also consistent 2D drawings at any stage and it can be extracted at any time in the project process. If any changes are incorporated in the model, it is updated immediately and also accurately and hence generation of fully consistent drawing can be done as soon as design modifications are entered.
20. The design intent of a building both quantitatively and qualitatively (3D visualization) can be checked early in the process. Thus helps in accurate and early estimating the cost.
21. More predictable and better understandable controlled whole-life costs and environmental data Environmental performance and life cycle costs can be estimated.
22. Detection of errors and omissions (Clash detection) is the most rated way of saving owners time and money using BIM. Clash detection: In traditional 2D drawings, any changes in one drawing are not updated in other related drawings leading to many inconsistency and hence lots of errors and omissions. Lot of these errors is detected only after the execution of work at the site, which might lead to many site conflicts, legal disputes and change orders. However, BIM usage eliminates these issues. Identification of conflicts can be done on beforehand than they rather detected at site and hence enhanced co-ordination between the designers and the contractors. Detection of errors speeds the construction process; there by reduces costs, minimizes legal disputes and provides a better project process.
23. Reducing conflicts and modifications. The errors and omissions are detected early in the design and results in fewer conflicts and changes. The reduced conflicts and changes add maximum value to the project.

B. BIM in Waste Minimization.

The challenge now is provision of a novel platform for the next generation of tools and techniques that would identify and resolve the fundamental causes and origins of construction waste. The basis for such an approach could utilize Building Information Modeling (BIM) and related technologies, in particular Virtual Prototyping, in order to provide a platform for 'virtual' waste evaluation which reviews and assesses the of waste generation though out all stages of the construction project lifecycle. Although BIM design methods are not currently as fully utilized in the construction industry as in other industries, but there is general recognition that BIM adoption will become more pronounced to demonstrate not only the entire building life cycle but also aid an assess and evaluate the environmental performance an impacts of buildings

C. BIM expectations for CDW management

Five major categories of BIM expectations for CDW management, which are:

1. BIM-based collaboration for waste management,
2. waste-driven design process and solutions,
3. innovative technology in waste intelligence and analytics,
4. Waste analysis throughout building lifecycle and
5. Improved documentation for waste management.

D. Constraints in BIM Applicability

Limitations in adopting C&D waste management and minimization

1. Avoidance conflict of long periods of on-site storage
2. Non-including of detailed cost in the budget about C&D waste management strategies (labor, auxiliary elements, transportation, taxes, etc.).
3. Non-estimating the types and quantities of generated C&D waste for each phase of work.
4. The limited quantity of C&D waste being reused and recycled.
5. Possibilities to utilization in construction activities that can admit reusable materials were not analyzed.
6. Design to reduce the amount of used materials was not optimized.
7. Design changes frequent occurrence.
8. During the design phase standardization and dimensional coordination of building elements were not considered.
9. Frequent occurrence of unnecessary material handling than can lead to fracture of materials on site.
10. Non-tracking of movement of generated C&D waste from the moment it was generated right up to its final destination.
11. Inadequate space on site for provision for correct C&D waste management.
12. Non storage of materials in a protected area on site to prevent premature damage.
13. On-site waste sorting was not done at the event of C&D waste was generated.
14. Non-separating the hazardous waste and storing in suitable containers clearly labeled and kept under cover.
15. A coordinator for C&D WM (waste management) plan was not designated and responsible for ensuring that the plan was followed on site.
16. All stakeholders were not involved in the coordination of the C&D WM during the planning and design phases.
17. Communication among project participants to improve C&D WM and minimization was poor
18. A C&D WM plan needs to be applied and compliance was not ensured on site.
19. The construction site should to be kept clean and also well organized.
20. Coordination and review meetings for C&D WM and minimization were not planned appropriately and regularly.
21. Non avoidance of conventional construction processes that can lead to additional construction waste generation. (e.g., timber formwork, bamboo scaffold, etc.).

Conclusion

The application and the potential use of building information modeling (BIM) to drive out construction waste generation during all the phase of the construction was investigated through an extensive literature review. Recently, a significant number of major construction companies embarked on the implementation of integrated information technology solutions such as BIM, Enterprise resource planning (ERP) systems to better integrate various business functions. However, these integrated systems in the construction sector present information gaps and a set of unique challenges. BIM helps project participants improve the processes and technologies in the planning, design, construction, and demolition phases, thereby managing and minimizing C&D waste efficiently. There is a lively debate on the application of Building Information Modeling (BIM) to construction waste management (CWM). BIM can be utilized as a less expensive, virtual, and also as a computational environment to enable designers to ponder different design options, or contractors to evaluate different construction schemes with a view to minimizing construction waste generation. The goal of the BIM implementation success model is to better evaluate, plan, and implement BIM projects and also help senior managers make better decisions when considering

BIM systems in their organizations towards minimization of waste, there by promoting a socio- economical project. To attain the goal of a circular economy within the construction industry, various CWM strategies aiming to reduce construction waste to the barest minimum with proposed the wide adoption of BIM. Circular economy in construction is generally associated with physical waste generated during onsite executed construction activities.

Reference

[1] Alicia & co, Hongping Yuan (2013), ‘A SWOT analysis of successful construction waste management‘, Journal of Cleaner Production.

[2] Amal Bakchan; Beatriz C. Guerra, & co (2019), ‘BIM-Based Estimation of Wood Waste Stream‘, The Case of an Institutional Building Project Computing in Civil Engineering.

[3] Amal Bakchana, Kasey M. Faustb, Fernanda Leiteb (2019), ‘Seven- dimensional automated construction waste quantification and management framework: Integration with project and site planning Resources‘, Conservation & Recycling 146 (2019) 462–474.

[4] Arif M, Bendi D, Sabbagh TT, et al. (2012), ‘Construction waste management in India: An exploratory study‘, Construction Innovation 12: 133–155.

[5] Arif M, Egbu C, Haleem A, et al. (2009a), ‘Green construction in India: Gaining a deeper understanding‘, Journal of Architectural Engineering 15: 10–13.

[6] Assem Al-Hajj KH (2011), ‘Material Waste in the UAE construction industry: Main causes and minimization practice‘, Architectural Engineering and Design Management 7: 37–41.

[7] Beatriz C. Guerra, Amal Bakchan a, Fernanda Leite, & co, (2019), ‘BIM- based automated construction waste estimation algorithms: The case of concrete and drywall waste streams‘, Waste Management.

[8] Binxin Yang , Xiangnan Song , Hongping Yuan , Jian Zuo (2020), ‘A model for investigating construction workers‘ waste reduction behaviours‘, Journal of Cleaner Production 265.

[9] Clyde Zhengdao Li , Yiyu Zhao, Bing Xiao , Bo Yu, Vivian W. Y. Tam , Zhe Chen , Yingyi Ya (2020), ‘Research trend of the application of information technologies in construction and demolition waste

management‘, Journal of Cleaner Production 263 (2020) 121458.

[10] Ektewan Manowong (2012), ‘Investigating factors influencing construction waste management efforts in developing countries: an experience from Thailand‘, Waste Management & Research 30(1) 56–71.

[11] Hongping Yuan, Abdol R. Chini, &co (2012), ‗A dynamic model for assessing the effects of management strategies on the reduction of construction and demolition waste’, Waste Management 32 (2012) 521– 531.

[12] Jaime Solís-Guzmán, Madelyn Marrero, & co (2009), ‘A Spanish model for quantification and management of construction waste‘, Waste Management 29 (2009) 2542–2548.

[13] Jianli Hao, Hongping Yuan Jing Liu, Chee Seong Chin, Weisheng Lu, (2019), a model for assessing the economic performance of construction waste reduction, Journal of Cleaner Production.

[14] Jiayuan Wang, Zhengdao Li, Vivian W. Y. Tam (2015), Identifying best design strategies for construction waste minimization‘, Journal of Cleaner Production.

[15] Jiuping Xu, Yi Shi, S. and Siwei Zhao (2018), Reverse Logistics Network-Based Multi period Optimization for Construction and Demolition Waste Disposal‘, American Society of Civil.

[16] Jongsung, Won, Jack C. P. Cheng (2017), ‘Identifying potential Opportunities of BIM for construction and demolition waste Management and minimization‘, Automation in Construction.

[17] Kamyar Kabirifar, Mohammad Mojtahedi, Changxin Wang, Vivian W. Y. Tam, (2020), ‘Construction and demolition waste management contributing factors coupled with reduce, reuse, and recycle strategies for effective waste management: A review‘, Journal of Cleaner Production 263 121265.

[18] Lei Dua, Yingbin Fengb, Wei Lua, Lingkai Konga, Zhi Yang (2020), Evolutionary game analysis of stakeholders' decision-making behaviours in construction and demolition waste management, ‘ Environmental Impact Assessment Review 84 106408.

[19] Li Yinga, Zhen Yin, Tingting Guo, Jing Zhoub (2011), ‘Analysis and Research of Management Policy of Construction Waste in Beijing, ‘Procedia Environmental Sciences.

[20] Lukman A. Akanbia, Lukumon O. Oyedelea, & co (2018), ’Salvaging building materials in a circular economy: A BIM-based whole-life performance estimator‘, Resources, Conservation & Recycling129.

[21] M Mohammed, N Shafiq, N A W Abdallah, M Ayoub and A Haruna (2010), ‘A review on achieving sustainable construction waste management: A lifecycle approach‘, 2nd International Conference on Civil & Environmental Engineering; Earth and Environmental Science.

[22] Muhammad Bilal; Lukumon O. Oyedele; & co (2016), ‘BigData Architecture for Construction Waste Analytics (CWA): A Conceptual Framework‘, Journal of Building Engineering.

[23] Muhammad Fikri Hasmori, Ahmad Faizul Md Zin, Sasitharan Nagapan, Rafikullah Deraman1, &co. (2020), ‘The on-site waste minimization practices for construction waste‘, The 2nd Global Congress on Construction, Material and Structural Engineering.

[24] Mullick A. K (2014), ‘Management of Construction and Demolition Waste- Current Status‘, Indian Building Congress.

[25] Olugbenga O. Akinade, Lukumon O. Oyedele, Saheed O. Ajayi (2018), Designing out construction waste using BIM technology: Stakeholders' expectations for industry deployment‘, Journal of Cleaner Production 180 (2018) 375e385.

[26] Olusanjo O. Fadiya, Panos Georgakis, and Ezekiel Chinyio, (2014), Quantitative Analysis of the Sources of Construction Waste‘, Journal of Construction Engineering Volume 2014.

[27] Oyeshola Femi Kofoworola, Shabbir H. Gheewala (2009), ‘Estimation of construction waste generation and management in Thailand‘, Waste Management.

[28] Paola Villoria Saeza, Mercedes del Río Merinoa(2013), ‘Best practice measures assessment for construction and demolition waste Resources‘, Conservation and Recycling management in building constructions.

[29] Ponnada MR and Kameswari P (2016), ‘ Construction and demolition waste management – A review‘, International Journal of Advanced Science and Technology 84: 19–46.

[30] Rahman, & co, (2012), ‘Issues on Construction Waste: The Need for Sustainable Waste Management‘. Saheed O. Ajayia, Lukumon O. Oyedeleb(2018),

[31] ‗Critical design factors for minimising waste in construction projects: A structural equation modelling approach‘, Resources , Conservation & Recycling 137 (2018) 302–313.

[32] Saheed O. AjayiaLukumon O. Oyedele, (2018), ‗Critical Design Factors for Minimising Waste in Construction Projects: A Structural Equation Modelling Approach‘, Resources Conservation and Recycling 137(2018):302-313.

[33] Saheed O. AjayiaLukumon O. Oyedele, (2018), Waste-efficient materials procurement for construction projects: A structural equation modelling of critical success factors‘, Pu.

[34] Shen LY and Tam VWY (2002), ‘Implementation of environmental management in the Hong Kong construction industry‘, International Journal of Project Management 20: 535–543. Swarna Swetha Kolaventi , TP Tezeswi and MVN Siva Kumar(2019), ‘An assessment of construction waste management in India: A statistical approach‘, Waste Management & Research 1– 16 © The Author(s).

[35] Swarna Swetha Kolaventi; T. P. Tezeswi; and M. V. N. Siva Kumar(2018), ‘A Modelling Approach to Construction Waste Management‘, Urbanization Challenges in Emerging Economies, Columbia University.

[36] Talyan V, Dahiya RP and Sreekrishnan TR (2008), 'State of municipal solid waste management in Delhi, the capital of India', Waste Management 28: 1276–1287.

[37] Weisheng Lua, Chris Websterb, Ke Chena, Xiaoling Zhangc, Xi Chena (2017), 'Computational Building Information Modelling for construction waste management: Moving from rhetoric to reality', Renewable and Sustainable Energy Reviews 68.

[38] Weisheng, Lua, Hongping , Yuanb (2010), 'Exploring critical success factors for waste management in construction projects of China Resources', Conservation and Recycling 55 (2010) 201–208.

[39] Xueqing ZHANG1 and Yashuai LI (2012), 'Multi-Attribute Decision Making in Choosing Suitable Construction Waste Management Methods', Construction Research Congress © ASCE 2012.

[40] Yashuai LI1 and Xueqing ZHANG2 (2012), 'Comparison and Analysis of International Construction Waste Management Policies', Construction Research Congress 2012 © ASCE 2012 1672.

[41] Yashuai LI1 and Xueqing ZHANG2 (2012), 'Policy Imperatives for Diverting Construction Waste from Landfill: Experts 'recommendations for UK policy expansion', Journal of Cleaner Production.

[42] Zeyad S Khaled, Dr. Basil S. Alshathr, Ali Hasan Hadi(2015), 'Development of Construction Material Waste Management System', Eng. &Tech Journal, Vol. 33, Part (A), No. 3, Part (A), No. 7.

[43] Zezhou Wu; Hongqin Fan; and Guiwen Liu (2014), 'Forecasting Construction and Demolition Waste Using Gene Expression Programming', American Society of Civil Engineers.

[44] Zhen Liu, Mohamed Osmani, Peter emian, Andrew Baldwin. (2015), 'A BIM-aided construction waste Minimisation framework', Automation in Construction 59 (2015) 1–2