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Construction Waste Prevention as a Sustainable tool in Building Mega Cities: A Theoretical Framework

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Abstract. In building of mega cities, the construction industry is contributing to alarming volumes of construction materials waste being generated causing an imbalance in the world's ecosystem. The study developed a framework for construction waste prevention strategies as a sustainable tool in building mega cities. Using content analysis of various literatures reviewed, the study developed a framework for preventing waste generation in construction projects in mega cities. In the building of present and future mega cities, there is need to submit mandatory construction waste prevention strategies as part of the contract documentation to the client, client representatives and the town planning authorities in order to build liveable and sustainable cities.

1.Introduction

Construction material resources go through several transformation from source before they are utilized in civil and building structures. These transformation exposes the drawbacks of construction materials in that not all these entities are utilized for the reasons for which they are requested. In this we realise that construction material waste is generated in construction delivery process, although, this study posits that construction waste may exist before the construction operation begins. General consensus has defined construction waste as the consequence of the processes of new developments, refurbishments and maintenance works in meeting the needs of mega cities[1].

As cities around the world are expanding, the magnitude and intricacies in construction material waste is mounting [2]. The world as at 2017 has over 47 mega cities and intends to graduate many other cities to this status soon due to high urban migration. The state of these mega cities require sustainable solutions to manage the rising social and environmental challenges arising from the mega city status. Mega cities due to their uncontrollable population are plagued with high slum dwellers, high crime, homelessness, urban sprawl, traffic congestion, gentrification, air pollution, high energy and material consumption leading to uncontrollable waste generation. Therefore, there is need to consider the hindrances in creating liveable mega cities such as construction waste generated while meeting the needs of housing and urban development projects. In building more mega cities of the future, there is need to tackle waste prevention rather than dealing with waste generation. Just like the common adage "Prevention is better than cure".

The unbecoming image of the construction industry as the major consumer of earth's resources thereby generating 40% of the green-house gas (GHG) and producing unsatisfactory levels of waste is a major reason for discourse. For example, in Nigeria; a developing country generated over 6 million tonnes of construction waste in five years, in England; a developed country, the industry generates the highest waste compared to other sectors from the over 400 million tonnes consumed in the



construction industry. This is evident from other international studies on the alarming rate of waste generation from the sector [3, 4], which is mostly linked to the loss of control in the design to construction processes. There is a necessity of treating materials wastage of the construction industry as part of the environmental problem, which, if not prevented or managed in a dedicated way, could lead to eco-imbalance in the world. Therefore, by understanding the sources of construction waste in the construction project delivery and the prevention techniques, the study would develop a framework for construction waste prevention as a sustainable tool in building mega cities.

2. Methodology

This paper brings together an in-depth review of ground breaking works on construction material waste by [1] and [2]. For this study, a desktop review was carried out which made use of content analysis to depict the result of the findings.

The study developed a framework for preventing construction material waste in the construction delivery processes of structures in mega cities. A lot of studies have been on waste generation and dealing with the waste generated in form of decreasing waste from source, reclaiming of construction waste, reprocessing, incineration and use of landfills. However, this study posits that in building mega cities, the best sustainable solution is hinged on prevention. As such, the study focused on prevention strategies that can be used as a sustainable tool. In other to understand the prevention strategies, the study identified the stages in the construction processes where waste could be generated as a result can be prevented using several strategies highlighted in this study.

3. Discussion

The study observed that waste prevention can be carried out from the root sources of waste generation based on six (6) major processes in building structures for mega cities. The stages were classified as design stage, procurement processes, construction material handling, construction operation, residual and other construction related causes of material waste. Figure 1 showed a network framework for construction waste reduction as a sustainable tool in building mega cities. Figure 1 showed that the construction processes from design to completion have certain inadequacies that could generate material waste but these can be prevented using the waste prevention strategies depicted in the figure.

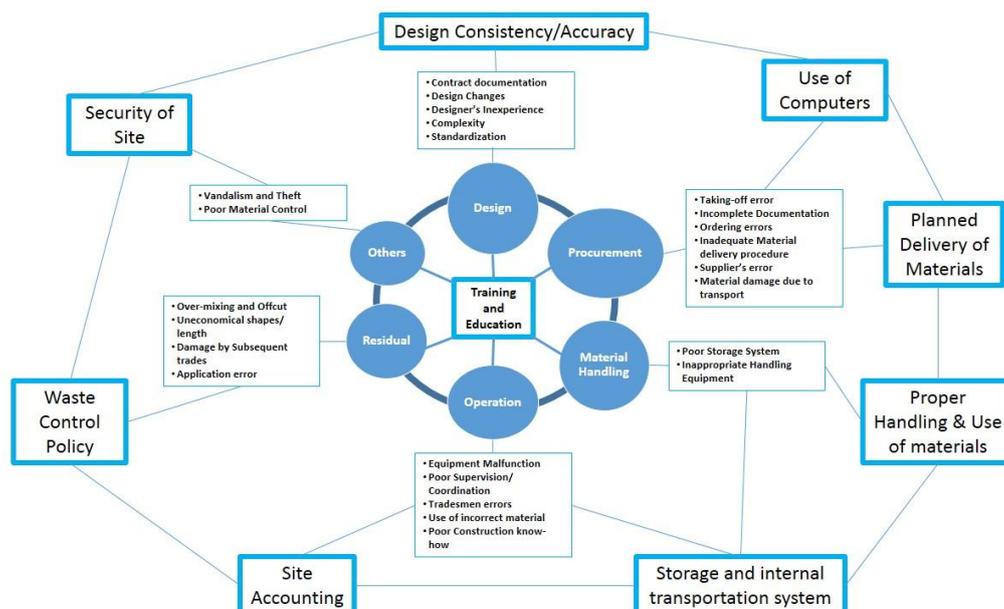


Figure 1: Framework for construction waste prevention as a sustainable tool in building mega cities. **Source:** Author’s Design

The research framework is explained further under the following headings;

3.1 Causes of materials wastage on construction sites.

[1] opined that the entire construction project delivery process is plagued with the production of construction wastes which can be linked to several factors creating them. Some of these factors are standalone while some of them are interwoven resulting in the generation of waste in the delivery process. However, for this study the causes that would be adopted will be the one proposed by [2]. The causes of material wastage whereby prevention techniques can be applied will include the following: (1) Design Stage (2) Material Procurement Process (3) Construction Material Handling (4) Construction Operation (5) Residual Related processes and (6) Other Construction activities.

3.1.1 Design Stage Design is the process of planning the form of a new object. It also refers to drawings of the proposed new object. The construction waste at this stage can be attributed to design errors due to designer's inexperience or carelessness, of which, site operatives or contractors may not be able to correct during the construction process. The carelessness at the design stage by the designer (either architectural, structural or services) can lead to demolition, rework or use of incorrect materials within the structure thereby resulting in huge pile of construction waste on the construction site [1]. Furthermore, errors in the details or specification can lead to huge economic loss to the client and the contractor. The following are means in which waste occurs from design: Failure to recognize undesirable consequences of a design decision; the inexperience of the specialist and lack of knowledge on the construction delivery process; difficulty by site operatives in understanding and translating complex details in working drawings; non-use of standardized products and dimensional variety of products; and time-constrained designs. The negligence and carelessness of the specialists at this stage in building structures for mega cities can also lead to building collapse which is a monumental waste, leading to loss of lives and economic value as witnessed in developing countries. Materials from collapsed buildings due to defective designs are a harm to the environment due to the resultant effect on landfills.

3.1.2 Material Procurement Process Procurement of materials is about obtaining the materials and monitoring of the project successfully. This stage is interwoven between the errors of the specialists, the estimators and the constructors. [1] highlighted the means material procurement errors result in waste as when estimators prepare incorrect bill of quantities due to inexperience or errors in the detailing of structures by the specialists. The critical nature of material procurement errors can be observed in that, over-ordering or under-ordering of construction materials have dire consequence on the project performance as well as the effect of generating construction waste. At this stage, experience and accuracy is key for construction professionals. It is worth to note that during transportation of construction materials that is ordered for use on the construction site, some of these materials may become damaged due to reckless driving, sub-standard quality of the materials or poor offloading techniques.

3.1.3 Construction Material Handling Materials wrongly handled or mishandled, even well stacked can easily be damaged. When construction workers are oblivious of the value a component of construction materials removes from the economic value of a structure it would lead to increase in construction waste. Apart from storage, when materials are stock piled in large quantities around the site, construction operatives may mishandle such materials. It is also important to use the right handling equipment for the appropriate material. The right equipment must be chosen as well as the operator must know how to handle such equipment in relation to the construction materials so as to avoid damage during movement. [1] stated that the level of construction waste increases when there are no storage spaces for materials on the construction site leading to more construction material handling errors. Due to the confined space, construction materials stored anywhere are subjected to adverse weather conditions such as rain washing away fine aggregates (sand), rusting of steel reinforcement and damage of other wood elements. Other expensive materials poorly stored can be

imperilled to sabotage and pilfering by construction operatives. In addition, some of the construction materials could be improperly used by tradesmen.

3.1.4 Construction Operation Operational is used to tag the stage of a project by which material is directly applied and used to make up the components of the building. This segment is the main part of construction where proper controlling is needed. Where there is no control, the construction waste is bound to be high. [1]referred to this stage as the Construction or Renovation waste. Therefore, the contractor must apply a large portion of control over the available construction materials. At this construction stage, the materials are going through conversion and therefore there must be utmost care in ensuring human error as a result of using the construction materials is brought to the barest minimum. Project Managers, site supervisors and general foremen on the building or civil engineering projects must be up-to-date on their project management skills in supervising the activities of tradesmen and coordinating the material flow.

3.1.5 Residual The residual related processes are an off-shoot of the construction operation. These are more specific to the job location. At this stage there is need for close monitoring of materials that are brought out of the store and the purpose for which are to be used. Material substitution should be strictly avoided as this may lead to construction waste. There must be adequate protection for works already completed so as to avoid damage by subsequent tradesmen on the same spot. It is common sight on construction site to witness over-mixing of wet materials as in the case of concrete or mortar which are indiscriminately disposed.

3.1.6 Others Others in this context refers to other factors which may cause material wastage on a construction site. This may include: poor project information, site stacking and storage, inadequate material planning and control techniques and poor waste management policies by the constructor. There are other subtle construction activities that construction professionals are not aware that can result in waste generation on construction sites and during design.

3.2 Waste Preventive Strategies

Waste prevention is about sound judgement in practical matters, desire to generate results and a cultural change in design to construction of structures in mega cities rather than new technologies or a new field of endeavour. Often waste prevention options have no price tag to implement but give results straightaway when implemented with little or no exertion on the construction delivery process. Waste preventive measure would include the following:

3.2.1 Planned Delivery of Materials When material is delivered to the construction site, proper material handling is essential to reduce loss or decreased caused by exposure of material to external weather e.g. bags of cement to be stored should be covered with either polythene bag or plastic to ensure the protection of the material agent agents of moisture and they can also be placed on pallets to prevent moisture from the ground from penetrating the bags of cement. [5]suggested that there should be an inclusive use of innovative tools or technologies in planning construction activities and materials as well as storing the stock levels as work progresses on site. The project manager must ensure that the materials to be used on site are well calculated before ordering to avoid shortage or over-supply. By engaging computing technologies, construction managers can estimate construction materials to least waste generation on construction projects[5]. Some construction managers having arrived at an accurate material quantities may use 'just in time' deliveries to reduce the need for storage space and material losses due to theft and vandalism. In case of storage, construction materials should be stored away from areas of heavy traffic, passers' by and workers; allow only single handling for fragile materials and stick to manufacturer's instruction.

3.2.2 Site Activities Proper control of material used on site requires controlled supervision at every stage of operation. Many large company employ material quantity control supervisors who visit the site regularly to check on materials in store and the use of materials during construction or the client will engage a clerk of work to supervise the work (especially under a direct labour contracts) and ensure that all materials are judiciously utilized. [6, 7] noted that the use of unskilled labour in handling construction materials increases the risk of materials wastage to a critical level due to their lack of construction technical know-how and less value of the components. Besides waste of materials on site, there are lots of damages done due to lack of proper supervision. This is obvious in the average construction site is not the responsibility of anyone, as it is impossible to keep with the overall situation on site, particularly a large contract. Construction operatives should be encouraged to work together as a team in building structures in mega cities. Site operatives should discipline operatives for untidy stockpiles and mishandling of materials. The supply and distribution of materials should be discussed regularly at site meetings.

3.2.3 Training and Education The orientation of all stakeholders in the construction industry should be directed towards effective material utilization to minimize construction cost. This is a pivotal role in waste prevention from design to completion. The designer, contractors, construction managers and site operatives need to be educated on the best practices in building structures that are sustainable. Continuous professional development should be at the core of professional bodies and trade association in preventing waste on construction sites. Construction stakeholders should be educated on issues such as climate change, rising sea levels and the environmental consequences of their actions. The roles of supervision by qualified professionals on construction sites for structures in mega cities should not be neglected. The qualified construction professionals should possess up-to-date technical know-how on preventive measures to tackle waste generation on construction projects.

3.2.4 Design Consistency/ Accuracy Most construction waste arise from the faulty design erroneously prepared by an inexperienced or careless designer or specialist. In dealing with design inconsistencies, the design stage should be a collaborative stage where all construction stakeholders including the client make tangible contributions before the construction begins. The final design should be trouble shoot through a buildability analysis in order to detect deficiencies which will help prevent subsequent construction waste. A common waste prevention technique at the design stage is by optimizing the building dimensions to correspond to set dimensions available in the market i.e. standardization, making sure that the detail design is prepared before construction work commences to avoid a lot of variation orders been issued.

3.2.5 Construction Waste Management Policy Every construction project in existing and upcoming mega cities should have a construction waste management policy. The primary target of this waste prevention strategy is to at first ensure that contractors and sub-contractors are aware about construction waste, how to prevent them and how to deal with the resultant waste during the construction process. When the prior strategies discussed above are not judiciously carried out it may defeat the essential goal of the construction waste management policy. Although, when construction waste is eventually generated on the construction site, the aim of the policy is to ensure that three-quarter of the volume of waste is redirect away from landfills or incineration by reuse or recycling.

4. Conclusion

The study examined construction waste prevention strategies as a sustainable tool in building mega cities. It was observed that construction material waste can protrude from design stage, material procurement process, construction material handling, construction operation, residual related processes and other construction activities. In the design process, the study noted that preventive measures of design consistency and accuracy can be put in place against errors and inadequacies in contract documentation, design changes, designer's inexperience, design complexity and non-use of

standardized products and dimensions. The study noted that in the procurement process the use of computers and planned delivery of materials can help curtail taking off errors by estimators, incomplete documentation, ordering errors, inadequate material delivery procedure, supplier's error and material damage due to transportation. During the material handling process, issues of poor storage system and inappropriate handling equipment can be prevented by using proper handling and correct use of materials and provision of adequate storage and internal transportation of materials on the site. In the construction operation, waste that could be generated from equipment malfunction, poor supervision and poor coordination, tradesmen errors, use of incorrect materials and poor construction know-how can be prevented through site accounting and increased training and awareness of the construction operatives. In the event of an application error, over-mixing of wet materials, offcut of materials and damage of materials, an effective waste management policy should be in place to prevent further materials wastage. The study showed that material wastage can arise from vandalism and theft of construction materials and this can be prevented through provision of adequate site security.

The study recommended that in the building of mega cities, there is need to put in place construction materials waste preventive strategies. There should be a conscious application of the waste preventive strategies. The framework developed showed that all the strategies revolve around training and education, therefore, construction stakeholders which include clients and professionals need to be adequate brought to speed on preventing waste generation rather than a "fire brigade approach" in dealing with construction waste. Seminars and workshops should be organized for construction professionals as a continuous professional development strategies. In the building of present and future mega cities, there is need to submit mandatory construction waste prevention strategies as part of the contract documentation to the client, client representatives and the town planning authorities.

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