CONSTRUCTION MATERIAL RESOURCES OPTIMIZATION IN NIGERIAN BUILDING industry

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ABSTRACT

This paper examined ways by which construction material resources can be optimised towards sustainable resource preservation. Material waste in construction contributes between 30-35% of project cost; thus leading to material loss and project cost overruns. Lack of concern by Governments and developers globally and Nigeria in particular is continuously affecting the use of these resources and leading to frequent visit of these materials natural reserve. The optimum use of these resources collectively leads to its sustainability. Questionnaire method has been used. A total of 100 questionnaires were administered to construction practitioners; 80 were returned giving 80% response rate. This was analysed using Descriptive Statistics. The objectives cover the extent of challenges on material resource optimization considering societal value systems in the Nigerian construction industry, investigated the major sources of material wastage at various construction stages and means of material resource optimisation were evaluated. The finding depicts that status symbol mentality by most users of material resources and flawed socio-cultural attitudes to material resource usage have been the highest resource optimization challenges in Nigeria construction industry. The research further ascertain that manual labour assumption during the bill rate computation, ordering too much/too little materials at a time and material handling during construction by contractors are the major factors that contribute to material wastage. Lastly, the study establish options should be considered as means for material resources optimization and include use of experienced and competent personnel to man the construction process, use of standard specifications and adoption of supply chain management. It recommends that better utilization of resources through lean production and prefabricated component processes, use of appropriate equipment and specification, recycling/re-using of old materials for new construction projects

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will assist greatly in reducing visiting of base materials, hence leading to resource optimization and protection of the environment.

Keywords: *Material, Resource Optimization, Sustainable Construction, Waste.*

Introduction

Sustainability is now a key concept in development thinking at all levels. Over the last two decades, sustainable development and sustainable construction have been of increasing concern throughout the world (Jaillon, Poon & Chiang, 2009). The building industry plays a vital role in the creation of physical assets which forms the basis of every aspect of development that results in the creation of most of man-made capital globally. The construction industry and the materials used in construction are one of the largest exploiters of natural resources. Their activities cause irreversible transformations of the environment and its major contributor of greenhouse gases emission (Spence & Mulligan 1995; Manish et. al. 2006).

Construction materials can be described as those ingredients used in the construction of roads, buildings and other construction related activities, and these materials come along with wastage during application on site. The word wastage means loss during usage or decay (Adeagbo and Kunya, 2002). In other word, waste can means any activity which does not add value (Slack, Chamber and Johnson, 2004).

Resource optimization in this context is the set of processes and methods to match the available resources (human, machinery, financial) with the needs of the organization in order to achieve established goals. The need to optimize resources is particularly evident when the organization's demands tend to saturate and/or exceed the resources currently available.

To reduce waste during construction, it is important that all the parties involved in the construction process are coordinated. A comprehensive construction waste management is urgently needed on every construction site. After identifying the causes of construction waste, it is of great importance to structure ways to minimize it as the most favorable solution to waste problem of any kind. (Tam& Tam 2006). The fear of not getting the resources that we are presently taking for granted in the near future has brought forth the challenge on sustainability. This is as equally applicable as it is in other spheres of human activities as in construction activities.

Historically, development before industrial revolution was nature base, whereby the local materials were used for various community immediate shelter need in Nigeria and globally. Subsequent development methods have being affecting our environment, human resources and transport system. This is straining the limits of the earth's ability to provide the resources required to sustain life while retaining the capacity to regenerate and remain viable (Cartlidge 2004).

Lack of concern by governments and industry practitioners globally and Nigeria in particular continues to affect the use of these resource materials. The recklessness in utilization of resource materials in Nigeria perhaps may be attributed to factors like: ostentatious tendencies in all

endeavours, seeming abundance of resources, status symbol/cultural attitude, lack of contemporary sustainable development knowledge, lack of political will by government to encourage resource optimization, inadequate security that lead to excessive protection of the structures (high fencing, burglar proofing, concrete fascia and double roofing), non-adoption of new technology on old materials etc. It is this recklessness that is the current challenge to material resource optimization and consequently unsustainable construction development. These glaring challenges are visible in Nigeria where the quality of construction, the inappropriate application of materials and impertinent use of design structures tend to limits their sustainability both in terms of lifespan of the structures and the lifecycle of the used materials. These do not compliment the principle of sustainability and that of Whole Life Cycle Assessment (Brundtland, 1987; Griffin, 1993 and Kishk et. al. 2005).

The construction industry resources utilisation touches areas like financial, human, equipment and materials application. The optimum use of these resources collectively leads to preservation of the base material resources and more affordable construction projects. Hence, this paper aimed to examine the ways by which construction material resources can be optimised towards general resource preservation.

CONCEPTION OF CONSTRUCTION MATERIAL WASTE

Al-Hajj and Hamani, (2011) defines construction material waste as "the by-products generated and removed from construction, renovation and demolition workplaces or sites of building and civil engineering structures". They further stressed that waste is anything that goes into a skip and ends up in landfill. For example, unused materials, off-cuts, damaged materials and products and demolition waste. Industry measures show that 13% of waste is new, unused material. Construction industry's waste is not only important from the perspective of efficiency, but also there is growing concern in recent decades about the adversarial consequence of the waste from construction industry on the environment (Carlos et. al. 2002; Motete et. al. 2003).

According to Begum, et. al. (2006) construction materials waste is becoming a serious environmental problem in many large cities in the world. It is considered as one of the major factors responsible for environmental effect; with enormous construction going on globally, a large quantity of waste is being generated (Vivian et. al. 2007). The excessive wastage of raw materials, improper waste management and low awareness of the need for waste reduction are common in the local construction sites (Begum et. al. 2006).

US EPA (2002) opined that waste reduction/elimination makes good economic and business sense, can improve production efficiency, profits, good neighbour image, employee participation, product quality and good environmental. In addition, current existing practices generate wastes throughout the life cycle of the project, ranging from design to usage. Details are highlighted below.

Design and specifications waste

Design and the specifications can contribute significantly to the amount of waste generated during the construction of a project particularly when uneconomical design solutions are selected or when unsuitable materials are specified. Example of waste arising from design includes among others: aluminium- cutting of lengths to fit openings or lap need; flooring- cuttings of floor tiles to fit room layouts with lots remainder, blockwork- cuttings of bricks and blocks to suit building dimensions and building services (Adewuyi, 2011)

Construction activities waste

The way construction activities are carried out impacts on the quantity of waste produced. These wastes are usually 'accidental' and is generated by the following factors: inaccurate or surplus ordering of materials that don't get used , damage through handling errors, damage through inadequate storage , damage generated by poor co-ordination with other trades , rework due to low quality of work , inefficient use of materials and temporary works materials (Adewuyi, 2011). Carlos et. al. (2002) asserted that at construction stage, materials wastage can be classified into direct (loss of materials) and indirect (over valued) material waste.

Wastage generated during Costing

It is a standard practice when estimating for any rate of construction item or element to include waste; but in the first instance why inclusion of waste item during costing? the following factors could be the reasons: storage waste, transit waste, residue waste (common with paints, glues and other materials which are normally delivered in containers and are never completely removed), Loading waste, application waste (occurs when most wet building materials such as paints, plaster and other finishes are used), stock Pile, cutting waste. Lap is another major source of waste in costing. Most horizontal laps can be eliminated or further minimized particularly in fabric reinforcement, roofing sheet covering, damp proof covering etc. These problem can solved through designing to standard space product (Ilori, 2012)

Materials procurement wastage

The critical point at which contractors can influence waste is when buying materials for a project, this activity determines the materials that are to be supplied and utilised on site. The waste allowances here are often generic and not project specific and as such run a risk of being inaccurate. This can lead to either order surplus materials (usually entering the waste stream) or a materials shortfall

Materials WASTE Management and Sustainable CONSTRUCTION

According to Bin-Ibrahim et. al. (2010) the cost of materials is over 50% of the total construction cost, depending on the construction form. They further stressed that the causes of material wastage were "poor workmanship, setting out error, order not meeting specifications, excessive use of materials, material not meeting requirements, breakage in handling materials, improper storage, and misdemeanour". This kind of waste typically accounts for 15 - 30% of urban waste

(Carlos et. al. 2002; Forsythe and Marsden 1999); construction waste represents a relatively large percentage of production cost (Viana et. al. 2012).

Materials wastage on construction site has recognizable implication on the stakeholders. To the contractor, it significantly reduces the predictable proceeds from a project whereas to the client, it escalates the development costs and undermines values. High rates of material wastage on construction site perhaps may responsible for the relevance of project cost overruns reported in several literatures (Al-Hajj and Hamani, 2011). Hence, there is the need for maximizing material wastage management on construction site with a view to enhance profit maximization, achieving value for money and also reduce cost of development (Ogunsemi 2006), also it is used as an important criterion for project success (Abdulrahman et. al. 2013).

In addition, the economic benefits of waste minimisation and recycling to the contractors is that it can increase their competitiveness through lower production costs and a better public image through reduction of materials going to landfill at a higher cost (Begum, et. al. 2006). They further stressed on the benefits of waste minimization in term of environmental sustainability to include prolong life of landfill sites and reducing resource base material requirements. The social benefit include among others: elimination/reduction of new landfill sites, construction cost reduction and health risk associated with waste disposal (Lingard et. al. 2000).

For successful sustainable construction you need to plan the timing of your purchases for just-in-time delivery of the required building stage, avoid keeping materials in storage for too long as this ties up your funds and may lead to damage, spoilage and pilfering, Identify storage requirements for building materials that you have to store and plan a place to store them, ensure building materials are stored correctly to avoid damage by damp, excess moisture, rain or daylight, and ensure supply chain management principle is in place for taking over remaining materials. Perhaps this may help to save money and reduce delays in your project caused by having to restock materials.

In recent years, reuse and recycling of waste have been promoted in order to reduce waste (save cost) and protect the environment. In addition, they assist in savings purchasing costs, cost savings from waste collection and transportation and landfill charge cost savings (Begum, et. al. 2006)

Public awareness of environmental issues has increased significantly in Nigeria. Property owners and clients are seeking commercial buildings that meet acceptable environmental and health levels. Unfortunately, there is lack of institutional structures promoting green buildings; awareness on the part of clients, tenants, professionals in the built environment and other stake holders (Nwokoro & Onukwube 2011) More so, lack of knowledge among the general public as well as social norms have adversely affect waste practices. For the successful implementation of waste management measures, a collective effort from all involved parties is important (Begum,et. al. 2009).

Means of Resource Optimization

Construction waste is understood in different ways and its represents a large percentage of production cost (Viana et. al. 2012). The following are considered as means of minimizing materials wastage and reduce visiting base resource materials for sustainability purpose:

Use with minimal/without waste

Waste minimisation is a process which avoids, eliminates or reduces waste at its source or permits reuse/recycling of the waste for benign purposes (Jaillon et. al. 2009). The quality and/or experience of the personnel used in the execution of the works will determine the extent of the non-value activities; for instance, concrete work which involve setting in formwork before concreting. If the carpentry work is defective, it automatically affects the concreting.

Selection of Alternative Building Materials

Selection of alternative sustainable building materials as against conventional building materials for new construction and renovation could reduce the need for pesticide application, periodic painting and other maintenance. The use of alternative building materials will reduce touching of the base materials thereby preserving them for future generations needs and as well as minimizing their impact on the environment (WBDG Sustainable Committee, 2010)

Use of Appropriate Equipment

Each piece of construction equipment is specifically designed by the manufacturer to perform certain mechanical operations. To estimate the equipment required for a project it is necessary to first determine machine productivity. To perform such analyses, the planner must consider both machine capability and methods of employment (Peurifoy et. al. 2006).

Appropriate Specification

Choice of appropriate material at both the design and implementation stages of construction will assist construction works to have full life span they were design for. For instance use of wall tiles/Glass on the toilet wall as against plastering and painting, will assist in preserving the building against early and subsequent maintenance

Lean Production

This is a process where sizes of the products are optimize and ensuring robustness. This encourage 50% reduction on everything leading to half human effort in the factory, manufacturing space, tools, engineering hours to develop a new products, and produces a greater and ever growing variety of product designed both to eliminate waste and constantly improve production output and quality (Womack, et. al 1990; McGivern, et. al. 2001).

Supply Chain Management

Approximately 13% of waste generated in the construction industry is new, unused material. Solution to the above problem is adoption of supply chain management (SCM) principle;

through finding suppliers who accepts returns or exchanges. Exchange material-which might appear of no value to you may be of value to someone else (Al-Hajj & Hamani 2011). SCM can assist with delivery that is just-in-time for the required building stage; and it avoid keeping materials in storage for too long as this ties up your funds and may lead to damage, spoilage and pilfering (Begum et. al. 2009).

Recycling /Reusing

There are many ways to improve the sustainability of the built environment such as using non-toxic and using materials in such a way that they can be re-used or recycled. The use of high recycle content construction materials on prospect projects will reduce frequency of visit to base material resources and this will reduce waste and protect the environment (Cartlidge 2004; Begum et. al. 2006). Reuse/Recycling program has assisted Hong Kong to reduce approximately 30% of construction waste to be disposed of in landfills and achieved economic benefit of around US$7 million from the construction waste disposal charging scheme (Chui, 2007).

Prefabricated Construction

According to Jaillon et. al. (2009) "Prefabrication is a manufacturing process, generally taking place at a specialised facility where various materials are joined to form a component part of the final installation". Prefabrication has been recognised as a means to reduce waste arising during design and construction phases. Hence, it is possible to reduce waste level up to approximately 52% through prefabrication. This implies that a wider use of prefabrication could considerably reduce construction waste generation and alleviate the burdens associated with its management (Jaillon et. al. 2009).

METHODOLOGY

Materials resources optimization is considered key to sustainable construction and is the bedrock of this research work. Structured Questionnaire method has been adopted using descriptive analysis. The questionnaire was used to collect data for large scale respondents, hence providing high validity and generalization of results. It is used for enquiry with a view to obtained opinions and facts about an existing problem; allowing for consultation with colleagues or documents (Naoum 2013). The questions asked were generated from pilot study and literature review. The questionnaires were administered to professionals in the construction industry.

Four point (4) point lickert scale method has been used to sought for the opinion of the respondent, with "4" and "1" being the highest point (highly significant) and lowest point (insignificant) respectively. The ranking of the factors were based on the means calculated, the higher the mean, the higher the ranking. All the respondents were based in Kaduna. Only 80 respondent correctly representing (80) % out of the total questionnaire administered.

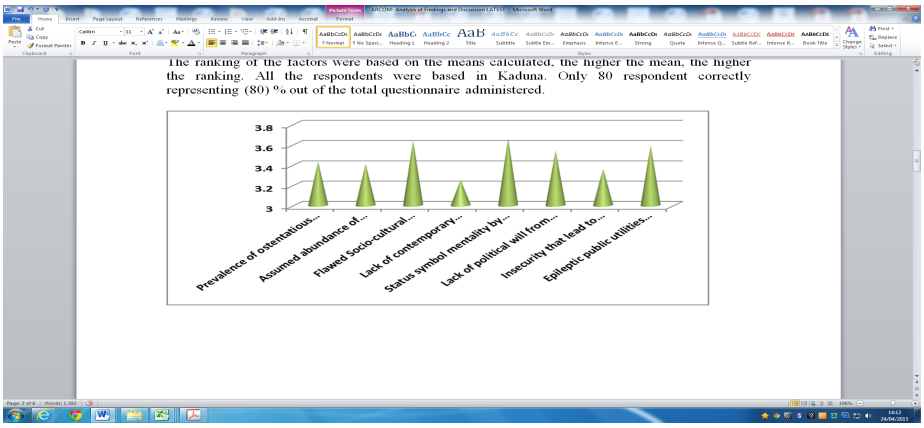

Figure 1: Extent of challenges on material resource optimization considering societal value systems in the Nigerian Construction Industry.

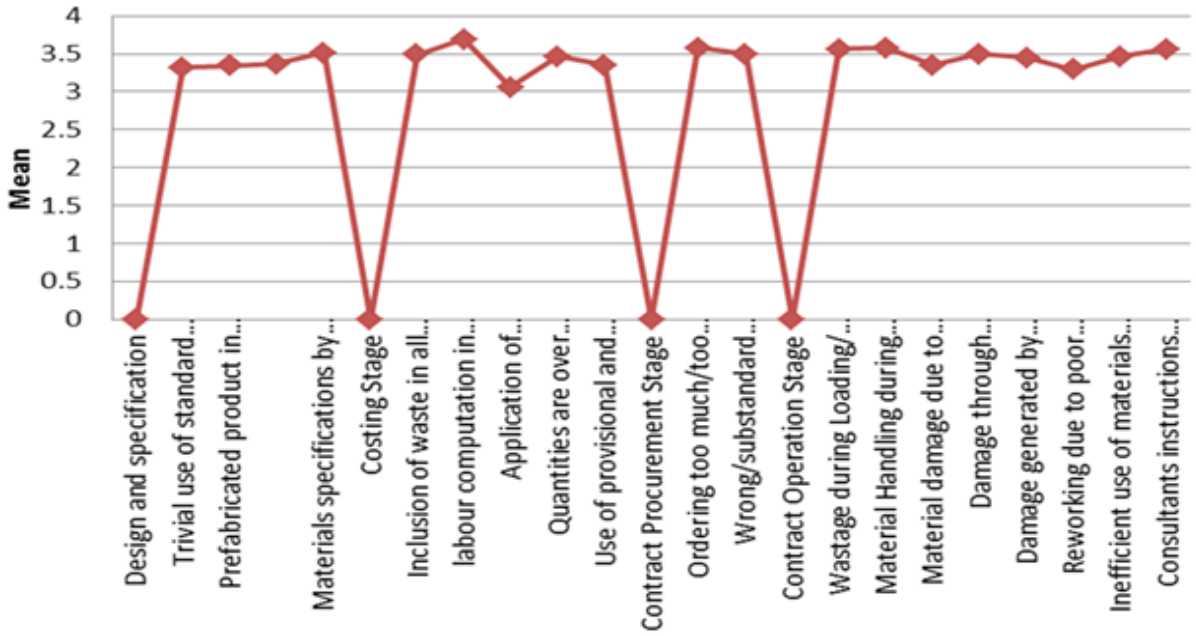

Figure 2: Extent of Material Waste on Resource Optimization in the Nigerian **Construction Industry**

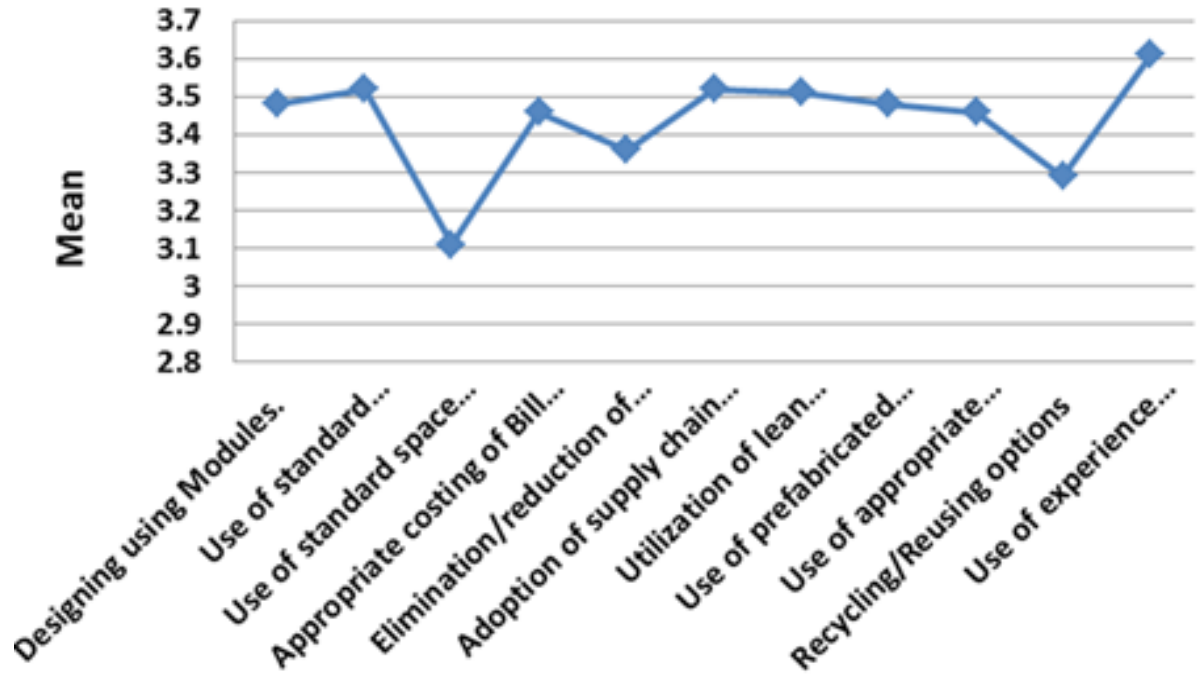

Figure 3: Rating of material resources optimization options that guarantee sustainability in the Nigerian construction industry

Analysis of Findings and Discussion

This study set out to achieve Material Resources Optimisation for sustainable construction in Nigeria. Resource materials optimization can be achieved at the various stages of construction. The first objective identified the extent of material Resources optimization challenges to sustainable Construction in terms of Nigerian societal value systems (see Figure1). The figure shows the various factors responsible for material wastage in the Nigerian Construction Industry based on societal value systems. The findings reveal that, Status symbol mentality by most users of material resources and flawed socio-cultural attitudes to material resource usage have the highest extent of Resource optimization challenge in Nigeria; this is as averred by Adewuyi & Otali (2013). The tendency of Nigerians to define their economic status by making statement with bogey structures, this tends to make the spending on such structures very high without adding functional values. Example, the concrete fascia is in vogue now in Nigeria. When comparing concrete facial with timber/wooden facial board; the concrete facial cost more than timber type by about eight times.

The second objective investigated the extent of material waste on resource optimization in the Nigerian Construction Industry (see figure 2). The study found that labour computation in building bills unit rate is done manually (mean 3.69), ordering too much/too little materials at a time (mean 3.58) and material handling during construction by contractors (mean 3.58) are the major factors that contribute to material wastage in the Nigerian construction industry. This is in

accordance with the study by Oladiran (2009). Efficient Material Management is critical for the success of any project considering the portion of material resources (around 50%) of the overall constructions project cost (Bin-Ibrahim 2010). Regular and adequate supply of material is crucial task as late, irregular delivery or wrong type of material delivery leads to poor productivity, time delay and cost overrun. More so, all the variables identified are highly significant considering the levels of their mean; therefore care should be taking in respect of materials at design and construction stages

In line with the last objective investigated, the study affirmed that material resources optimization options that guarantee sustainability in the Nigerian construction industry includes; use of experienced and competent personnel to man the construction process, use of standard specifications and adoption of supply chain management, which agrees with Saka and Mudi (2007). There appears a lack of comprehensive and value enhancing approach to supply chain issues. Approximately 13% of waste generated in the construction industry is new and unused materials. Solution to the above predicament is the adoption of supply chain management (SCM) principle (Al-Hajj & Hamani 2011)

CONCLUSION AND WAY FORWARD

For any project to be successful it is highly dependent on adequate availability and efficient management of materials required for every stage of construction. Hence, it is important that adequate arrangement to provide materials resources (adopting supply chain management principle) is made prior to commencement of any project. If material resources are not optimized, given their fraction to the overall cost of construction project, it will result in construction cost overrun, thus affecting all the stakeholders including the environment. Proper planning of the project from the design stage is very important as this study has pointed out that the highest source of wastage occurs at the design stage. The planning at the design stage and preparation of budget assist in reducing material wastage.

This study contributes empirically in highlighting the major sources of construction waste in Nigerian construction industry with a view to optimise material resources utilisation, when manual labour assumptions are adopted in building up bill rate. It further highlights the challenges of resource optimization; this reveals that it is important to have a competent personnel to man the construction process. This has high impact in resource optimization and can lead to time overrun if foreign products are utilised as experienced on many projects in the country. Status symbol mentality and flawed socio-cultural attitudes to material resource usage has the highest extent of resource optimization challenge in the Nigeria construction industry. This is the case of General Motors / Japanese Cars (show off as hallmark of capitalism).

Better utilization of resources can be achieved by adopting the use of standard specification and products and adoption of supply chain management from design stage; these play a crucial role in maximising material resources utilisation. Lean production processes, materials usage with minimal/without waste in construction works, use of appropriate equipment and specification, recycling/re-using of old materials for new projects will assist in optimising material resources in

construction industry. Also, development of material schedule software will assist greatly in reducing wastage of material.

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