DOI: 10.2478/jtes-2020-0006

sciendo

*Journal of Teacher Education for Sustainability,*
*vol. 22, no. 1, pp. 66–83, 2020*

# Construction Waste Reduction Awareness: Action Research

Hyginus Osita Omeje, Godwin Keres Okereke, and
Daniel Uchenna Chukwu
University of Nigeria, Nsukka, Nigeria

## Abstract

The study focused on construction waste reduction awareness as a step within Education for Sustainable Development (ESD) at the University of Nigeria, Nsukka. The method of collaborative action research was used with a questionnaire as an instrument. Data collected from 61 participants were analyzed using descriptive statistics (percentage, mean, and t-test) and multiple regressions. Results revealed that there were graduates of different degree levels and non-graduates working at the construction sites, where 4.9 % and 27.9 % had PhD and Master degrees, respectively. Improper material storage was agreed to be the main cause of construction waste, while the most effective reduction measure was applying source reduction through the calculated procurement. Multiple regressions revealed that awareness was significantly positively predicted by gender, qualification and status. However, both cause and reduction of construction waste were noted to be human related, thereby necessitating a campaign against construction waste at various sites, with the aim of raising motivated and inspired change agents.

*Key words*: sustainable development, sustainable construction, waste, construction waste, education for sustainable development, action research

## Introduction

The quest for sustainability in the construction industry has made the topic of waste management or control a recurring discussion amongst practitioners and researchers. This is vital as the construction industry is a major contributor to global waste generated (Poon, 2007) and the highest consumer of the earth's abundant resources estimated at 40 % (Dahiru, Dania, & Adejoh, 2014), owing to conventional constructions. Thus, one step towards sustainability in the industry involves the reduction of resource consumption (Faniran & Caban, 1998). Reduction is the first step in the 3R principle of reduce, reuse and recycle of waste management (Peng, Domenic, & Charles, 1997). It is believed that resource consumption in the industry is directly related to construction waste generated. Thus, reduction is essential in altering both input (resources) and output (waste). Hence, a lot of studies have been conducted to understand the causes of waste in the construction industry (Latas, 2011; Wahab & Lawal, 2011; Osamani, Glass, &

Price, 2008; Begum, Satari, & Pereira, 2010; Faniran & Caban, 1998). However, the possibility of reduction is challenged greatly by the incessant yield of human management error that constitutes a greater reason for waste generation in the construction industry. Teo and Loosemore (2001) discovered that human attitude based on knowledge and awareness was the major cause of lackadaisical use of resources resulting in more construction waste. To drive sustainability in the construction industry, the idea of construction waste, causes of construction waste, its environmental, economic, and social effects (Nagapan, Rahman, & Asmi, 2012; Salīte, 2008, 2015; Fedosejeva, et al., 2018) are a key to motivation required for actions.

Waste management entails curtailing generation and disposal of materials in a way that averts adverse environmental effects. Waste can be reduced, and if generated, possible reuse and recycling are engaged while disposal comes as a last option.Literature reveals that human resources are at the baseline of all waste generated in construction. Thus, poor designs are made by a human; excessive or insufficient procurement of materials, wrong construction planning and methods (Luangcharoenrat, Intrachooto, Peansupap, & Sutthinarakorn, 2019) are all human-related factors (Fig. 1). It has also been long established that construction waste does not depend on the type of building environment or the engaged company, but on the site and the workers (Faniran & Caban, 1998; Ma, 2011). Moreover, sustainability goals are expected to be achieved by humans. The place of human in the chain of events leading to waste generation and the need for reduction cannot be overemphasized. The campaign for waste reduction must begin with practitioners and key players in the construction industry. Therefore, ascertaining the awareness (Katherine, 2017) of site workers and students cannot be out of place.

Furthermore, the issue of construction waste cannot be jettisoned in Nigeria and its environs as it increases with the increasing population causing tremendous demand in the construction industry (Katz & Baum, 2011). There is an obvious increase in the population of Nigeria, leading to more rural-urban migration, increased housing development and city decongestion strategies across states (Chukwu, Anaele, Omeje, & Ohanu, 2019). Decreasing construction waste generation cannot equally be left to chance; hence, Begum et al. (2009) and Siew (2019) observed an unseen stoppage in offshoot of development in commercial buildings, infrastructure and other housing projects. It, therefore, suggests that except actions are taken to drive the movement for sustainability, beginning with the environment of advocates, the attitude of workers and resultant effects in waste generation would most likely maintain the negative trend. The present research, thus, focuses on redirecting actions of humans towards desired construction waste reduction, a step traceable in the Education for Sustainable Development (ESD) agenda. The study is an action step in advocating for ESD. It aims at teaching and redirecting steps to reduce construction waste generation and provide possible insights in: sustainability awareness of the students and construction site workers within the school environment; existing actions of site workers towards reducing construction waste; construction waste take-off actions, and what next?

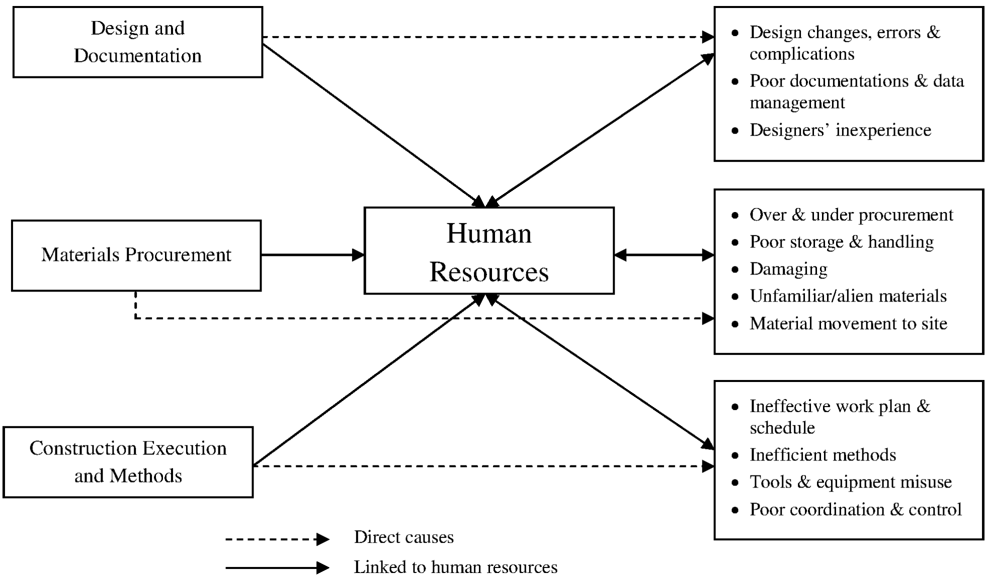


*Figure 1*. Linking causes and categories of construction waste to human resources, adapted from Luangcharoenrat et al. (2019)

**Construction Waste: Causes and Reduction Strategies**

Waste is simply the unused resource of time, materials, equipment and human, initially intended for one purpose or another but lost to the environment or abandoned without any plan of consumption or recovery. According to Ferguson (1995), waste connotes unwanted products and materials. Waste from construction, according to Luangcharoenrat et al. (2019), is all construction materials that cannot be reused, including leftover construction materials and materials damaged while working or via improper handling. Construction waste refers to valueless left-over material by-products of buildings by human and industrial engagements (Alarcon, 1994). There are variant classes of construction waste in literature. For instance, Nagapan et al. (2012) classified construction waste into physical (masonry, metals and packaging waste) and non-physical (cost overruns and time delays). Physical waste results from construction, renovation and demolition, which yield solid waste such as bricks, blocks, concrete, steel, tiles, wood, glass, cements, reinforcement off-cuts, vegetation and other related materials (Katz & Baum, 2011). These materials are damaged to the point of recovery in most cases and are majorly disposed to landfills (Nagapan et al., 2012; Rao et al., 2007). Recent literature denotes this category of waste as construction and demolition waste (CDW) (Huang, Wang, Kua, Geng, Bleischwitz, & Ren, 2018; Kibert, 2013; Poon et al., 2001; Rao et al., 2007). Non-physical waste relates to time and cost overrun, repair, waiting time, delays, inefficiency, idling among others (Nagapan et al., 2012; Ma, 2011). Another classification by the Government of Hong Kong (GOVHK) is put into two: inert and non-inert waste; where inert waste consists of materials subject to reuse onsite such as stone, fragments, asphalt, soil, concrete and masonries; non-inert waste comprises woods, bamboos, plant, packaging and organic materials that may not be easily utilized onsite but subject to recycling or disposal to landfills. In spite of the different classification of waste, the causes and environmental effects requiring sustainability measures are the same.

Causes of construction waste, according to Faniran and Caban (1998), include: changes in design, leftover material, packaging waste, errors in design or detailing, and poor weather condition. Internationally, waste generation during construction has been attributed to similar causes. Different studies, performed in countries such asthe United Kingdom, Singapore, the United Arab Emirates, Indonesia and Honk Kong, reported that construction waste is mainly caused by design (last-minute changes, causing rework/ variations, creating off-cuts, repairs), operation error and poor material handling (due to non-skilled workers and lack of supervision) (Alwi, Hampson, & Mohamed, 2002; Ekanayake & Ofori, 2004; Osmani, Price, & Glass, 2006; Wan, Kumraswamy, & Liu, 2009; Al-Hajj & Hamani, 2011). In Ugandan, Kenya, and Nigeria, available literature also coheres with the above causes in addition to a lack of skilled workers, alien/unusual product integration, poor storage, security breakdown and vandalisms, working environment/conditions, creating unfamiliar shapes and forms among others (Muhwezi, Chamuriho, & Lema, 2012; Mbote, Kimtai, & Makworo, 2016; Adewuyi & Otali, 2013). Similarly, studies have categorized causes of construction waste into design, handling, labor and human behavior, management, construction methods, materials, site conditions, procurement and external factors such as weather (Luangcharoenrat et al., 2019; Nagapan et al., 2012). However, Luangcharoenrat et al. (2019) in the recent study exhaustively categorized these causes into four, namely: design anddocumentation (DEDO), material and procurement (MAPR), construction method and planning (COPL), and human resources (HUMA). The study showed that in relative importance index, causes due to design and documentation, as well as human resources were ranked first and second, while causes due to construction methods and planning, material and procurement ranked third and fourth, respectively.

Notwithstanding the category of causes, waste is a product of poor business (Ma, 2011) which invariably increases the cost of construction. Sustainability can be undertaken from the savings recovered through waste reduction. Hence, waste reduction entails using fewer materials with less likelihood of landfill disposals but sorting, reusing and recycling. Although waste generation lies not only in construction, construction waste seems to be most uncontrollable amongst other stages of raw material extraction, processing and manufacturing (Merino, Garcia, & Azevedo, 2010). Practical solutions for reducing construction waste are vital, easy and most times inexpensive. According to Ma (2011), waste reduction begins with eradicating 10 % extra in all traditional material quotations. The author argued that such a measure ensures 10 % fewer vehicle travels, thereby reducing transportation cost, production cost and environmental impacts. The non-physical (Nagapan et al., 2012) construction waste (waiting, overdoing, redoing, design misinterpretations) can also be reduced through the quick and accurate supply of materials, adequate briefing and supervision, and information crosschecking (Ma, 2011). Kibert (2013) suggests off-site fabrication over on-site, negotiating for buy-backs for not customized products and proper auditing of materials before deconstruction. Furthermore, Merino et al. (2010) suggest source reduction during design and procurement, and, most importantly, imbibing in all workers the consciousness to be partaker of the waste reduction goal, an ESD step to sustainability.

### Education for Sustainable Development

Sustainability strives to meet the needs of the populace now and in the future. It stems from the famous definition of sustainable development as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (United Nations, 1987). According to HEC-Global Learning (2009), sustainable development is the process of change, in which the exploitation of resources, direction of investments, orientation of technological development and institutional change are all in harmony and enhance both current and future potential to meet human needs and aspirations. Furthermore, sustainable construction is a progeny of the same concept. Kibert (2013) states that sustainable construction addresses the role of the built environment in contributing to the sustainability vision; hence, constructions that conform to the seven principles of sustainable construction – reduce resource consumption, reuse resources, use recyclable resources, protect nature, eliminate toxins, apply life-cycle costing, focus on quality – result to sustainable/green buildings (Kibert, 2013). Efforts are constantly made to align education, institutions, nations, and individuals to pursue environmental, social and economic pillars of sustainability. These efforts have given rise to ESD.

ESD is learning informed and responsible actions for environmental, social and economic preservations and sustenance. According to UNESCO, ESD is holistic and transformational education that addresses learning content, pedagogy and learning environments, societal transformations with outcomes such as climate change consciousness, sustainable consumption and lifestyles necessary to sustain both present and future. Simply put, ESD is "education that enables every human to acquire knowledge, skills, attitudes and values necessary to shape a sustainable future" (UNESCO, 2014). According to Commonwealth of Australia (2009), the six principles of ESD include transformation and change, education for all and lifelong learning, systems thinking, envisioning a better future, critical thinking and reflection, participation and partnership for change. To achieve the principles, ESD requires engaging the community with defined approaches, vision and measurable goals to inspire and motivate change in actions such as reducing waste in constructions. This study posits as an action taken to integrate more participants (community of study) in the sustainability move; redirect the thought patterns of participants to enhance change in behavior; engage education for all through an awareness campaign and create partners for change.

## Methodology

### Research Design

This study adopted an action research method to engage participants in a campaign against excessive waste in construction sites. Action research specifically refers to a "disciplined inquiry done by a teacher with the intent that the research will inform and change his or her practices in the future" (Ferrance, 2000). It uses collaborative action research (Ferrance, 2000) involving the teacher, members of the class, construction sites within the school environment and workers available onsite. The method was adopted to improve students' knowledge, learning, and practice within the school and its environs. It was necessary to identify awareness of practices and proffer solutions as well as campaign for adherence; hence, one importance of action research is to produce change agents (Burns, 2009) that will stand for global practice in construction waste management.

The process of action research follows a path through: identifying a problem, data collection, interpretation, action based on data and reflections (Burns, 2009; Ferrance, 2000). The researchers, therefore, begins with the question: "if the construction industry is the highest in resource consumption and waste generation, what are the ways to change the trend?" To arrive at the answer more questions were asked: what are the causes of construction waste? How aware are the site workers concerning sustainable measures to reduce construction waste? What actions are necessary to reduce construction waste?

The instrument for data collection was designed, and data collected, analyzed and interpreted, while findings guided the campaign actions.

### Participants: Students and Site Workers

The participants are 61 comprising 23 third-year (300 Level) students of the Department of Industrial Technical Education, Faculty of Vocational and Technical Education, University of Nigeria (Nsukka) and 38 site workers at construction sites within the school vicinity. Industrial Technical Education (also called Technical Education) is an aspect of vocational education concerned with developing recipients' knowledge, skills and attitude relevant to enter and make progress in occupations such as automobile mechanics, metalwork, electrical/ electronic installation and maintenance works, woodwork and building construction. Industrial Technical Education program is tailored to produce sub-professionals who would work alongside engineers in executing technical jobs across industries. Graduates from this area of study have the opportunity of choosing to be employed as teachers of technical subjects in schools and colleges, technologists in industries, further their education or venture with the acquired skills to create employment and contribute meaningfully to the development of the nation (Federal Republic of Nigeria [FRN], 2013).

However, the study stemmed from the course: Building Construction III with the course code ITE 321. Building construction is one of the many trade courses in Technical Education taught at vocational schools. The course has among its contents design considerations for building materials. The researchers are aware of the trends in sustainable designs and capitalized on the opportunity of teaching the course in academic year 2018/2019 to explore the contemporary requirements, introduce and instill the consciousness of sustainability in the students. Conventional material selections are guided by availability, cost and performance mainly related to human satisfaction.In this era of sustainability, materials for construction are considered in the light of renewable or replaceable sources, recycled and recyclable products, use/reuse capabilities, environmental impact and affordability. Therefore, the concept of sustainability in construction was taught as an embedment in design considerations for building materials. The aim is to extend the vision of ESD in awakening the consciousness and extending the knowledge, skills and right attitude, towards limited resources and intolerable environmental degradation resulting from waste. Knowledge empowers and causes recipients to speak forth; the students are equally expected to campaign against any form of construction practice liable to generate preventable waste.

### Data Collection

Data was collected from students (23: 20 male and 3 female) and site workers (38: 37 male and 1 female) through direct administration and retrieval using a structured questionnaire. The questionnaire was measured on a 5-point Likert scale with 5 (Strongly Agree) – 1 (Strongly Disagree); and 2-point measure of awareness (2 = Aware, 1 = Unaware). The instrument has two parts; the first part ascertains demographic information and the second part measures the causes of construction waste, awareness of waste reduction strategies and level of agreement or disagreement on the strategies. Causes of construction waste contain 28 items adapted from Luangcharoenrat, Intrachooto, Peansupap and Sutthinarakorn (2019) with a reliability coefficient of 0.985; construction waste reduction strategies have 11 items adapted from Chukwu et al. (2019) with a reliability coefficient of 0.79.Three experts (two from the Department of Civil Engineering and one from the Department of Industrial Technical Education) were asked to validate the instrument by crosschecking the items and purposes intended. Suggestions on rewording of some items were effectively integrated. The instrument was tested on 18 Civil Engineering students ofthe University of Nigeria, Nsukka. The reliability coefficients showed causes of construction waste, 0.895; construction waste reduction actions, 0.947; while the overall was 0.806. According to the suggestions by Nunnally (1978), a reliability coefficient of 0.70 is suitable for analysis. Retrieved instruments were analyzed using descriptive statistics, t-test for comparison and multiple regressions of the Statistical Package for Social Sciences (SPSS), version 21.

## Research Findings

The following subsections explain the data gathered and the analyses through descriptive statistics and t-test, and multiple regressions.

### Descriptive Statistics and T-Test

Table 1
*Demographic Variables of Respondents*

| Variables | Category | Number | Percentage (%) |
|---|---|---|---|
| Status | Students | 23 | 37.7 |
| | Site-Workers | 38 | 62.3 |
| Highest Qualification | Ph.D | 3 | 4.9 |
| | M.Sc/M.Tech./M.Ed. | 17 | 27.9 |
| | B.Eng./B.Sc./B.Ed. | 32 | 52.4 |
| | FSLC (Primary School) | 9 | 14.8 |
| Gender | Male | 57 | 93.4 |
| | Female | 4 | 6.6 |

The demographic variables in Table 1 present the number of respondents, a total of 61. Among the category of siteworkers were three PhD holders who were met at different construction sites working either as supervisors/contractors and/or as managers of the industry. The students who responded to the questionnaire were automatically categorized as Bachelor degree holders alongside other fresh and older graduates who possessed the first degree, thereby bringing the total number of that category to 32. It is equally observed from Table 1 that some siteworkers have not seen or are yet to see the four walls of a higher institution. This category of respondents possesses the First School Leaving Certificate (FLSC), which represents primary school graduation certificate as their highest qualification. Generally, Table 1 gives insight into the details of those whose status, qualification and gender played out in analyses.

Table 2
*Causes of Construction Waste*

| S/n | Causes of construction waste | All participants | | Students *(N = 23)* | | Site-Workers *(N = 38)* | | *t-cal* | *p-value* | *Remark* |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Mean | SD | Mean | SD | Mean | SD | | | |
| 1 | Change to design | 3.66 | 1.11 | 3.39 | 1.08 | 3.82 | 1.11 | -1.46 | 0.15 | NS |
| 2 | Inattentive working attitudes and behaviours | 3.64 | 0.97 | 3.17 | 0.89 | 3.92 | 0.91 | -3.13 | 0.00 | S |
| 3 | Improper material storage | 4.61 | 0.86 | 4.52 | 1.08 | 4.66 | 0.71 | -0.59 | 0.55 | NS |
| 4 | Designers´ inexperience | 4.23 | 0.59 | 4.39 | 0.66 | 4.13 | 0.53 | 1.70 | 0.10 | NS |
| 5 | Incompetent workers | 4.16 | 0.80 | 4.35 | 0.88 | 4.05 | 0.73 | 1.41 | 0.16 | NS |
| 6 | Complicated design | 4.36 | 0.66 | 4.43 | 0.73 | 4.32 | 0.62 | 0.68 | 0.50 | NS |
| 7 | Design errors | 4.23 | 0.76 | 4.35 | 0.83 | 4.16 | 0.72 | 0.94 | 0.35 | NS |
| 8 | Ineffective planning and scheduling | 4.11 | 0.61 | 4.30 | 0.56 | 4.00 | 0.62 | 1.94 | 0.06 | NS |
| 9 | Control and supervision | 4.20 | 0.70 | 4.35 | 0.71 | 4.11 | 0.69 | 1.31 | 0.19 | NS |
| 10 | Poor waste management | 4.23 | 0.72 | 4.35 | 0.65 | 4.16 | 0.75 | 1.00 | 0.32 | NS |
| 11 | Wrong teams/ subcontractors selection | 4.28 | 0.76 | 4.35 | 0.88 | 4.24 | 0.68 | 0.55 | 0.58 | NS |
| 12 | Material ordering problems | 4.20 | 0.73 | 4.35 | 0.83 | 4.11 | 0.65 | 1.27 | 0.21 | NS |
| 13 | Construction drawing errors | 4.31 | 0.67 | 4.30 | 0.70 | 4.32 | 0.66 | -0.06 | 0.95 | NS |
| 14 | Improper material handling | 4.25 | 0.70 | 4.48 | 0.67 | 4.11 | 0.69 | 2.07 | 0.04 | S |
| 15 | Documents problems | 4.15 | 0.79 | 4.30 | 0.88 | 4.05 | 0.73 | 1.21 | 0.23 | NS |
| 16 | Construction methods | 4.34 | 0.57 | 4.43 | 0.51 | 4.29 | 0.61 | 0.96 | 0.34 | NS |
| 17 | Material transporting problems | 3.54 | 0.96 | 3.74 | 1.18 | 3.42 | 0.79 | 1.26 | 0.21 | NS |
| 18 | Reworks | 3.59 | 1.01 | 3.78 | 0.90 | 3.47 | 1.06 | 1.17 | 0.25 | NS |
| 19 | By-process waste | 3.51 | 1.04 | 3.65 | 0.88 | 3.42 | 1.13 | 0.84 | 0.41 | NS |
| 20 | Coordination problems | 3.64 | 1.07 | 3.83 | 0.89 | 3.53 | 1.16 | 1.07 | 0.29 | NS |
| 21 | Tools and equipment misuse/malfunction | 3.51 | 0.99 | 3.70 | 0.97 | 3.39 | 1.00 | 1.15 | 0.26 | NS |
| 22 | Defective materials | 3.44 | 1.09 | 3.70 | 0.97 | 3.29 | 1.14 | 1.42 | 0.16 | NS |
| 23 | Construction errors | 3.56 | 1.09 | 3.70 | 0.97 | 3.47 | 1.16 | 0.77 | 0.44 | NS |
| 24 | Packaging problems | 3.52 | 1.03 | 3.65 | 0.93 | 3.45 | 1.08 | 0.75 | 0.45 | NS |
| 25 | Lack of suppliers involvement | 3.41 | 1.04 | 3.52 | 1.12 | 3.34 | 0.99 | 0.65 | 0.52 | NS |

*See next page for continuation of table*

*Continuation of Table 2*

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| 26 | Damaged materials | 3.56 | 1.20 | 3.70 | 1.15 | 3.47 | 1.25 | 0.69 | 0.49 | NS |
| 27 | Material quality problems | 3.57 | 0.85 | 3.70 | 0.76 | 3.50 | 0.89 | 0.87 | 0.39 | NS |
| 28 | Misuse of material | 3.61 | 0.99 | 3.87 | 1.06 | 3.45 | 0.92 | 1.64 | 0.11 | NS |

The data in Table 2 show the groups' mean with values ranging from 3.41 to 4.61. Based on the average mean value of 3.50 (for a 5-point scale), only two items (25 and 22) out of 28, have values less than the benchmark. It could be deduced that the respondents agree to 26 causes of construction waste, whereby "improper material storage" (item 3) has the highest mean of 4.61 followed by causes due to "complicated design" (item 6), "construction methods" (item 16) and "construction drawing error" (item 13) with mean values of 4.36, 4.34 and 4.31, respectively. It could equally be observed that the standard deviation values in Table 2 were not too high, showing that the responses were not far distinct.

The t-cal and p-values in Table 2 reveal the comparing results of the two groups using mean values. It shows that the responses were not significantly different but for items 2 and 14 with p-values of 0.00 and 0.04, respectively. Therefore, students and siteworkers do not differ in their responses with respect to 26 causes of construction waste within the school environment.

Table 3
*Construction Waste Reduction Measures*

| S/n | Ways of reducing construction waste | All participants | | Students *(N = 23)* | | Site-Workers *(N = 38)* | | *t-cal* | *p-value* | *Remark* |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Mean | SD | Mean | SD | Mean | SD | | | |
| 29 | Apply source reduction through calculated procurement | 4.57 | 0.62 | 4.52 | 0.79 | 4.61 | 0.50 | -0.51 | 0.61 | NS |
| 30 | Meter / measure resources onsite | 4.33 | 0.63 | 4.22 | 0.67 | 4.41 | 0.60 | -1.13 | 0.26 | NS |
| 31 | Acquaint site workers to waste management strategies | 4.39 | 0.64 | 4.39 | 0.66 | 4.39 | 0.64 | -0.02 | 0.98 | NS |
| 32 | Source materials off-site | 4.28 | 0.73 | 4.22 | 0.74 | 4.32 | 0.74 | -0.50 | 0.62 | NS |
| 33 | Ensure timely delivery of materials, fittingly fabricated | 4.36 | 0.75 | 4.30 | 0.82 | 4.39 | 0.72 | -0.45 | 0.65 | NS |
| 34 | Avoid 10% extra procurement in tendered document | 4.49 | 0.60 | 4.43 | 0.59 | 4.53 | 0.60 | -0.58 | 0.56 | NS |
| 35 | Negotiate for buy-backs of materials not used | 4.39 | 0.74 | 4.26 | 0.92 | 4.47 | 0.60 | -1.10 | 0.28 | NS |
| 36 | Use designated/designed sections for mixing and concreting | 4.31 | 0.76 | 4.17 | 0.98 | 4.39 | 0.59 | -1.09 | 0.28 | NS |
| 37 | Audit materials before deconstruction or demolition | 3.75 | 0.96 | 3.78 | 0.95 | 3.74 | 0.98 | 0.18 | 0.86 | NS |

*See next page for continuation of table*

*Continuation of Table 3*

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| 38 | Sort onsite waste materials using designated areas | 3.64 | 1.00 | 3.48 | 0.95 | 3.74 | 1.03 | -0.98 | 0.33 | NS |
| 39 | Reuse would-be wastes onsite e.g. concrete masonry unit waste for filling | 3.61 | 0.94 | 3.61 | 0.84 | 3.61 | 1.00 | 0.01 | 0.99 | NS |

Table 3 shows ways of reducing construction waste with a consensus on 11 measures amongst the respondents. All the items in Table 3 have mean scores above the average mean value of 3.50, which implies that the respondents agree that measures tested are valid in curbing construction waste. Moreover, t-cal and p-value in Table 3 indicate another parallel agreement of all parties irrespective of the category. Therefore, it is deduced that there is no significant difference in the mean values of the responses of students and siteworkers on the ways of reducing construction waste.

## Multiple Regression Analysis

Table 4
*Model Summary of the Awareness of Construction Waste Reduction Measures*

| Model | R | R Square | Adjusted R Square | Std. Error of the Estimate |
|---|---|---|---|---|
| 1 | .623[a] | .389 | .356 | .98581 |

a. Predictors: (Constant), Gender, Qualification, Status

Table 4 reveals the R-value of 0.623. This implies that awareness is strongly positively correlated with the variables (gender, qualification and status). The adjusted $R^2$ of the model is 0.356 and $R^2 = 0.389$, indicating that 38.9 % of the variance in the awareness of the respondents can be explained by the combined influence of gender, qualification and status. This further shows that gender, qualification and status of the respondents significantly predict awareness of construction wastes reduction measures.

Table 5
*Statistical Significance of the Relationship*

| | Model | Sum of Squares | df | Mean Square | F | Sig. |
|---|---|---|---|---|---|---|
| 1 | Regression | 35.208 | 3 | 11.736 | 12.076 | .000[b] |
| | Residual | 55.394 | 57 | .972 | | |
| | Total | 90.601 | 60 | | | |

a. Dependent Variable: Awareness
b. Predictors: (Constant), Gender, Qualification, Status

Table 5 shows the statistical significance values of the F-ratio. F-ratio in Table 5 reveals that the regression model fits the data well. Hence, the independent variables (gender, qualification and status) are statistically significantly different at $p < 0.0005$, $F(3,57) = 12.076$. It shows, therefore, that although the variables possess a good level of prediction (Table 4), there are significant differences in the relationship among the variables.

Table 6
*Estimated Model Coefficients*

| Model | Unstandardized Coefficients | | Standardized Coefficients | T | Sig. | 95.0% Confidence Interval for B | | Collinearity Statistics | |
|---|---|---|---|---|---|---|---|---|---|
| | B | Std. Error | Beta | | | Lower Bound | Upper Bound | Tolerance | VIF |
| 1 (Constant) | 19.034 | 1.184 | | 16.071 | .000 | 16.662 | 21.406 | | |
| Status | -1.282 | .311 | -.510 | -4.123 | .000 | -1.905 | -.660 | .701 | 1.427 |
| Qualification | -.829 | .184 | -.545 | -4.501 | .000 | -1.197 | -.460 | .731 | 1.367 |
| Gender | -1.246 | .524 | -.253 | -2.376 | .021 | -2.295 | -.196 | .946 | 1.057 |

a. Dependent Variable: Awareness

Data in Table 6 show how the awareness of the respondents varies with each independent variable when other variables are held constant. Unstandardized coefficients reveal that the predicted awareness value is a result of subtracting from B, 19.034 the multiples of 1.282, 0.829 and 1.246 for status, qualification and gender, respectively.In Table 6, due to the presence of multiple independent variables, the Beta weights compare the relative importance of each independent variable in standardized terms. It could be deduced that gender has a higher impact compared to qualification and status (beta values = -0.253, -0.510 and -0.545, respectively). Table 6 also shows t-values and p-values (0.000, 0.000 and 0.021 for independent variables), indicating that all variables (status, qualification and gender) have significant differences in their relationship at 0.05 level of significance.

The collinearity statistics in Table 6 show tolerance and variance inflation factor (VIF) used to verify multicollinearity of data or simply toascertain the extent to which the independent variables are correlated with each other. The tolerance values for gender, qualification and status in Table 6 are0.946, 0.731 and 0.701 with VIF values of 1.057, 1.367 and 1.427, respectively. Thus, the data have no suspicion of multicollinearity as all tolerance values are greater than 0.1 and VIF values are less than 10.0.

The normal P-P plot (Fig. 2) and scatter plot (Fig. 3) show further evidence of the normality of data and homoscedastic compliance of the data, respectively. Thus, while the P-P plot compares the observed distribution function (CDF) of the standardized to the expected CDF of the normal distribution, the scatter plot shows the linearity of the variables.

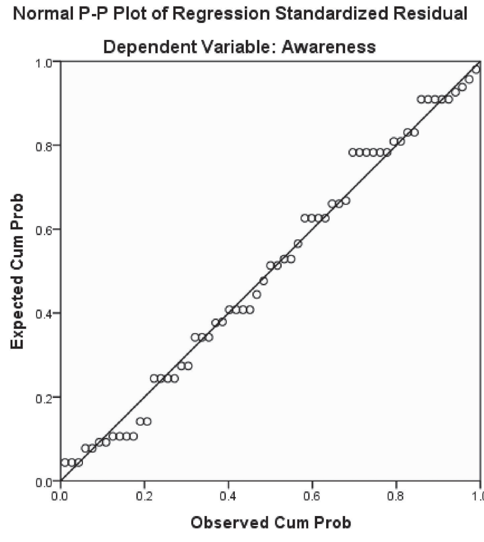


*Figure 2*. Normal P-P plot

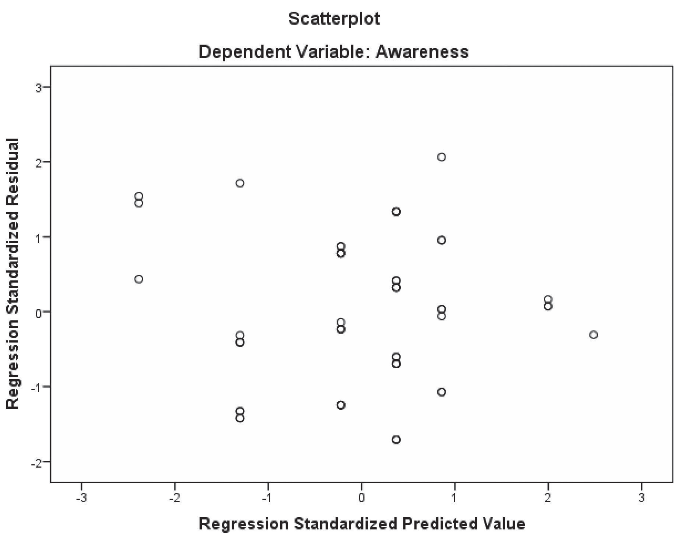


Figure 3. Scatter plot

## Discussion

The result in Table 2 shows the causes of construction waste with mean values validating the extent of the respondents' agreement. From Table 2, improper material storage, complicated design, construction methods, construction drawing errors and wrong team/subcontractor selection are the five causes with the highest mean values. Improper material storage is a human resource error atthe construction site (where provision is not made for the storage of equipment, materials and consumables or the provision made is inadequate and/or isnot efficiently utilized). In some cases, the little store receives a mixture of materials without proper sorting and stacking due to inadequate facilities. US Department of Labor (n.d.) advocates that efficient handling and storing of materials are vital to the industry, as it ensures workflow, proper use, cost reduction, waste reduction and environmental protection. According to the Health and Safety Executive (2019), proper material storage is a function of good cooperation and coordination amongst parties involved – clients, contractors, suppliers and laborers. Thus, the failure of any or part of the team involved results inwaste of materials in construction. The study by Luangcharoenrat et al. (2019) found "improper storage of material" as the third highest ranked cause of construction waste and suggested that suitable storing methods and appropriate protection be applied.

Complicated design and errors arising from drawings were found to be equally responsible for the waste generated during construction. Designs are complicated when the available manpower lacks the skills to interpret and execute the project. Hence, competences are important in curbing construction waste (Luangcharoenrat et al., 2019). On the other hand, errors can occur from unrealistic inclusions and ambiguities in drawings. Adewuyi and Otali (2013) found that rework wasthe resultant effect of these waste generating causes. The authors found that "rework contrary to drawings and specifications" is the highest cause of construction waste. For Han, Lee and Pena-Mora (2012), these causes can simply be referred to as non-value adding efforts, which can be avoided through proper planning, execution, monitoring and control.

The construction method is also undertaken by humans. Adewuyi and Otali identified a wrong construction method as a cause of construction waste, which should be addressed. Fadiya, Georgakis and Chinyio (2014) related the wrong construction method to tradespersons' error while operating machines or installing materials. The authors equally observed that wrong construction methods occurred more when contractors/subcontractors tookto speed instead of environmental and minimal waste consciousness. In all, every error identified has a pointer to human resources suggesting that control of laborers, the decision of workers (Luangcharoenrat et al., 2019) and understanding of the need to reduce waste in construction are vital steps worth taking.

Table 3 ascertained construction waste reduction measures. Applying source reduction through calculated procurement leads to ordering the exact quantity of materials needed onsite. It further buttresses the need to eliminate the extra material procurement initially apportioned to waste during construction tendering (Ma, 2011). In other words, over-ordering and under-ordering of materials (Adewuyi & Otali, 2013) are avoidable mistakes. Negotiating for buybacks from suppliers is necessary as much as it is important to acquaint siteworkers with waste management strategies. Chen and Bell (2011) advocate for buybacks of unused goods in a supply chain, adding that the strategy results in less environmental waste, more profit and a win-win for customers, retailers and producers.

Lastly, multiple regressions analysis showed that awareness of construction waste reduction measures can be predicted by status, qualification and gender. According to Desa, Kadri and Yusooff (2012), awareness of solid waste management in schools is a driver of waste management practices among parents and entire households of the students. Awareness is directly affected by the education of the people; thus, an increase in awareness about causes of construction waste and measures of reductions can be achieved through education (Maddox, Doran, Williams, & Kus, 2011). It implies, thus, that students and graduates of universities working atconstruction sites stand a better chance of being aware of waste reduction measures than non-graduates. Older studies reported that the level of education had no significant relationship with waste reduction dispositions (Nixon & Saphores, 2009; Meneses & Palacio, 2005; Vining & Ebero, 1990) and were supported by Setiawan (2020). However, Han et al. (2018) found that the education period (qualification) had a high significantly positive correlation and regression with waste control. Arguably, education without a tone or hinge towards waste management, construction, environmental preservation among others would certainly have no role to play in predicting awareness of waste reduction measures but not otherwise.Gender also has a role to play in awareness of waste and its mitigating measures. The findings by Setiawan (2020) confirm that females are a key in achieving waste sorting, as most females engage in waste disposal than the male counterpart.

## Conclusions

This study took action research steps in investigating the knowledge of the Building Construction students and siteworkers at the University of Nigeria, Nsukka. The causes of construction waste were accepted to be the same with 26 of the 28 items having mean values above the benchmark 3.50 (see Table 2). Notable among the causes are improper material storage, complicated design, construction methods, construction drawing errors and wrong team/subcontractor selection among others. Likewise, there was a concession in the ways of reducing construction waste (Table 3) and it was discovered that many respondents had little idea of these measures to be taken while onsite. The poor awareness of the respondents about measures to reduce construction waste necessitated further action of an awareness campaign.

Having found the need for a campaign on awareness of construction waste reduction measures, the public beginning with the ongoing construction sites atthe University of Nigeria(Nsukka) deserves to know these pertinent measures. An awareness campaign is one action in putting forward the right methods and right thinking, and beginning from one's environment can go a long way in changing the negative attitudes of humans, especially the students.

Therefore, the researchers shared the result of the study with the class members, entertained questions and commissioned them as agents to drive the construction waste reduction campaign, as part of their semester assessment. A total of 18 students were sent out to sensitize the workers at six different sites. As a form of identification, the students wore a tag "construction waste reduction task force". The six sites visited were still at the foundation level, thereby allowing the workers the opportunity to incorporate the knowledge shared with them into everyday schedules. The advocates were given guidelines, one of which wasto inform the supervisor/foreman/contractor in-charge of the site of their intentions, thereby securing approval and a date for the sensitization.

Accordingly, construction reduction measures advocated were the findings in Table 3, from the highest mean to the least. The action steps required to ensure that the generation of construction waste was reduced include:

- applying source reduction through the calculated procurement;
- avoiding 10 % extra procurement in the tendered document;
- acquainting site workers to waste management strategies such as sorting, recycling, etc.;
- negotiating for buy-backs of materials not used;
- ensuring timely delivery of materials, fittingly fabricated;

- metering/measuring resources onsite;
- using designated/designed sections for mixing and concreting (one of the most violated with effects seen in leaching, etc.);
- sourcing materials off-site;
- auditing materials before deconstruction or demolition;
- sorting onsite waste materials using designated areas.

The reduction measures listed can help a community, team or individuals change actions, catch a vision in line with waste reduction, define approaches to undertake and join the global move for sustainability consciousness. This, no doubt, can change the world, one person's world per time!

## References

Adewuyi, T. O., & Otali, M. (2013). Evaluation of causes of construction material waste-case of Rivers State, Nigeria. *Ethiopian Journal of Environmental Studies and Management*, 6, 746–753.

Alarcon, L. F. (1994). Tools for the identification and reduction of waste in construction projects. *Journal of Lean Construction*, 365–377.

Al-Hajj, A., & Hamani, K. (2011). Material waste in the UAE construction industry: main causes and minimization practices. *Architectural Engineering and Design Management*, 7, 221–235.

Alwi, S., Hampson, K., & Mohamed, S. (2002, November 11–13). Waste in the Indonesian construction projects. In *Proceedings of the 1st International Conferences of CIB W107 – Creating a Sustainable Construction Industry in Developing Countries, Stellenbosch, South Africa*, *23*, 541–549.

Begum, R. A., Satari, S. K., & Pereira, J. J. (2010). Waste generation and recycling: comparison of conventional and industrialized building systems. *American Journal of Environmental Sciences*, 6(4), 383–388.

Burns, A. (2009). Action research in second language teacher education. In Burns, A., & Richards, J. C. (Eds), *The Cambridge guide to research in language teaching and learning*. Cambridge: Cambridge University Press.

Chen, J., & Bell, P. C. (2011). Coordinating a decentralized supply chain with customer returns and price-dependent stochastic demand using a buyback policy. *European Journal of Operational Research*, *212*(2), 293–300.

Chukwu, D. U., Anaele, E. A., Omeje, H. O., & Ohanu, I. B. (2019). Adopting green building constructions in developingcountries through capacity building strategy: Survey of Enugu State, Nigeria. *Sustainable Buildings*, *4*(4), 1–13.

Commonwealth of Australia (2009). *Living sustainability*. Retrieved from https://www.iau-hesd.net/sites/default/files/documents/2009__living_sustainably_the_australian_governments_national_action_plan_for_education_for_sustainability_fr.pdf

Dahiru, D., Dania, A. A., & Adejoh, A. (2014). An investigation into the prospects of green building practice in Nigeria. *Journal of Sustainable Development*, 7(6), 158–163.

Desa, A., Kadir, N. A., & Yusooff, F. (2012). *Environmental awareness and education: A key approach to Solid Waste Management (SWM) – a case study of a University in Malaysia*. Intech Open. doi.org/10.5772/48169

Ekanayake, L. L., & Ofori, G. (2004). Building waste assessment score: design-based tool. *Building and Environment*, *39*, 851–861.

Fadiya, O. O., Georgakis, P., & Chinyio, E. (2014). Quantitative analysis of the sources of construction waste. *Journal of Construction Engineering,* 1–9.

Faniran, O. O., & Caban, G. (1998). Minimizing waste on construction project sites. *Engineering, Construction and Architectural Management*, *5*(2), 182–188.

Federal Government of Nigeria (2013). *National policy on education* (5th ed.). Abuja: Ministry of Education.

Fedosejeva, J., Boče, A., Romanova, M., Iliško, Dz., & Ivanova, O. (2009). Education for sustainable development: The choice of pedagogical approaches and methods for the implementation of pedagogical tasks in the Anthropocene age. *Journal of Teacher Education for Sustainability*, *20*(1), 157–179.

Ferguson, J. (1995). *Managing and minimizing construction waste: A practical guide*. London: Institute of Civil Engineers.

Ferrance, E. (2000). *Action Research*. Retrieved from https://www.brown.edu/academics/education-alliance/sites/brown.edu.academics.education-alliance/files/publications/act_research.pdf

GOVHK (2018). *Construction Waste*. Retrieved from https://www.gov.hk/en/residents/environment/waste/constructionwaste.htm

Han, S., Lee, S., & Peña-Mora, F. (2012). Identification and quantification of non-value-addingeffort from errors and changes in design andconstruction projects. *Journal of Construction Engineering and Management*, *138*, 98–109. doi: 10.1061/(ASCE)CO.1943-7862.0000406

Han, Z., Duan, Q., Fei, Y., Zeng, D., Shi, G., Li, H., & Hu, M. (2018). Factors that influence public awareness of domestic waste characteristics and management in rural areas. *Integrated Environmental Assessment and Management. Environmental Management*, *14*(3), 395–406. doi: 10.1002/ieam.4033

Health and Safety Executives [HSE] (2019). *Materials storage and waste management*. Retrieved from https://www.hse.gov.uk/construction/safetytopics/storage.htm

HEC – Global Learning (2009). *Sustainable development*. Retrieved from http://www.hec.fr/var/fre/ storage/original/application

Huanga, B., Wanga, X., Kua, H., Geng, Y., Bleischwitz, R., & Ren, J. (2018). Construction and demolition waste management in China through the 3R principle. *Resources, Conservation* & *Recycling*, *129*, *36–44*. Retrieved from http://dx.doi.org/10.1016/j.resconrec.2017.09.029

Katherine, T. A. (2017). Circular economy in construction: current awareness, challenges and enablers. *Institutional Civil Engineering*, *170*, 15–24.

Katz, A., & Baum, H. (2011). A novel methodology to estimate the evolution of construction waste in construction sites. *Journal of Waste Management*, *31*, 353–358.

Kibert, C. J. (2013). *Sustainable construction: Green building design and delivery*. New Jersey: John Wiley & Son Inc.

Llatas, C. (2011). A model for quantifying constructionwaste in projects according to the European wastelist. *Journal of waste management*, *3*, 1261–1276.

Luangcharoenrat, C., Intrachooto, S., Peansupap, V., & Sutthinarakorn, S. (2019). Factors influencing constructionwaste generation inbuilding construction: Thailand's perspective. *Sustainability*, *11*, 3638. doi:10.3390/su11133638

Ma, U. (2011). *No waste: Managing sustainability in construction*. UK: Gower Publishing Ltd.

Maddox, P., Doran, C., Williams, I. D., & Kus, M. (2011). The role of intergenerational influencein waste education programmes: The THAW project. *Waste Management*, *31*, 2590–2600.

Mbote, R. P., Kimtai, A. K., & Makworo, M. (2016). An investigation on the influence of factors causing materialwasteon construction cost of residential building frame: A case of northern region of Nairobi. *International Journal of Engineering Research & Technology (IJERT)*, *5*, 436–447.

Meneses, G. D., & Palacio, A. B. (2005). Recycling behavior: A multidimensional approach. *Environmental Behaviour*, *37*, 837–60.

Merino, M. R., Gracia, P. I., & Azevedo, I. S. W. (2010). Sustainable construction: Construction and demolition waste reconsidered. *Waste Management & Research*, *28*, 118–129. doi: 10.1177/073424X09103841

Muhwezi, L., Chamuriho, L. M., & Lema, N. M. (2012). An investigation into materials wastes on building construction projects in Kampala-Uganda. *Journal of Engineering Research*, *1*, 11–18.

Nagapan, S., Rahman, I. A., & Asmi, A. (2012). Factors contributing to physical and non-physical waste generation in construction industry. *International Journal of Advances in Applied Sciences (IJAAS)*, *1*(1), 1–10.

Nixon, H., & Saphores, J. D. M. (2009). Information and the decision to recycle: Results from a survey of US households. *Journal of Environmental Planning and Management*, *52*, 257–77.

Nunnally, J. C. (1978). *Psychometric Theory*. New York: McGraw-Hill.

Osmani, M., Glass, J., & Price A. D. F. (2008). Architects' perspectives on construction waste reduction bydesign. *Journal of Waste Management*, *28*, 1147–1158.

Osmani, M., Price, A., & Glass, J. (2006). Architect and contractor attitudes to waste minimization. *Proceedings of the Institution of Civil Engineers – Waste and Resource Management*, *159*(2), 65–72.

Peng, C. L., Domenic, E. S., & Charles, J. K. (1997). Strategies for successful construction anddemolition waste recycling operations. *Construction Management and Economics*, *15*(1), 49–58.

Poon, C. S. (2007). Reducing construction waste. *Journal of Waste Management*, *27*, 1715–1716.

Salīte, I. (2008). Educational action research for sustainability: Constructing a vision for the future in teacher education. *Journal of Teacher Education for Sustainability*, *10*, 5–16.

Salīte, I. (2015). Searching for sustainability in teacher education and educational research: Experiences from the Baltic and Black Sea Circle Consortium for educational research. *Discourse and Communication for Sustainable Education*, *6*, 21–29.

Santos, J. R. A. (1999). Cronbach's alpha: A tool for assessing the reliability of scales. *Journal of Extension*, *37*(2), 1–5.

Setiawan, R. P. (2020). Factors determining the public receptivityregarding waste sorting: A case study inSurabaya city, Indonesia. *Sustainable Environment Research*, *30*(1), 1–8. doi: 10.1186/s42834-019-0042-3

Siew, R. (2019). Are we ready for circular economy? Towards zero waste in construction. *Sustainable Building*, *4*(2), 1–5.

Teo, M. M., & Loosemore, M. (2001). A theory of waste behaviour in the construction industry. *Construction Management and Economics*, *19*(7), 741–751. doi: 10.1080/01446190110067037

United Nations (1992). *Earth Summit: UN conference on environment and development*. Retrieved from www.un.org/geninfo/bp/enviro.html

UNESCO (2014). World conference Education for Sustainable Development: What is ESD? Retrieved from http://www.unesco.org/new/en/unesco-world-conference-on-esd-2014/resources/what-is-esd/

US Department of Labour (n.d.). Occupational Safety and Health Administration: Materials handling and storage. Retrieved from https://www.osha.gov/Publications/OSHA2236/osha2236.html

Vining, J., & Ebreo, A. (1990). What makes a recycler? A comparison of recyclers and non-recyclers. *Environment and Behaviour*, *22*, 55–73.

Wahab, A. B., & Lawal, A. F. (2011). An evaluation ofwaste control measures in construction industry in Nigeria. *African Journal of Environmental Science and Technology*, *5*, 246–254.

Wan, S. K., Kumaraswamy, M. M., & Liu, D. T. (2009). Contributors to construction debris from electrical and mechanical work in Hong Kong infrastructure projects. *Journal of Construction Engineering and Management*, *135*(7), 637–646.

Correspondence concerning this paper should be addressed to Daniel Uchenna Chukwu, University of Nigeria, Onitsha Rd., Nsukka, Nigeria. Email: chukwu.daniel@unn.edu.ng