SUSTAINABLE APPLICATION OF MATERIALS FROM CONSTRUCTION AND DEMOLITION WASTE: A REVIEW

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ABSTRACT
The high level of waste produced by construction and demolition (C&D) is a major threat to the environment and human well-being, and is responsible for about half of global solid waste. There is an urgent need to employ methods of sustainability in managing waste, so as to alleviate the prevailing issues and environmental challenges which are caused by their disposal. The need for a sustainable approach to construction has been appraised in this review, considering the current sustainability practices along with their benefits and barriers. Focus was given to the sustainable use of construction and demolition (C&D) waste. Important materials that can be gotten from the C&D waste stream were evaluated, and methods of their possible reuse and recycling were examined. The appraisal also presents methods used to treat C&D waste, encouraging reuse and recycling of recycled materials to develop a healthy and liveable environment. It further promotes research and development on the reuse and recycling of C&D waste stream materials.

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1.0 INTRODUCTION
The constant increase in building and demolition waste generated throughout the world requires serious concerns. This increase can majorly be attributed to the escalating growth in population, which has resulted in a high demand for buildings, and the rising collapses of buildings in the country.

Construction and demolition (C&D) waste means waste material derived from buildings, roads and bridges, either in the course of construction, rehabilitation or demolition of any structure. For instance, Portland concrete, asphalt: cement, wood, drywall, asphalted shin, metal, carton, plastic and soil (Ganiron Jr, 2015) are waste components.

As urbanization has rapidly changed and building booms occurred almost all over the world over the 1990s, the volume of C&D waste produced conventionally in deposits has grown to uncontrollable standards (Elgizawy et al., 2016). Building materials contribute to about half of all the materials used and about a half of all the solid waste produced in the world (DSEWPC, 2011).

Each step of the construction process has an environmental impact, from the extraction of raw materials, through manufacture, transport, construction and disposal at the end of the useful
life of a building. Nigeria generates more than 15 MT of solid waste annually from building industries, including waste sand, gravel, bitumen, bricks and concrete (Otoko, 2014).

Some studies have revealed the construction industry as one sector that has contributed most largely to waste generation, especially when considering the exploitation of natural resources and the amount of C&D waste and environmental pollutants released by the activities of the sector (Ekanayake and Ofori, 2000; Macozoma, 2002). Landfilling is however not a very preferable option of managing C&D waste as a result of some factors which include the expensive cost of constructing adequate landfills, public resistance, and limitations in creating landfills that have capacity to continue serving for very long period of time (Jeffrey, 2011).

Therefore, the major participants in the construction sector have come under intense pressure to engage creatively in the sustainable use of C&D waste by means of reuse and recycling. Herrador et al., (2011) observed that the reuse of C&D waste materials significantly minimizes the impact of construction work on the surrounding environment.

2.0 THE DEMAND FOR SUSTAINABILITY IN CONSTRUCTION

Sustainable Development has become an everyday word emphasizing standards which promote the importance of balancing conservation of the environment and economic development (Meyer, 2005). In 1987, GroBruntland, the then Prime Minister of Norway, propounded the definition for sustainability as “meeting the needs of the present without compromising the ability of future generations to meet their needs” (Kim, 2002). This definition for sustainability has become widely accepted. Sustainability lies at a very core position in design and construction, if there must be full benefits environmentally, socially and economically (DBERR, 2008). However, there are severe threats to sustainable development, some of which include rapid urbanization, global warming, environmental pollution, water shortage and scarcity, and excessive waste generation (Sabnis, 2015).

The rapid increase in the population of urban centres has consequently resulted in a higher demand for housing needs. Several urban households are suffering gravely from the problem of housing as a result of the high cost of urban lands and housing (Chynoweth et al., 2007). Even though the challenge of housing is considered worldwide, it has been discovered to be more critical in the third world countries. Nigeria inclusive, having one of the highest urban growth rates in the world (Taiwo and Adeboye, 2013). It is therefore essential for stakeholders to place a high value on the impact of sustainability in this regard.

Moreover, the amount of energy expended in construction, either in the course of production and transportation of materials (embodied energy) or in their operational use (operational energy), contributes largely to the threat to sustainability in construction (Ortiz et al., 2009; Ogundeji and Adecirik, 2014). One important measure of the environmental impact of construction and effectiveness of recycling is the amount of embodied energy generated. For an office building, the embodied energy can be as high as 30 times the annual operating energy of the building (DSEWPC 2011).
The process of production of cement also contributes largely to the problem of sustainability. It stands out as one of the industrial processes that consumes energy the most all over the world. In producing cement, the energy cost grows to as high as 50 - 60% of the direct production cost of cement (Sabnis, 2015). As a matter of fact, the process of cement production contributes up to 7% of atmospheric CO2 (the major greenhouse gas in global warming), with as much as one ton of CO2 released into the atmosphere just in the production of a ton of Portland cement Meyer (2005). This makes crucial and urgent the need for development of environmentally friendly alternative materials for use in the course of construction and renovation of buildings and roads.

In addition, the amount of water consumed by the construction industry has been overlooked by many stakeholders. In construction sites, water is used for different purposes including manufacturing of concrete and mortar, curing of concrete, cleaning of tools and surfaces, and human needs to serve the demands of employees on the construction sites (Santos et al., 2015). Besides, waste water is found through leakages, damages, and inadequate management. Meyer (2005) revealed that the construction industry uses over a trillion gallons of water worldwide per year, thus placing large stress on areas with inadequate availability and supply of water. It therefore becomes essential to seek means of water management on construction sites in order to ensure sustainability goals are achieved.

Furthermore, C&D wastes stand as one of the major contributors to solid wastes all over the world (Elgizawy et al., 2016; El-Haggar, 2007). This challenge arises as a result of several factors some of which include using processes that make disposal difficult, using materials that are not potentially reusable or recyclable, using materials that are inefficient, and using designs and details that give room for much waste in executing jobs on site (Dolan et al., 1999). Hence, it is needful to focus on means of reducing the rate at which C&D waste is generated, as well as to seek effective methods to manage them in a sustainable manner.

2.1 Sustainability Practices in the Construction Industry and Barriers to their Implementation

With the increasing need to create structures whose design and construction have limited negative environmental impacts on the built environment, different strategies have been set in place for the purpose of ensuring sustainability in construction. One of the most vital methods in reducing the environmental impact of the construction industry is recycling. Recycling provides several benefits which include reduction in cost of concrete production, conservation of landfill space, and mitigation of pollution arising from disposal of waste (Arum, 2011). Other methods of sustainability in construction, include the application of supplementary cementitious materials such as fly ash and slag (by-products of some industrial activities), improvement of mechanical properties and durability of materials used in construction, and so on (Meyer, 2005; Lu, 2012). US Environmental Protection Agency (EPA) has also developed schemes targeted at promoting the refurbishment and possible reuse of polluted land areas, examples of which are abandoned manufacturing and industrial facilities/sites, also referred to as brownfields (Sabnis, 2015).
Nevertheless, major barriers yet exist to the implementation of sustainability standards in construction, especially in third world countries like Nigeria. Most of the barriers are largely associated with fostering
3.1 Materials Obtainable from the C & D Waste Stream

The kinds of materials obtainable from the C & D waste stream are largely dependent on a number of factors. Some of these factors include the kind of structure being built or demolished, the choice of material used in the building/structure, and the technique employed in the construction or demolition of the structure. These factors consequently determine the quantity, quality or type of waste being generated (Jeffrey, 2011).

Giving due consideration to their origin, Spivey (1974) classified C & D waste into concrete waste, packaging waste (e.g. paper, cardboard, plastic etc.), wood waste, asphalt waste, sanitary waste, scrap-metal waste, rubber and glass, and pesticide and non-pesticide cans. When it comes to residential construction, the waste generated is basically constituted of wood, gypsum wallboard, brick, roofing and metals (USEPA, 2003). Other examples of materials in the C & D waste stream range from granite, sand, ferrous and non-ferrous metals, to masonry (e.g. bricks and mortar), plastic (e.g. PVC pipes, wall coverings), marbles, ceramic tiles, insulation material (e.g. styrofoam, mineral wool installation), drywall/gypsum boards etc. (Elgizawy et al., 2016).

There are variations in the quantities of the various materials available in the C & D waste stream. Moreover, the ease with which the materials gotten can be recycled are comparatively different from one another. Concrete rubble represent the most prominent proportion of C & D waste, and they are relatively easy to recycle compared to some other materials. The crushing of these rubble enables them to be used in freshly prepared concrete, and in road pavements (either as the base or sub-base layer). The aggregates gotten from the process of crushing and reuse of these aggregates are referred to as recycled concrete aggregates (Otoko, 2014). Metals, on the other hand, have very great potentials in being reused in construction as they can be more easily collected from the waste stream and recycled. Plastic waste such as polyvinyl chloride pipes, polythene bags or sachets and expanded polystyrene (EPS) also have a significant chunk in the waste stream. However, they are many times not as easy to recycle as metals and concrete rubble due to contamination. A rating of C & D waste materials in order of their ease of recycling from 1 to 5 was proposed by Elgizawy et al. (2016), as shown in Table 1.

Table 1. Rating of C & D Waste materials in order of their ease of recycling (Elgizawy et al., 2016)

<table>
<thead>
<tr>
<th>Waste</th>
<th>Score</th>
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<tbody>
<tr>
<td>Ferrous Metal</td>
<td>5</td>
</tr>
<tr>
<td>Non-ferrous Metal</td>
<td>5</td>
</tr>
<tr>
<td>Paper</td>
<td>5</td>
</tr>
<tr>
<td>Concrete</td>
<td>4</td>
</tr>
<tr>
<td>Glass</td>
<td>4</td>
</tr>
<tr>
<td>Ceramic Tiles</td>
<td>4</td>
</tr>
<tr>
<td>Masonry</td>
<td>3</td>
</tr>
<tr>
<td>Plastic</td>
<td>3</td>
</tr>
<tr>
<td>Wood</td>
<td>3</td>
</tr>
<tr>
<td>Filling Materials</td>
<td>3</td>
</tr>
<tr>
<td>Marble</td>
<td>3</td>
</tr>
<tr>
<td>Mineral wool</td>
<td>2</td>
</tr>
<tr>
<td>Styrofoam</td>
<td>2</td>
</tr>
<tr>
<td>Drywall</td>
<td>2</td>
</tr>
</tbody>
</table>
3.2 Sustainable Practices for Management of C & D Waste

Over the years, some relevant methods have been observed in management of C & D waste which give effective results. Outlined below are some of these practices.

3.2.1 Adaptive Reuse

The process of adapting old structures for new uses is termed adaptive reuse. It involves transformation and development of older buildings for new functions, especially when they no longer effectively serve the former purposes (Sarafides, 2007). This method supports reduction in emission and protection of global climate (Conejos et al., 2011).

This practice grew popular in the architectural profession during the 1960s and 1970s as environmental concerns were heightened. It has since been an essential tool for preservation of historic structures (Cantell, 2005). Considering some case studies, some researchers have shown that the re-use of buildings is highly beneficial for the environment and offers cost savings over the future life of the buildings. Moreover, the aesthetic and historical values of existing and historic buildings are enhanced through this approach. In addition, the wasteful process of demolition and reconstruction is easily bypassed when buildings are re-used, thus minimizing the depletion of non-renewable resources and improving sustainability (Conejos et al., 2011; The Heritage Council, 2004; The Concrete Centre, 2016; Sarafides, 2007; Bullen, 2007). It is significant to note that the reuse of buildings transcends the reuse of stationary buildings to the movement of the whole building in order to be used in a new environment.

Structures made of concrete or bricks are almost impossible to move. However, this system finds applicability in structures made of metals and timber. Nova Scotia is one of the countries in which this practice has been found applicable with successes attained in moving wooden framed buildings with the use of trucks and custom made trailers (Jeffrey, 2011).

3.2.2 Selective Demolition and Deconstruction

Selective demolition is another method through which materials found valuable in a structure are removed by hand for reuse and recycling, after which the remains of the structure is broken down. It may also involve removal of the structural elements piece by piece, in a process known as selective dismantling (Chini and Bruening, 2003; Jeffrey, 2011).

There are numerous advantages that deconstruction offers over conventional demolition. The potential reuse of structural components is the foremost advantage of this method. Consequently, the case at which the materials can be recycled is greatly enhanced. Moreover, the rate at which demolition waste are disposed into landfills is largely reduced, hence enhancing the protection of the natural environment.

However, there are major issues militating against the method of deconstruction of buildings. One of the most significant among challenge is that several buildings existing today have not been designed for disassembly. Furthermore, many building materials that have been used have not catered for possibility of being disassembled. Another drawback is that the required skilled manpower and equipment for deconstruction are not usually
available, and building codes have not really addressed the reuse of building components. Nevertheless, with improved research and changes in design and policy, these challenges can be dealt with (Kibert et al., 2000).

3.2.3 Reuse and Recycle

(i) Concrete and bricks
Concrete stands out as one of the most largest proportion of materials in construction and demolition waste stream. There are several benefits that can be derived from recycling concrete some of which include conservation of landfill space, conservation of energy and resources for concrete production and overall reduction in construction cost (Arum, 2011). The process of recycling concrete simply involves breaking, removing and crushing of existing concrete into materials of specific size and quality. Figure 1 shows the process of recycling waste concrete.

![Diagram of recycling waste concrete](image)

Figure 1. The process of recycling waste concrete

The most relevant materials recovered from waste concrete are recycled aggregates (RA) or recycled concrete aggregates (RCA). These refer to aggregates obtained from concrete that has been formerly used in construction after they have been crushed and graded. They can be obtained from crushed concrete and masonry. Usually, they are graded and used in a similar manner to natural aggregates after they have been processed through crushing, preliminary sizing, sorting and screening, and removal of contaminants (Ganiron Jr, 2015; Zhang and Ingham, 2010). Price (2002) gave a distinction between RAs and RCAs based on their performance as specified in BS 8500-2 (2002) (as shown in Table 2). He noted that the performance of RCAs are better than RAs, in that the masonry content in RCAs is not allowed to be more than 5%. They are made solely on concrete and can be classified as shown in Table 2. There are quite tremendous benefits and applications for RCAs in construction. RCAs can be used in fills, protection of banks, road construction, embankments, and even as noise barriers (Sabnis, 2015). Some significant benefits derived from the use of RCAs include conservation of landfill space due to reduction in concrete waste deposition, lower demand for new materials and resources, significant cutback in transportation and production costs etc. (Tam, 2009; Shahidan et al., 2017; Arum, 2011).

Nevertheless, it is important to note that the quality of concrete produced using recycled aggregates is largely dependent on the quality of the recycled material. When considerable amounts of contaminants are present, the quality of concrete produced is highly reduced. Some of these contaminants include wood, bitumen, gypsum, organic substances, chlorides, chemical admixtures, metals, glass, and so on. Researches have shown that recycled aggregate concrete do not comparatively perform as well as natural aggregates, and hence they are not recommended for structural purposes (Ganiron Jr., 2015; Ferriz-Papi and Thomas, 2017; Xiao et al.,)
Table 2. BS 8500-2 (2002) Requirements for Recycled Aggregates

<table>
<thead>
<tr>
<th>Aggregate</th>
<th>Maximum Masonry Content</th>
<th>Maximum Fines</th>
<th>Maximum Lightweight material</th>
<th>Maximum Asphalt</th>
<th>Maximum Other Foreign materials e.g. glass, metal, plastics Mass Fraction (%)</th>
<th>Maximum Acid Soluble Sulfate (SO₄) Mass Fraction (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>RCA</td>
<td>Mass Fraction (%)</td>
<td>5</td>
<td>0.5</td>
<td>5.0</td>
<td>1.0</td>
<td>1.0</td>
</tr>
<tr>
<td>RA</td>
<td>100</td>
<td>3</td>
<td>1.0</td>
<td>10.0</td>
<td>1.0</td>
<td>1.0</td>
</tr>
</tbody>
</table>

Table 3. Advanced methods of improving the quality of recycled aggregates in Japan (Tam, 2009)

<table>
<thead>
<tr>
<th>Methods</th>
<th>Description of the technological method</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heating and grinding</td>
<td>The heating and grinding method makes the hardened cement paste which adheres to concrete waste soften by heating concrete waste to about 3000°C. After that, parts of the hardened cement paste adhered to original aggregate mass can then be separated by a grind process resulting in clean original aggregate from the concrete waste</td>
</tr>
<tr>
<td>Screw grinding</td>
<td>The screw grinding method uses a shaft screw consisting of an intermediate part and an exhaust part with a warping cone to remove mortar adhered to the aggregate’s surface</td>
</tr>
<tr>
<td>Mechanical grinding</td>
<td>The mechanical grinding method uses a drum body which finely separates partition boards with same-sized holes. The steel balls can move horizontally and vertically by rolling the drum. The quality of aggregate can then be improved in narrowing the inside space by using the partition boards</td>
</tr>
<tr>
<td>Gravity concentration</td>
<td>After processing with a jaw crusher, an impact crusher and an improvement rod mill, aggregates of over 8 mm are divided into recycled coarse aggregate and mortar particles. Aggregates with sizes less than 8 mm are divided into two types: recycled fine aggregate of sizes 5 mm and 5-8 mm. The wet gravity concentration machine is used to move: i) light weight things such as mortar particle and wood waste upward; and ii) heavy weight things such as aggregate grain downward.</td>
</tr>
</tbody>
</table>
2014; Safiuddin et al., 2013). However, with a higher water-cement ratio than that of the original concrete, treatment of the aggregates and/or with addition of admixtures, the performance of recycled aggregate concrete can be greatly improved (Hansen and Narud, 1983; Corinaldesi, 2011). Hansen (1992) advocated that provided that necessary limits are imposed on the amount of allowable impurities in recycled aggregates, there will be better quality of recycled aggregate concrete produced. Presented in Table 3 are some advanced technologies that have been used to improve the quality of recycled aggregates in Japan.

(ii) Wood

Wood can also be obtained from the C&D waste stream and reused for valuable purposes. Two types of identified in the C&D waste stream are clean wood and contaminated wood. The term “clean wood” depicts sawn timber without addition of glues, resins or other materials. Meanwhile, “contaminated wood” (also known as dirty wood) is made up of engineered wood products to which glues, resins, paints or stains have been applied (Jeffrey, 2011). Plywood, particle board, laminated wood products are examples of engineered wood include plywood, particle board and laminated wood products. Clean wood can be used to make materials like engineered particle board, re-milled for flooring, mulch (cover of soil), fuel etc. (Kuosa, 2012). Being a very adaptable material, it is easy to use timber obtained from the C&D waste stream in construction of new structures (Winkler, 2010). Moreover, in light-framed structures, the use of heavy machinery can be avoided in deconstruction, hence leading to savings in cost (Guy et al., 2006).

(iii) Metals

Several kinds of metal wastes obtainable from the C&D waste stream can find relevant application in new construction projects. Examples of ferrous metal wastes include steel reinforcement bars, steel studs, strappings, and framing pieces, while non-ferrous metal wastes can be gotten from copper-pipe offcuts, aluminium sheetings, electrical cable cut-offs etc. (Winkler, 2010). Most of these wastes arise from commercial demolition sites, and as much as 95 per cent steel and about 5 per cent non-ferrous metals can be obtained. The use of relatively inexpensive magnets can easily help in recovery of ferrous metals like steel (DSEWPC, 2011). Different ways in which these metals find application include reuse in construction sites, melting and reuse, as concrete filler material, for protecting steel galvanized after fabrication. These metals can also be sold to recycle centres for recycling, thus offering also economic benefits in providing opportunities for employment in these recycling industries (Nadarason et al., 2018). However, there are observed disadvantages involved in the use of recycled metals. Some of the metals like aluminium usually degrade after every cycle of their reuse, thus leading to variation in the quality of final products. The presence of impurities in many recycled metals, cost, energy and time involved in collecting, sorting and transporting these metals are also considerable challenges in the use of recycled metals (Rush, 2019).

(iv) Asphalt

The road construction sector is the most potential generator of asphalt material. The beauty of asphalt is that it has a 100 per cent potential of being recyclable. The wearing course (generally about 25
to 40mm) is found to be replaceable every 10 to 15 years. On the average, asphalt pavements contain about 4 per cent bitumen and 96 per cent aggregate. By using a milling machine, the wearing course (which represents the top layer of asphalt) can be removed and recycled in an asphalt plant, where it is sorted and batched. With this, recycled asphalt can have the appropriate ratio of bitumen to aggregate, as well as adequate proportion of aggregate size and air voids in the mix (DSEWPC, 2011).

As a matter of fact, recycling of asphalt shingle (RAS) has become an interesting area of research and development for several years, and can be used in several road applications. They can be used in preparation of hot-mix asphalt, in construction of lightweight pavements such as driveways and parking lots, and in road patching products. They can also be used in rural road maintenance and as components of the fill of a road base (Krivit, 2007). One of the most significant economic benefits is that there is marked reduction in cost incurred in aggregate and binder consumption (Santos et al., 2010). One of the observed disadvantages of using recycled asphalt pavements (RAPs) is that the plant efficiency can be reduced if the reclaimed material is not properly heated (Santos et al., 2010). It is also observed that the performance of the asphalt can be affected when more than 5% of RAS is used in the hot-mix. However, with the incorporation of a softer grade of virgin asphalt cement in the hot mix, this problem can be addressed (Krivit, 2007). Another observed problem is the possible leaching of contaminants from the RAP. However, the concentration limits of heavy metals and polycyclic aromatic hydrocarbons are relatively low in affecting drinking water (Shedivy and Meier, 2012; Brantley and Townsend, 1999).

(v) Gypsum board/Plasterboard

Gypsum boards are also relevant materials that can be recycled in the C&D waste stream. They may also be referred to as gypsum drywall, gypsum wallboard, plasterboard, gyprock or sheet rock. The components of gypsum drywall are about 90 percent gypsum (calcium sulphate dehydrate - CaSO₄·2H₂O) and 10 percent paper facing and backing (Elgizawy et al., 2016). They have found applicability in producing new gypsum boards, replacing old gypsum plaster as the major interior surface of walls, as a substitute for virgin gypsum during the production of cement, and in agriculture as soil additives and compost. One major challenge with recycling of gypsum drywall is its contamination with waste. It is important that gypsum must be separated from the paper facing when recycling gypsum board, because the paper facing reduces the fire resistance of the board (Elgizawy et al., 2016, Jeffrey 2011).

(vi) Glass

Waste glass has been found to have significant proportion in the waste generated from C&D waste stream. This is because glass has found more application in buildings over time, such as exterior wall panels, doors and tiles. A very interesting and unique property of glass is its ability to be reused as many times as possible without changing its chemical properties (Shayan, 2002). Waste glass can be reused as landscaping material, in fills, in acoustic insulation, in fibre production, in production of foam glass and containers, in sand blasting, and can serve as abrasives, and water filtration media in paints. Recycled glass are also used as partial replacement for aggregates (fine or coarse aggregates) in concrete. They can as well be
used in hot-mix asphalt, where it can replace about 40% of the aggregate (Jeffrey, 2011; Kuosa, 2012). However, one major concern in using recycled glass in concrete is the possibility of the occurrence of alkali-silica reaction (ASR). This reaction is a chemical reaction between amorphous silica in reactive aggregates and the alkalis in Portland cement. This reaction leads to the formation of an amorphous gel which continually expands with the absorption of water, causing expansion and cracking of the surrounding concrete matrix (Pan et al., 2012). Some measures have been prescribed for avoiding or mitigating the effects of ASR in concrete when glass is used. Among these measures include grinding the glass into very fine particles (less than 75 μm), use of mineral admixtures to act as ASR suppressants such as fly-ash, lithium nitrate etc., use of low-alkali cement (Shayan, 2002; Meyer et al., 2001).

(vii) Plastics

Different types of plastics obtainable from the C&D waste stream include polyvinyl chloride (PVC) pipes, high density polyethylene (HDPE), expanded polystyrene (EPS) etc. Landfilling or incineration of plastics poses serious environmental threat, both to air and water quality. It takes plastics several years before biodegradation. This makes it very essential that they are not indiscriminately disposed and essentially recycled. Plastics can be recycled mechanically and chemically. Mechanical recycling of plastics requires that recovered plastic waste are cleaned, shredded and processed for removal of impurities. They are then melted and extruded into pellets. Meanwhile, in chemical recycling, heat and pressure is used in breaking down the plastics into chemical compounds. This method is most desirable for mixed plastic waste (APPRICOD, 2004). Plastic waste can be adopted for partial replacement of inorganic aggregates in lightweight concrete. They may also be used as plastic fibres in concrete, where they can provide improved resistance to corrosion, impact and shrinkage cracking (Kamarrudin et al., 2017; Kuosa, 2012).

4.0 CONCLUSION

It is obvious that C&D wastes being generated by the construction industry is a major threat to a sustainable environment. Hence, this paper has considered the essence of relevant sustainability practices that can be employed in effectively managing these wastes. It has been identified that high cost of sustainable building options, inadequate training of skilled professionals, absence of proper regulations, lack of reliable information and integration among stakeholders, are some major hindrances to the implementation of sustainable practices in managing C&D wastes. Adaptive reuse of buildings, deconstruction and reuse or recycling are all viable means of management of these wastes. While this study presents an overview to some available methods in management of C&D wastes, it advocates the need for further research into new methods that can be exploited in managing these wastes and effectively tackling the challenges confronting the reuse and recycle of these materials.

REFERENCES


Assessing the Potential of Plastics Recycling in


Kim, J. J. (2002). "Introduction to sustainable design." Masterbuilder, 3(6), pp. 34-44.


Construction: Green Building with Concrete." Journal of Civil and Environmental Engineering, 2(5).


"Use of Recycled Concrete Aggregate In Concrete: A Review". Journal of Civil Engineering and Management, 19(6), pp. 796-810.


