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Aminu Lawan Abdullahi and Angela Lee

Full Length Research Paper

A comparative study of sustainable end-of-life management in automobile and construction industry: A case of Kano City, Nigeria

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It was argued that either the construction industry to continue to be conservative and inefficient on the premise that it was distinctive or it should have opened-up to learn lessons from the best practices models in other sectors like manufacturing. This paper is a comparative study of the sustainable end-of-life management practices in the automobile and the Nigerian building sector with the aim of examining the feasibility of construction industry learning lessons from model of the automobile industry. While the practices in the automobile sector were obtained from literature, the practices in the Nigerian construction industry were investigated using in-depth, semi-structured interviews. The participants were construction industry experts with experience in building demolition as directly identified by the researchers or identified using snowball technique. The results of a comparative evaluation of the practices in the two industries shows that the practices in the construction industry can be improved by adopting five sustainable practices from the automobile industry. These are materials sorting techniques, maintaining materials database, reverse logistics and extended manufacturer responsibility, standardisation, and application of advanced material handling technology.

Key words: End-of-life, waste management, automobile, construction, Kano Nigeria.

INTRODUCTION

Imagine a situation where to procure a car, you have to order parts in pieces while signing series of contracts, and for most days leaving the unfinished vehicle exposed to the weather while the contractors closed from work; such is the analogy of the automotive to the construction industry (Solís, 2009). In the construction industry, buildings are procured by ordering parts in pieces, while signing series of contracts and for most of the days in the construction phase, the building is exposed to the

weather when workers close from work. The construction industry is usually challenged for being conservative and inefficient more especially if compared with the other industries like manufacturing, and there has been the urge for improved efficiency (Egan, 1998; Latham, 1994). Unlike manufactured products, every building is in the words of Koskela, “one-of-a-kind” product that is different from any other of its type, made up of large quantities and wide range of constituents. While the construction

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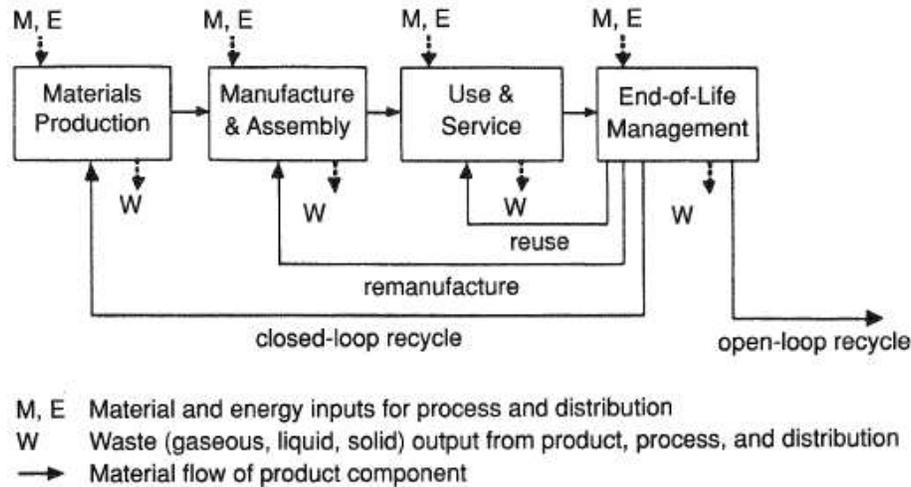


Figure 1. General products life cycle system.
Adopted from Keoleian et al. (1997).

industry is considered as a “conglomerate of industries” characterized by many inadequacies and paradoxes (Koskela, 2000; Solís, 2009), it is often described as less receptive to innovations and characterised by wide segregation of duties with unsteady workforce (Kibert et al., 2000). Moreover, the industrial culture inherent in construction industry can be yet another reason for the industry to be more conservative (Brockmann and Birkholz, 2006). These shortcomings of construction industry are often cited as justifications for the need of construction industry to learn lessons from other sectors like manufacturing as demonstrated in a study by Sanvido and Medeiros (1990) and Koskela (1992). It is now compelling for the construction industry to tread the path of other industries for increased efficiency, control, quality, productivity, and minimum cost of production (Solís, 2009).

In line with this thinking, this paper compares the Nigerian building construction industry with automobile industry in terms of the best sustainable practices in end-of-life management based on the premise that the construction industry is behind and should learn from other sectors. The paper starts by establishing the benchmark for what are good sustainable end-of-life practices from the literature. The prevalence of these practices in the Nigerian building construction sector was explored through semi-structured qualitative interviews with participants cutting across the major stakeholder groups in building construction sector within the case study site. The findings from this interview were compared with the practices in the automobile sector obtained from literature.

The research is towards providing an improved model for the end-of-life management of buildings by exploring the adoptable sustainable practices from the automobile industry.

Establishing the benchmark for sustainable practice for the end-of-life management of materials

There are four phases in the life cycle of products in general: - materials production, manufacturing and assembly, use and service, and end-of-life management (Figure 1). The end-of-life of products may be sustainably managed by remanufacturing and/or reusing, or recycling (Keoleian et al., 1997; Mayyas et al., 2012).

Nonetheless, reuse and recycling are not the only options of handling materials at the end of service. Waste management techniques are in hierarchy from the sustainably most preferable to the least preferable as recommended by the EU in what is usually referred to as *waste pyramid*. According to this concept, the best option is avoiding generating waste wherever possible. The next preferable approach is to reuse, thereafter recycle, and least preferable is energy recovery by incineration, sometimes termed as “*waste to energy*”. The other unsustainable method is dumping the waste in a Landfill, more especially when it contains hazardous materials (Figure 2) (Department of the Environment (DOE), 2012; Kibert, 2005; McDonough and Braungart, 2009; Nowak et al., 2009).

What makes a good or bad practice in the end-of-life management of materials is summarized in the statement accredited to McDonough and Braungart (2002), cited in Berge (2009): “*Seen from the perspective of industrial ecology, waste can be defined as resources in the wrong place- resources that have gone astray. The goal is to bring all resource flows back into closed loop where they circulate within the human economic system, so that the extraction of new raw materials as well as final discarded waste becomes an absolute minimum*” (McDonough and Braungart, 2002).

This research therefore established six (6) parameters



Figure 2. Waste pyramid.
Adopted from DOE (2012), Kibert (2005) and Nowak et al. (2009).

that can be used to assess the efficiency of a system in bringing resources back to economic cycle at the end of service as follows:

- i) Rate of materials recovery by recycling or reusing
- ii) Materials sorting technique
- iii) Establishing materials database
- iv) Role of original materials manufacturers
- v) Standardisation of salvaged materials
- vi) Use of advance technology and tools.

The above six (6) parameters were used to assess the efficacy of the Nigerian practice of end-of-life management of buildings and the findings were evaluated in comparison with practices in the automobile industry.

METHODOLOGY

Research approach

Finding out the prevalence of sustainable practices in the Nigerian building construction sector being exploratory in nature justifies the use of case study approach. Case study is considered convenient for exploratory and descriptive inquiries that seek to answer the how and what questions as described by Yin (1981) and Yin (2009). Case study is a synchronous study of situations whereby the subject is not distinct from the context with lowest researcher's control over events.

Kano city was selected as the site for the study. According to the National Population Commission (2010, 2016), Kano is the second most populated city in Nigeria and the most populous among the second-class townships recognised by the Townships Ordinances Act of 1917. The city of Kano has heterogeneous composition (Olukoju, 2004), and currently remains a vibrant commercial and cultural centre. Moreover, as described by Urquhart (1977), four

different types of settlements emerged in the urban centres of northern Nigeria with official recognition. The ancient walled city usually left intact, the European official settlements popularly known as GRA (an acronym for Government Reserved Area), the "*Tudun Wada*" as settlement for non-indigenous northerners, and the "*Sabon Gari*" as the living quarter for settlers from the southern Nigeria (Urquhart, 1977). This structure still exists in Kano and makes the city a confederation of all Nigerian nationalities, as observed even in the main stream media such as the British Broadcasting Corporation (BBC) (BBC, 2014).

Information was solicited from real-life projects in which the research participants partook through a semi-structured in-depth interview guided by six themes that form the benchmark of good practices of sustainable end-of-life management of materials. Qualitative in-depth semi-structured interviews were described as effective in providing detailed explanation of human phenomena (Petty et al., 2012). Sixteen research participants were selected for the interview using snowball technique, however, to address shortcomings of the snowball technique often criticised as presenting a viewpoint of a small circle of participants familiar with each other, more participants were identified directly by the researchers (Figure 3).

In order to minimise bias, the research participants were distributed across seven predetermined construction stakeholder groups developed from two merged schemes by Chinyio and Olomolaiye (2010) and Oyegoke (2010) (Figure 4). Nevertheless, it was observed that some participants belong to more than one stakeholder group as indicated in Table 1.

Thereafter, the interviews were transcribed verbatim for analysis using template analysis with the aid of "*QDA Miner*", which is a brand name for a computer-assisted qualitative data analysis software. Template analysis was described by its proponent as being flexible for use in different research scenarios, more especially with presumptive themes otherwise referred to priori themes (Brooks and King, 2014; King, 2012). The main feature of template analysis is a flexible coding template that may be developed without the need to comply to any rigid format or differentiating between descriptive and interpretive data. Template analysis was demonstrated to be applicable in a variety of methods including quantitative and qualitative (King, 2012).

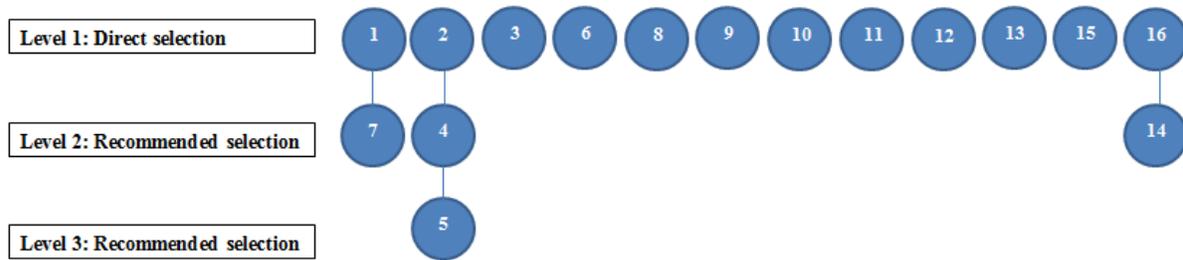


Figure 3. Research participant's selection process.

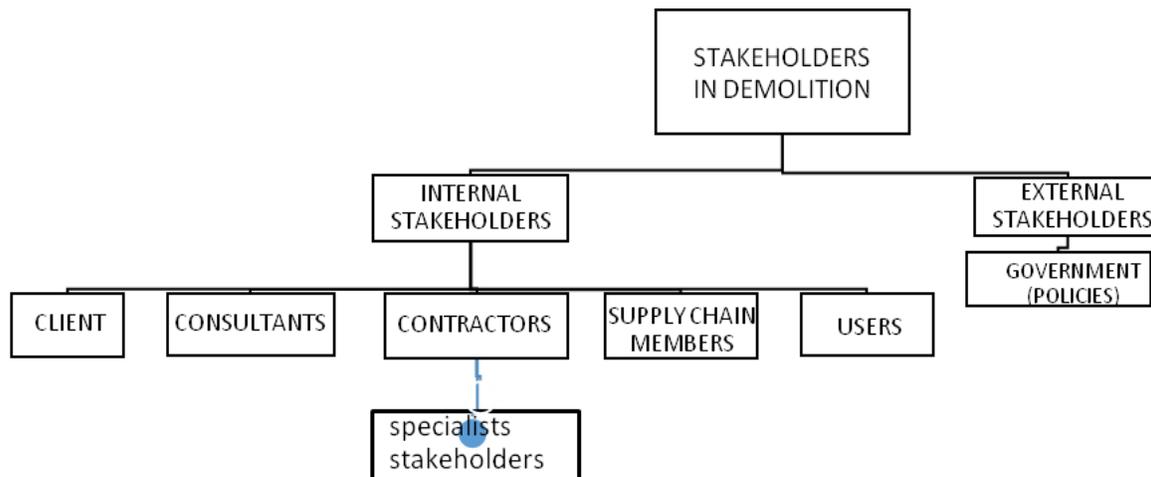


Figure 4. Construction stakeholder groupings developed from Leung and Olomolaiye and Oyegoke schemes.

FINDINGS

Materials recovery

All of the research participants reported that very negligible quantity of materials is taken to the landfill when a building is demolished except in some exceptional circumstances. According to research participant 13 (E13), all materials are recovered for reuse in another building or for recycling except in the case of small pieces of glasses that cannot be resized for reuse.

“Not quite; as I told you every piece of metal, if it were not to be used in another building, even the minute piece of window if metallic, were taken by the people and sold for recycling. Maybe the pieces of broken glasses, not sizeable ones, because even the sizeable ones are recycle (reuse); in public buildings, we have large windows, and even if broken parts of it can be resized for reuse in smaller windows; actually there was no waste” [sic] (E13).

Statements from the other participants supported this information; participants 1, 3, 4, and 12 (E1, E3, E4, E12)

mentioned damaged ceiling boards as the only materials that are taken to the landfill, while participants E5 and E11 mentioned some types of roofing sheets that usually break in the process of demolition and therefore taken to the landfill.

Reuse of materials

All the participants reported that salvaged materials are primarily reused sometimes on the same site or sold to specialised marketers who sell the materials for reuse in another building on a different site. Participant E11 narrated the story of a building demolition project where he acted as the consultant. The client briefed him to assess the structure before demolition to identify materials that can be reused in the new building to be reconstructed on the same site and other materials to be sold. The assignment was executed with some level of success according to the original plan. In the words of the participant E11-

“When we packed all those materials aside, we grouped them; the plumbing in one place, the wood in one place,

Table 1. Profile of building demolition stakeholders interviewed.

S/N	Research Code	Occupation	Stakeholder Group/Role	Experience (Years)	Projects (No)
1.	E1	Marketer/PT Contractor	Supply Chain/Contractor	20	5
2.	E2	Civil servant/Engineer	Client Representative/Consultant	26	9
3.	E3	Architect/Contractor/Consultant	Contractor/Consultant	14	4
4.	E4	Architect/Planner	Contractor/Consultant	33	3
5.	E5	Self-employed/Bricklayer/Foreman	Specialist Stakeholder	11	9
6.	E6	Retired CivilServant/ Architect/Contractor/Consultant/Developer	Client Representative/User	40+	2+
7.	E7	Group of four (4) Tinkers/Marketers/Contractors	Re-processors/Marketers/Contractors	Varies	6
8.	E8	Academic/Administrator	Client Representative	17	1
9.	E9	CivilServant/Architect	Client Representative/Consultant	25+	5
10.	E10	Tipper Truck Driver	Specialist Stakeholder	11	2
11.	E11	Civil Servant/Architect/Consultant/Contractor	Client Representative/Consultant/Contractor	26	4
12.	E12	Civil/Servant/Quantity Surveyor	Client Representative/Consultant/Contractor	10+	3+
13.	E13	Civil/Servant/Architect/Contractor	Client Representative	30	3
14.	E14	CivilServant/Architect	Government Representative/Development control	25	4
15.	E15	Civil Engineer/Contractor	Contractor	15	3
16.	E16	Civil Servant/Planner	Government Representative/Development control	26	4+

the doors and windows in one place. Then we go to “Yangwangwan”, and we called one person to come and inspect them except that wood; we wanted to use the wood”[sic] (E11) (Yangwangwan refers to the specialized dealers of the salvaged building materials in the local Hausa language).

Or as stated by another research participant E7, “...Some of the roofing materials were neatly removed that we reserve it for reuse in other buildings instead of reprocessing it to another product; we call it “ta-koma”[sic] (E7). “Ta-koma” means reusable material in the local Hausa language.

Materials sorting

The process of demolition the building is usually executed carefully according to the different components of the building in what can be described as “*elemental disassembly*”, according to the narration of 7 of the research participants (E1, E3, E4, E6, E8, E9, and E12). Participant E8 described the demolition process as follows:

“As I told you there were experts, even the committee had representatives from different units- plumbing units, electric, and those people were able to sort out the materials. The materials were sorted according to area of specialisation. These people ensure that the material are of good condition and can be used before it is sold. Each expert identifies material relevant to his area of

specialisation and examine the physical condition of the materials for possible reuse”[sic] (E8).

While participant 3 described the process as follows:

“after fencing the property for safety purposes, a separate specialist was engaged for every item to be removed safely, like a plumber remove the plumbing fixtures, a carpenter bring down the roof with the rafters and other roof members in a sound condition”[sic] (E3).

Building materials database

There were variant views from the research participants about keeping building materials database for ease of disassembly and disposal when buildings are decommissioned as practiced in the automobile industry. Over 40% of the research participants are optimistic that introduction of materials database documentation can promote best practices in the end-of-life management of buildings in Nigeria. Participants E2, E8, E9, E13, E14, E15, and E16 thought it was a good idea to encourage such practice in the Nigerian construction industry. Participants E13 and E16 thought that material database should form part of the original construction documentations produced by architects and other professionals.

However, participants E3, E6, E11, and E12 were sceptical about the idea; participant E6 simply remarked “*While! In Nigeria?*”, to express the extents of his pessimism about the idea.

Original manufacturers

The research participants were asked if the original manufacturers of the building materials play any role when a building is demolished in Nigeria, and they all (100%) answered in the negative. Research participants E7, E8, and E12 made reference to the activities of some recycling enterprises that purchase steel and aluminium scraps for recycling; however this is for general recycling with no relationship with any extended manufacturer's responsibility.

Standardisation of the salvaged materials

All of the research participants supported the idea of standardisation of the salvaged building materials before it is reused in another building. Moreover, research participant E1 described an informal system of standardisation that is used by the marketers using common sense. He said:

"Materials are graded informally for the purpose of marketing and maximising profit. Naturally, materials are not sold at the same price. The condition and level of deterioration of the item determine the price. The buyers too are aware and they buy according to their budget and the purpose for which it is going to be used" (P1).

Nevertheless, this is short of the conventional testing of the materials quality which may involve technical laboratories.

Use of advanced technology and modern tools

Three participants (E1, E9, E15) reported that advanced technology and modern tools are not employed in the demolition of buildings in Nigeria and its introduction will improve the practice. According to participant E1, *"Building demolition in Nigeria can be improved if the government and other people can introduce more advanced and modern tools to be used for the demolition. Currently, buildings are demolished manually in Nigeria" (E1).*

DISCUSSION: COMPARATIVE ANALYSIS WITH AUTOMOBILE INDUSTRY

Materials recovery and recycling

The success story of automobiles reportedly between 74 and 94% recoverable (Thierry et al., 1995), makes its potential for transferring ideas to the construction industry more especially when the data of demolition wastes is considered. Nevertheless, the data from Nigerian

construction industry as reported by the research participants cited above, suggests otherwise. Maximum recovery of building demolition by-products was reported by all of the research participants with only negligible quantity of materials that cannot be reused or recycled whatsoever are taken to the landfill. It can therefore be argued that in the context of the Nigerian construction industry, there is no possibility of any lesson to be learnt from the automobile industry in terms of materials recovery.

Advanced materials separation techniques

Effective materials separation processes are used in the automobile industry including air separation processes that separates materials based on weight, non-ferrous separation that is used to separate ferrous and non-ferrous materials, and magnetic separation technique that can be used for separation of metals. Other methods of separation are Eddy current and density separation. Any of these methods or a combination of methods may be aimed to achieve a particular target or to separate a particular material (Keoleian et al., 1997; Knight and Sodhi, 2000).

One account of the research participants in the demolition of buildings, materials may be separated for appropriate treatments; nevertheless, there are no records of employing such advanced techniques. The use of advanced materials separation techniques in the demolition of buildings similar to that of automobile industry is considered desirable for improved performance and safety.

Reuse of materials

In the automobile industry, standardisation, remanufacture and the procedure for dismantling of components makes the reuse of materials more suitable. At the dismantling stage, reusable parts are first separated and marketed, hazardous materials are equally separated and treated appropriately, while the remaining hulks are prepared for shredding or other processes (Go et al., 2011).

Similarly, in the Nigerian construction industry reuse of salvaged materials is an entrenched practice as stated by all of the research participants. The *"Yangwangwan"* specialists is the term used to describe the dealers of the salvaged building materials in the local Hausa language in the study site. Depending on the material and its condition, it may be reused in another building construction or for a slightly different purpose. Nonetheless, there is a need for standardisation of the salvaged materials before it is reused as canvassed by the research participants. It can therefore be established that the Nigerian construction industry has little to learn

from the automobile industry in terms of reuse of materials from a decommissioned product except standardisation and testing of materials before it is reused.

This might be due to experience in the reuse of materials in the construction industry, as sometimes, exhibition pavilions are a typical typology of structures that are designed to be demountable and reused at another location. Some examples include the Crystal Palace, the British and Venezuelan pavilion at the Seville Expo'92, and the Millennium Dome O2 arena. The Crystal Palace was first assembled in 1851 for an exhibition at Hyde Park, and later enlarged and reassembled in the same London in 1854 (Chilton, 2009). Moreover, there are on-going further promotion of reuse of materials in building construction such as aggregates in concrete (Brito and Saikia, 2012), and mission statements by trade associations such as the American Construction and Demolition Recycling Association (CDRA, 2016), which is promoting the recovery of over 325 million tonnes of construction and demolition waste in the United States. There are crusades for giving a new life to old wood (Fast, 2001; Pacheco-Torgal et al., 2013), and private entrepreneurs reuse of building materials (Eat Sleep Live Ltd, 2016; PGT International Limited, 2016; Pinterest Ltd, 2016).

Materials sorting, standardisation and database

The end-of-life management of products can be simplified from the design stage. In either of the automobile or construction industry Design for Deconstruction (DFD) is an accepted concept (Keoleian et al., 1997; Sassi, 2008). Nevertheless, other sustainable design ideas employed in the automobile industry are not commonly applied in the construction industry. These include materials combination, materials identification and standardisation, database of materials properties and disassembly instruction.

The materials combinations from the design, manufacturing or construction stages may disqualify the materials otherwise individually suitable for reuse or recycle. This makes material database and disassembly instruction even more imperative; however, these practices are more entrenched in the automobile industry compared to the construction industry as exemplified by such initiatives as the *International Dismantling Information System (IDIS)*, *Vehicle Recycling Partnership (VRP)*, *Cooperative Research and Development Agreement (CRADA)* (Hedlund-Åström et al., 2005; Mayyas et al., 2012). Therefore, the construction industry in general and the Nigerian construction industry in particular should look forward to the design and construction of buildings with documentation of the materials database and disassembly instruction; which becomes even more practical with the advent of the

informatization of the construction industry otherwise known as Building Information Modelling (BIM).

Reverse logistics and original equipment manufacturer (OEM) responsibility

It was reported that in United States recyclers pay to acquire automobiles, while in Europe owners may pay to dispose a vehicle; new legislations however, are now shifting responsibility of handling a retired vehicle to the Original Equipment Manufacturers (Brissaud et al., 2006; Go et al., 2011). Nevertheless, when a built facility is decommissioned, between the contractor and the owner, who should be responsible for the waste generated?

In the construction industry there is no clearly defined responsibility of the parties though in England there was Site Waste Management Plan Regulation 2008 that makes it mandatory for all buildings costing over £300,000 to produce a comprehensive waste management plan. Nevertheless, the responsibility for the parties were not clearly defined and the legislation was repealed in December, 2013 (Environment Media Group Ltd, 2013).

Another impediment for the implementation of the Original Equipment Manufacturer responsibility or "producer pays principle" as it may be called in the construction industry is that the lifecycle of built facilities is relatively longer. Buildings that last over hundred years are not uncommon. If the construction industry must adopt such policies for good, then the uniqueness of the industry should be given consideration.

The unsuitability of the use of this concept in the construction industry is further corroborated by all of the research participants who do not consider the original material manufacturers to have any role to play in the end-of-life management of building materials in Nigeria.

Conclusion

The construction industry may be distinct from the other sectors, however, to address its' characteristic limitations, it is imperative to assimilate good practices from other industries as demonstrated in the transfer of the concept of lean production in the area of operations management as adopted in the construction industry from the automobile industry successfully. Similarly, this study explored the sustainable end-of-life management practices that can be adopted from the automobile industry into the construction industry. There are five concepts identified in this study that can be adopted to the construction industry from the automobile industry to enhance the end-of-life management practices. These include the concepts of the use of advanced materials separation and sorting techniques, standardisation and creating and maintaining materials database. Others are,

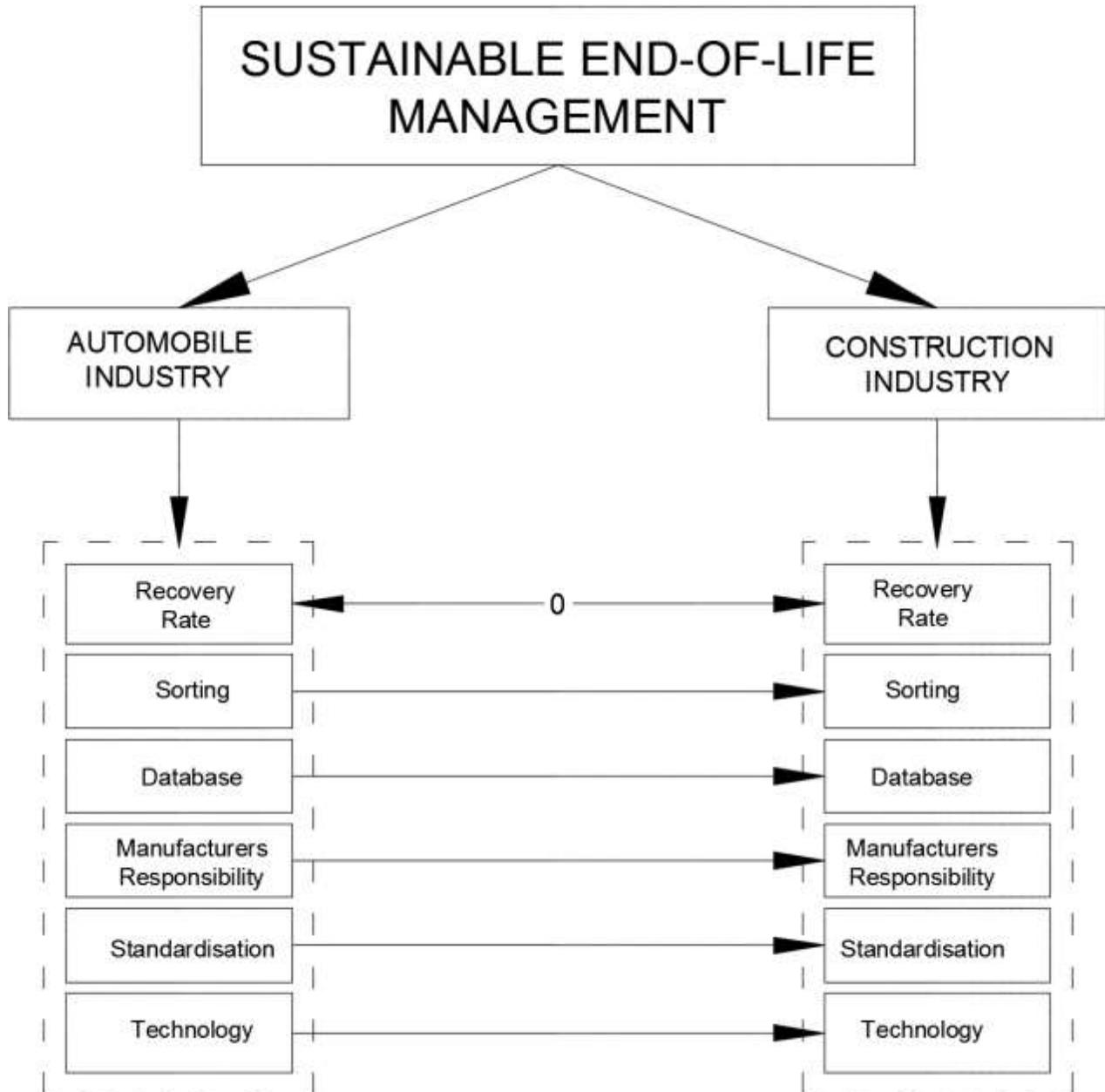


Figure 5. Conceptual summary of sustainable practices that can be transferred from automobile to construction industry.

reverse logistics and assigning of responsibilities to stakeholders such as Original Equipment Manufacturer responsibility scheme and use of advanced technology. Figure 5 is the conceptual diagram illustrating the idea of transferring sustainable practices from the automobile to the construction industry.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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