Interdependence between Structural Engineering and Construction Management
Edited by Ozevin, D., Ataei, H., Modares, M., Gurgun, A., Yazdani, S., and Singh, A.

ISBN: 978-0-9960437-6-2

THE USE OF LIFE CYCLE ASSESSMENT TO ACHIEVE SUSTAINABLE CONSTRUCTION

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This study assesses the benefit of sustainable construction and the use of life cycle assessment (LCA) in the South African construction industry to achieve sustainable construction. The data used in this was derived from both primary and secondary resources. The primary data was collected through a questionnaire approach. The study revealed that LCA could be used for product comparison, product development, formulating of product eco-labels, evaluating construction processes and decision-making processes in the construction industry concerning materials. Furthermore, the study revealed that LCA has various strengths, challenges and weakness, this is due to the fact that there is a requirement of the high quality of knowledge and data when conducting a detailed LCA study. However, this study revealed that life cycle thinking is a cornerstone for developing policies and programs, which meet sustainability criteria and there is a great room for the development and use of LCA in the South African construction industry. Therefore, it is recommended that the South African Construction industry invest more in environmental tools such as LCA.

Keywords: Environmental impacts, Sustainability, Construction industry, Long-term company policy.

1 INTRODUCTION

The construction industry is a large employer of persons in economies, hence Hans *et al.* (2011) added that there are a few sectors in South Africa that have the kind of employment impact the construction industry has, particularly in relation to the employment of skilled and semi-skilled labor. Although the importance of the construction industry is clearly recognized worldwide, it is impossible to overlook the contribution it has on the environmental burden facing the country.

The construction industry plays an important role in the social and human development; at the same time, it is a contributor to environmental issues. Clements-croome (2000) stated that around half of all non-renewable resources that mankind consumes are used in construction, and therefore it is one of the least sustainable industries in the world. According to Baloi (2003), the traditional ways of the industry have been based on the fact that innovations and investments drive the economy and satisfy the consumer's needs. However, it is equally important to understand that construction activities make excessive use of natural resources, various sources of energy and water, and that the construction industries products and process have undesirable impacts on the environment. The evidence emanating from the study of Baloi (2003) has shown that raw material extraction, transportation, and manufacturing result in resource depletion and energy consumption. Further, construction processes' produced emissions contribute to global warming and wastes that pollute the air and water. Consequently, these problems have triggered the adoption of measures to mitigate them. It is becoming a key responsibility for construction organizations to deliver projects that address the environmental, economic, and social dimensions of sustainability.

In order to be able to manage the impact of construction activities to the environment, the use of Life Cycle Assessment (LCA) has been suggested to solve problems associated with the impacts of construction on the natural environment. LCA is described as a standardized method of tracking and reporting the environmental impacts of a product or process throughout its full life cycle. South Africa Bureau of Standards (SABS ISO 14040) 1998 also describes LCA as the calculation and evaluation of the environmentally relevant inputs and outputs and the potential environmental impacts of the life cycle of the product, material or service. Environmental inputs refer to the demand for natural and to emissions and solid waste.

The construction industry is a contributor to the environmental impacts that are experienced today. Sartori and Hestnes (2007) described it as an industry which consists of many phases, starting from mining, manufacturing, construction use, and demolition; within each phase, there is a large amount of energy consumption and considerable released emission as well. In addition, researchers (Asif *et al.* 2007, Zabalza *et al.* 2009) discussed that recent studies show that building is responsible for 30-40% of energy consumption and uses up to 40-50% of greenhouse emission. This impact on the environment has led to the conducting of this study to the reduction of environmental impacts through the use of Life Cycle Assessment.

Life Cycle Assessment is a technique used to evaluate the potential environmental and economic performances of building envelopes and products throughout their lifecycle (Stazi *et al.* 2012). According to Lindfors and Rosenquist, (1995) the European environment agency series states that Life Cycle Assessment is a process to evaluate the environmental burdens associated with a product system or activity and identifying and quantitatively describing the energy and material used and wastes released to the environment. The process includes the entire life cycle of the product or activity, encompassing extracting and processing of raw materials.

According to Klöpffer (2006), LCA has become a widely used methodology because of its integrated way of treating topics like framework, impact assessment and data quality. In addition, Klöpffer (2006) outlines that the LCA has four major stages which are: 1) Goal and scope definition where the purpose, objective, function and system boundaries are defined, 2) Inventory analysis which involves the collection of all data relating to the inputs, processes, emissions and others of the entire life cycle, 3) Impact assessment which involves environmental assessment and quantifying the input resources based on the inventory assessment, and 4) Interpretation wherein the result calculated from the impact is interpreted (Ortiz *et al.* 2009).

2 USE OF LIFECYCLE ASSESSMENT IN THE CONSTRUCTION INDUSTRY

Given the environmental impacts resulting from the construction industries processes, the use of the LCA tool becomes very important and without its use the sustainability and green building initiatives will be difficult to achieve. The LCA study has been used in different fields but its use in the construction industry is recent (Singh *et al.* 2011). Lifecycle assessment can be used in various ways and integrated environmental management information series nine (2004) stipulated the following uses:

By Manufacturers:

Product improvement – Lifecycle assessment can be used to reveal processes, components and systems to target environmental enhancement (Kataji 2003).

Product comparison – Lifecycle assessment can be used to identify and process systems that are major contributors to environmental impacts. For example, the Integrated Environmental Management Information Series Nine (2004) pointed out that BMW and Volvo use LCA to determine materials and methods to enable their vehicles to become more recyclable and reduce the generation of waste in the manufacturing and disposal phase.

Product development – New products are frequently developed from old designs and concepts. LCA makes use of that concept by taking "old information" and equating it with projections estimates for new product and service.

Development of product eco-label- Eco-labeling is a way of granting acknowledgement for products that attains a certain minimum standard in "environmental friendliness". In this case, LCA can be used to develop long-term policy regarding environmental impacts and risks posed by the materials and processes throughout the life cycle. LCA can also be used in evaluating resource conservation effects associated with source reduction and alternative waste management techniques. Lastly, LCA can be used to provide information to the public about the resource characteristics of products or materials. For example, Integrated Environmental Management Information Series Nine (2004) also pointed out that chemical companies like Unilever use LCA as a means of testing their products for eco-friendliness and legal compliance.

Product Information- Authorities might in some instance require product information for purpose of licensing or legal compliance, therefore the information produced from LCA can be used to supply information confirming the validity of data and product related decisions and choices.

By Public policymakers:

Formulating long-term company policy – LCA can contribute significantly to the development and adjustment of company policies in specific areas. For example, guidance on the choice of raw material use could directly affect the company's strategy for handling waste materials.

Application for construction systems and process evaluation- Evaluation of environmental impacts on construction includes more than just a simple combination of individual product and material assessment. However, LCA can also be used to assess this. In the study carried out by Keoleian *et al.* (2000)., evaluated life cycle energy use, greenhouse emission, and cost of the conventional residential home covered the pre-use (Material production and construction), use (Including maintenance) and demolition phases. It was discovered that the use phase accounted for approximately 91% of the overall life cycle energy usage over a 50-year life. The authors modelled a functionally equivalent energy-efficient house that combined 11 energy efficient strategies and discovered that these approaches led to a serious decrease in the total life cycle energy use.

Life cycle assessment is generally used as a research tool to analyze buildings or manufacturing processes that aid decision making (Simonen 2014). Moreover, the main application of LCA in the construction industry evaluating manufacturing process, developing product labels, comparing materials and methods and analyzing whole buildings.

When evaluating manufacturing, a manufacturer or research organization can commission an analysis of their manufacturing process, and this analysis will only focus on the "cradle-to-grave" impacts that a manufacturer can control. Again, Simonen (2014) stated that LCA application can be in developing product label, which includes a comprehensive report of LCA data of information of a product as well as rules.

As mentioned before, LCA can be used to compare materials and method. Through such comparisons, an environmentally preferable method or material can be identified and adopted

(Simenon 2014). Life cycle assessment can also be used in whole building to assess the impacts of manufacturing and construction in line with the operations and maintenance impacts. However, to do this, assumptions must be made about its life. Simonen (2014) explained that these assumptions would include the establishment life, the use of the building, maintenance, refurbishment and its end of life treatment. With the mentioned ways on how LCA can be used, it is important that in order to achieve the sustainable construction and healthy environment. LCA should be an integral part of any decision-making in the process of development in the construction industry.

3 METHODOLOGY

This study adopted a quantitative research approach in order to achieve the aim of the study, and a questionnaire was developed from an extant review of the literature. Practising construction professionals in the Gauteng Province construction industry in Johannesburg, South Africa were engaged in the collection of the primary data. The criteria for selecting a professional is that they had worked on a construction project in Johannesburg in the last year and are presently listed with a built environment professional council at any level. Fifty questionnaires were randomly distributed, among these selected construction professionals and 43 were retrieved with 40 ascertained to fit for analyses. The remaining three questionnaires were dropped due to poor completion and missing information. This represents an 80% response rate, and this was deemed adequate considering the limitation in the geographical scope of the study. The designed questionnaire adopted an agreement scale of 1 to 5 with 1 being strongly disagreed and 5 strongly agreeing. Data analysis was done using mean item score and standard deviation, and the mean were ranked in descending order. The ranking made it possible to cross compare the relative importance of the items as perceived by the respondents.

4 FINDINGS

The following results are based on the ranking (R) and the calculated standard deviation (SD) and the mean scores on the use of life cycle assessment. The following was observed to be among the dominant; making procurement decision and developing regulations (SD = 6.80; mean 4.10), making long-term policy regarding material use (SD = 7.10, mean 4.10), product improvement (SD = 7.30, mean = 4.10).

These findings are in agreement with a study conducted by Simonen (2014) stating that the main application of LCA in the construction industry includes evaluating manufacturing process, developing product labels, comparing materials and methods and analyzing whole buildings.

The data obtained from the questionnaires as answered by the respondents regarding the assessment of the use of life-cycle assessment to achieve sustainable construction in the South African construction industry was presented and analyzed in relation to research questions and literature review.

4.1 Results and Findings

Respondents were asked to rank the assessment of the use of Life Cycle Assessment to achieve sustainable construction. Table 1 below revealed that “Making procurement decision and developing regulations” was tied first with a mean score of 4.1 and SD of 6.80, “Making long term policy regarding material use” was tied first with the mean score of 4.1 and SD of 7.1, “Product improvement” was tied first with a mean score of 4.1 and SD of 7.3, and “Product development” was tied first with a mean score of 4.1 and SD of 7.3. The table further revealed that "Evaluating manufacturing processes" was ranked second with the mean score of 4.0 and SD 7.60, and "Natural resource conservation" was ranked third with a mean score of 3.9 and SD of 5.90. Lastly, "Aid decision-making process" was ranked fourth with a mean score of 3.8 and SD of 5.8.

Table 1. The use of LCA to achieve sustainable construction.

Lca uses	**SD**	**MIS**	**Ranking**
Making procurement decisions and developing regulations	6.80	4.10	1
Making long term policy regarding material use	7.10	4.10	2
Product analysis	7.10	4.10	2
Product improvement	7.30	4.10	3
Product development	7.30	4.10	3
Evaluate manufacturing process	7.60	4.00	4
Natural resource conservation	5.90	3.90	5
Product comparisons	6.20	3.90	6
Whole building analysis	6.20	3.90	6
Evaluating resource effect techniques	6.30	3.90	7
Aid decision-making process	6.70	3.80	8
Development of product eco-label	7.80	3.80	9

5 CONCLUSIONS AND RECOMMENDATIONS

This study assessed Life Cycle Assessment (LCA) as a tool to be used in the aim of achieving sustainable construction in the South African construction industry. Findings concerning the use of LCA in the construction industry were also in agreement with the reviewed literature in terms of it being fully adapted and used as a tool to mitigate environmental burdens imposed by the construction industry.

In line with the results from the study, there is a strong case for the construction industry to mitigate the impacts it imposes to environment; to achieve this, the construction industry must invest more into the development and the usage of tools such as life cycle assessment

From the findings, making procurement decision in the planning phase is important, as it shapes the purchase of sustainable materials for the construction phase of the project. This procurement decision cannot be done without the analysis of the building, which will include the pre-planning phase to post-completion phase; most clients and building professionals do not plan for the post-completion phase of the study. In addition, once the procurement decisions have been made, they will assist in the long-term development of policy that will guide the use of materials in the construction industry. Lastly the development of LCA will lead to the development of eco-label. Therefore, it is important that the implementation policies be carried out by construction professionals, and strict penalties be enforced if this is not followed. Incentives such as tax breaks and reduction of levies such as import tax should be offered to construction firms to ensure that practising LCA methodologies is not a burden.

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