A MECHANISM FOR WASTE REDUCTION IN STRUCTURAL DESIGN PROCESS IN SOUTH AFRICA CONSTRUCTION

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Abstract

Structural design process (SDP) consists of three processes of inception; preliminary design and detail design. Each of these processes is laden with wastes that adversely affect project performance. Therefore, this study seeks to identify such wastes so as to develop a mechanism for its effective management. To achieve this, action research study will be conducted in some consulting engineering firms situated in Bloemfontein, South Africa. It is expected that the results will provide the platform for the development of a suitable mechanism for reduction / elimination of wastes in structural design process.

Keywords: Action research, Lean construction, Structural design, Waste

1. INTRODUCTION

The design phase of construction projects is made up of three processes: the compilation process where clients' ideas and speculations are developed into physical drawings that define the needs and requirements; the process where the drawings are judged standard or not by the appropriate authority and the implementation process where the certified drawings are actualized and turned into physical structures on site. However, the compilation process of construction design is laden with wastes that affect site activities. Among these are defects (correction), and waiting time due to motion variability (Marzouk et al., 2011:43; Al-Aomar, 2012: 109; Simms, 2007: 4). Waste is any activity that produces costs directly or indirectly and takes time, resources or requires storage, but do not add value or progress to a particular product (Koskela, 2013: 3; Al-Aomar, 2012: 105; Zoya-Kpamma and Adjei-Kumi, 2011: 102; and Koskenvesa et al., 2010: 477). Waste in construction has been the subject of several research projects around the world (Koskela, 2013: 3; Nagapan et al., 2012: 22; Mossman, 2009: 13 and Li et al., 2008: 915). Construction Industry Institute (CII) (2005: 5) opines that project actors involved in construction contribute to waste. This includes actors who design materials, plant and building; actors who specify and communicate concepts; for example, the engineers, quantity surveyors and environmental specialists; particularly site managers and site operators. Abdelsalam et al. (2010: 749) as well as Ndihokubwayo and Haupt (2008: 126) suggest that clients could also be a source of waste through variation orders during the design process. Osmani et al. (2008: 1147), Oladiran (2008: 1) and Gunhan (2007: 68) emphasize that potential material waste in construction is caused by inefficiencies in design, procurement, material handling, and operation.

A research study focusing on waste was conducted in United Kingdom (UK) to identify the most relevant factors that produce wastes in construction design process (El. Reifi and Emmitt, 2013: 195; 2011: 50). The study concluded that poor design management is a major source of waste. It is essential to know that wastes in construction is not only focused on the quantity of materials on-site, but also on several activities such as overproduction, waiting time, material handling, processing, inventories and movement of workers (Ko and Chung, 2014: 464; Sahoo et al., 2008: 451 and Gunhan 2007: 68). These wastes can be categorized as: rework, defects, delays, waiting, poor material allocation, unnecessary material handling and material waste (Lopez et al., 2010: 399; Hwang et al., 2009: 187; Love et al., 2008: 234 and Sommerville, 2007: 391). Zhanwen (2009: 1) categorized the various sources of waste in construction project into eight deadly forms, which are: over-production, delays, unnecessary transport, inappropriate process, inventory, unnecessary movement, making defective items and unexplored creativity of employees. Zhanwen (2009: 3) further states that these wastes could occur during different phases of construction project, most importantly, at the design phase (design errors and changes).

However, the highlighted wastes in construction projects can be reduced through the application of lean concepts (Ko and Chung 2014: 463; Ko and Tsai, 2013: 2409; Ko and Chen, 2012: 101; Arayici et al., 2011: 189 and Hicks, 2007: 233). According to Shah and Ward (2007: 785), lean production (LP) is an integrated socio-technical system, which aims to eliminate waste by concurrently reducing supplier, customer and internal variability. Lean Construction Institute-Australia (LCI-A) (2013: 1) defines lean construction (LC) as a production management-based project delivery system emphasizing the reliable and speedy delivery of value. Womack and Jones (2003: 92) reveal that LP techniques are based on five principles to guide management's actions toward success. These principles include:

- Precisely specify value in terms of a specific product;
- Identify the value stream for each product;
- Make value flow without interruptions;
- Let the customers pull value from the producers, and
- Pursue perfection.

The five lean principles have been adopted relatively quickly by construction industry in terms of services to clients (Velarde et al., 2009: 77). The principles have however been slow to catch on in the aspect of design where decisions have a major influence on the construction process (Zimina et al., 2012: 393 and Bakry, 2010: 43). Chang et al. (2007: 2) observe that about 40% of the total construction period is wasted due to design deficiencies. Ko and Chung (2014: 463), Abdelsalam et al. (2010: 749), Song et al. (2009: 12), Li et al. (2008: 915), and Chang et al. (2007: 1) opine that many of the problems confronted at the construction phase are the results of ineffective decisions in design, which for variety of reasons result in uncertainties where there is little option than to confront the problems. The design process is a phase at which many of the construction wastes can easily be minimized (Song et al., 2009: 12; Li et al., 2008: 915 and Osmani, 2008: 1147). Despite project complexity, researchers had investigated how lean philosophy could be applicable to construction design so as to weed out waste in the process (Marzouk et al., 2011: 42 and Yang, 2007: 1). Marzouk et al. (2011: 42) worked on computer simulation as a tool for assessing the impact of applying lean principles to design processes in construction consultancy firms to aid decision making at early stages of construction projects. A comprehensive model for the design process was built by the researchers after which the principles of LC were depicted. The research concluded that applying the five LC principles to design process significantly help in decisions making at early stages of construction projects. Yang (2007: 1) proposes lean concept to every step and process of construction design in order to form a superior project plans and introduce how design proposals are chosen to avoid waste. The findings in the reviewed literature indicate that lean practices are now common place on construction site / production activities, the design process is still largely unaffected by the principles.

2. PROBLEM STATEMENT

The compilation process of structural design is heavily loaded with wastes that affect site activities. Many structural engineers carry out design tasks without putting these wastes into consideration. This has led to wastes with consequent decline in construction industry performance. Song et al. (2009: 12) and Hwang (2009: 187) opine that little interaction among the design and construction teams is the major causes of defects in construction designs and the consequences on site are excessive request for information (RFI), supervision, lack of constructability, inappropriate use of material, and a great number of change orders. According to Simms (2007: 4), every form of monetary waste in construction design is over processing and is caused by the substitution of a material for more expensive one; the execution of simple tasks by an over-qualified worker; or the use of highly sophisticated equipment where a much simpler one would be enough. For instance, common among structural designers is the use of software that has high aesthetic function without regard to its purchase and operating cost. Over processing can also occur at the compilation process of construction design due to the creation of designs that are too complex to understand on sites (Simms, 2007:4). Processing an order before it is needed or any processing that is done on a routine schedule regardless of current demand is known as over production (Ohno, 1988: 45). Printing of drawings that may change over time, production of too many drawings such as details and sections that are not necessary needed on site but are produced by the designers in order to meet up with the approval standard or requirements and excessive or unnecessary supervision of every task on site before and after completion by different construction professionals are all forms of waste that can be classified as over production.

In engineering process, motion is a form of waste that can be equated with the efficiency of the software (Simms, 2007: 4). The number of clicks of a mouse button and the number of routines it takes to complete a structural drawing before taking it for approval is motion that can be quantified and improved upon. Simms (2007: 3) shows that the certification process of construction design also contribute to construction waste as it determines the starting and finishing times of projects. Common problem associated with the certification process of structural design is the waiting time required for the approval of work. Waiting for the approval of work by appropriate authority before site activities commence takes longer time than expected. Lean has been effectively adopted as a strategy for waste eradication in construction projects (Marzouk et al., 2012: 1522; Bakry, 2010: 52; Zhanwen, 2009: 1 and Hicks, 2007: 233).

However, such principles have only been marginally used in SDP. Therefore, this research problem statement state that 'lack of a mechanism for wastes identification and reduction in structural design process promotes task conversion problems on construction sites'.
Based on the aforesaid, the intent of the research is to proffer context specific answers to the following questions:

- What type of waste is synonymous with the structural design process?
- What are the remote and immediate origins of such waste?
- What are the impacts of such waste on construction projects?
- How should lean construction remove waste in the structural design process?
- What mechanism should be used to remove waste in the structural design process?
- How should lean thinking drive practice in the structural design process in South Africa?

3. RESEARCH METHODOLOGY

Leedy and Ormrod (2009: 93) describe data as a link between absolute truth and the researcher's inquiring mind. Leedy and Ormrod (2009: 93) further state that data contain facts, but in a state that may not be easily understood and needs to be analysed and presented in a recognised research format for better understanding. Data can be primary or secondary depending on the source (Yin, 2009: 52). A research may require to be conducted with one of the two sources or combination of both. In this study, the two sources of data will be adopted.

The primary data will be obtained from members of consulting engineers in Bloemfontein, South Africa. The unit of analysis will consist of a design team within each studied firm. In the context of this study, professionals such as structural engineers', designers and technologists that had been working together as a team across various design projects (residential, commercial and industrial) for over five years will be the representation of the design team.

The secondary data are the existing literatures or information in the research area. The secondary data in this study comprises of books, articles, and electronically retrieved information related to wastes in construction design process as well as the methods of eliminating the wastes.

3.1 Research Approach

Different approaches had been used extensively by many researchers to carry out research. Among these are qualitative, quantitative, mixed methods (Morgan, 2007: 48 and Yin, 2009; 54) as well as action research (Chein et al., 1948: 33; Buchy and Ahmed, 2007: 358 and Hughes, 2008: 1). The choice of approach for a particular research may extensively depend on factors such as the nature of the research or the type of information required. As this study tends to develop a mechanism that can improve the current condition of SDP in South African construction, studies of such nature have the same approach that is best described as actions research (AR) (Kemmis & McTaggart, 2007: 596 and Ivankova, 2015: 33). The Open University (TOU) (2005: 4), Buchy and Ahmed (2007: 358) and Hughes (2008: 1) opine that AR is any practical research undertaken by those involved in the practice area. It is a process of enquiry by a researcher into the effectiveness of a particular organization. Kemmis & McTaggart (2007: 596) and Hinchy (2008) cited by Ivankova (2015: 33) concur with this definition that AR could be participatory in nature (PAR) as it involves multiple stakeholders to generate knowledge.

McNiff and Whitehead (2011: 49) opine that the cyclical process in AR is a complex research approach and should be incorporated with different methods from other approaches of data collection. This opinion is aligned to the viewpoint espoused by Creswell and Tashakkori (2007: 306) that a researcher can adopt any methodological idea to carry out a research once it is possible to utilize the approach in obtaining the necessary information. According to Mill (2011: 19), a researcher could make use of either qualitative (interview) or quantitative (questionnaire) approach in some or all the cycles involved in AR for data collection. The researcher further opines that there are situations that could warrant a researcher to adopt the two approaches in a single study. This approach is known as mixed method action research (MMAR). Creswell and Tashakkori (2007: 306), James et al. (2008: 81), Mill (2011: 19) and Ivankova (2015: 50), define MMAR as research design in which qualitative and quantitative approaches are incorporated into AR in types of questions, research methods, data collection and analysis procedures, and / or inferences. Typical example of a situation where MMAR is applicable according to Koshy et al. (2011) cited by Ivankova (2015: 51) is when a research intends to be conducted in a health care centre where information will be required from both the health workers and patients. Such research may be to improve the levels of patients' satisfaction through staff services. In such a scenario, the required information from the health workers will first be obtained through interviews.

Such information may be to understand some of the current problems confronting the centre as well as the possible solutions. The data obtained through the interviews will then be used to create a change in the health care centre after which questionnaire with semi-structured questions will be developed and administered to the patients so as to evaluate the new change that might have been created. Mill (2011: 19) philosophy on MMAR is supported by Ivankova (2015: 50) in recent study in which the researcher recommends the use of both qualitative and quantitative approaches for data collection in some of the cycles involved in the MMAR methodological framework. Hence, the MMAR as recommended by Ivankova (2015: 50) will be adopted for this research. The proposed methodological framework is shown in figure 1.

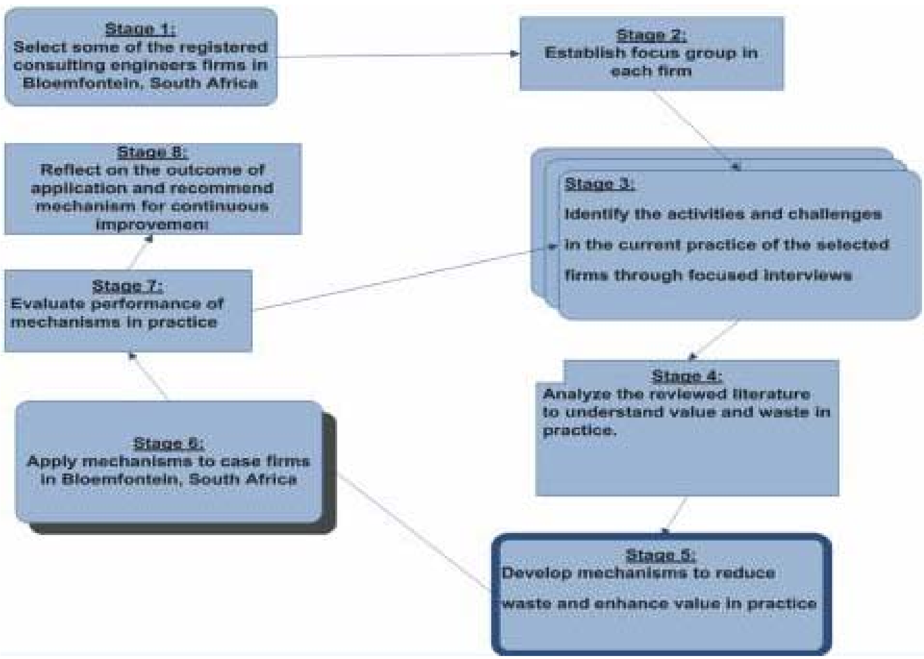

Figure 1: Methodological Framework (MMAR Cycle) for SDP study.

4. CONCLUSION

This study seeks to identify wastes in structural design process so as to development a mechanism for its effective management. In other words, it is expected that this study outcome will provide the platform for the development of a suitable mechanism for reduction / elimination of wastes in SDP. The study will reduce waste in South Africa construction which will consequently reduce the stress level of construction participants, create conducive working atmosphere and improve the quality as well as the performance standard of the industry.

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