AIMS AND SCOPE

The JOURNAL OF CONSTRUCTION (JOC) is the official journal of the ASSOCIATION OF SCHOOLS OF CONSTRUCTION SOUTHERN AFRICA (ASOCSA). ASOCSA has committed itself to foster excellence in construction communication, scholarship, research, education and practice and the JOC provides the medium to achieve this commitment. JOC is at this stage a bi-annual refereed journal serving all stakeholders and participants in the building construction and civil engineering sectors.

JOC publishes quality papers written in a conversational style aiming to advance knowledge of practice and science of construction while providing a forum for the interchange of information and ideas on current issues. JOC aims to promote the interface between academia and industry, current and topical construction industry research and practical application by disseminating relevant in-depth research papers, reviews of projects and case studies, information on current research projects, comments on previous contributions, research, innovation, technical and practice notes, and developments in construction education policies and strategies. Some issues might be themed by topic.

Topics in JOC include sustainable construction, education and professional development, service delivery /customer service, information and communication technology, legislation and regulatory framework, safety, health, environment and quality management, construction industry development, international construction, risk management, housing, construction-related design strategies; material, component and systems performance; process control; alternative and new technologies; organizational, management and resource issues; human factors; cost and life cycle issues; entrepreneurship; design, implementing, managing and practicing innovation; visualization, simulation, innovation, and strategies.

In order to maintain and ensure the highest quality in JOC, all papers undergo a rigorous system of blind peer review by acknowledged international experts.

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Dear Industry Stakeholder,

Once again we are proud to send out this first issue of 2015, being Issue 8 Volume 1.

For the past 7 years we have been publishing a Department of Higher Education and Training (DoHET) Accredited Journal that adds value to the construction sector both academic and industry.

In this issue we once again raise issues that the academic sector believes are relevant to the industrial sector both nationally and internationally.

At this time of publication we are fast approaching the Annual 9th Built Environment Conference in the series of Built Environment (BE) conferences that started back in 2006. The BE Conference is also one of only two South African Built Environment Conferences that is accredited by the DoHET.

For this reason we believe that the conference plays a vital role in the Construction Education Landscape. In addition the South African Council for the Quantity Surveyors Professions, (SACQSP) through the Association of South African Quantity Surveyors (ASAQS) and the South African Council for the Project and Construction Management Professions (SACPCMP) have awarded CPD points for attendance of the conference.

The 9th BE Conference will be held in Durban from the 2nd-4th August 2015. If you haven’t registered yet do so urgently. The Conference flyer is in the Journal.

At the Durban conference we will also be electing a new Executive for the ASOCSA. I have served the Association since the founding in 2005 and the time has come to bring in new blood.

In addition JoC will also be welcoming a new Editorial team as discussed by the outgoing Editor in Chief Prof. Haupt.

To the Construction Industry we acknowledge that we are still going through tough times and we wish you all the best for the future. All that I can say is that the current situation can only improve and that the SA Government must release the Billions or as some have said R1.5 Trillion in infrastructure money that is supposed to be available for infrastructure development in the country.

To Academia the time has come for us to relook at how we educate our future construction leaders. Let’s get involved in the debate. Our Elder Statesmen Bob Hindle and Prof. Theo Haupt have raised important issues with regard to getting rid of the Silos in which construction professionals have been educated. Let’s get involved in the debate for the improvement of construction Education.

All the best to all of you

Ferdinand
F C Fester
President
ASOCSA
March 2015
EDITORIAL

The first issue of Volume 8 of the Journal of Construction (JoC) hosts four papers that cover various topics in construction contributed by authors from Africa. Firstly, Khodair suggested in her paper a number of guidelines for integrating maintenance considerations into the life cycle of the building. Secondly, Mushonga, and Van Der Poll HM investigated the applicability of the Activity Based Costing system to the construction industry in Southern Africa as a viable alternative to the Traditional Costing systems. Thirdly, Oyeyipo and Odusami, examined the effectiveness of post contract cost management practices of contractors as an approach for guaranteeing profit and continues achievement of the long term goals of the construction companies. Finally, Olubunmi focused in his paper on furnishing the understanding of how to successfully deliver green building projects through analyzing the current research development of the subject area.

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SUGGESTED GUIDELINES 
FOR INTEGRATING 
MAINTENANCE 
CONSIDERATIONS INTO 
THE LIFE CYCLE OF THE 
BUILDING

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PURPOSE: The main concern of this paper is suggesting specific guidelines that enable the integration of maintenance considerations into the whole life cycle of the buildings. The ultimate purpose is to achieve better performing buildings regarding maintenance aspects.

ABSTRACT

PURPOSE:
Maintenance of buildings is a crucial process that has a great impact on both buildings’ performance and the efficiency of their embedded systems. However, the building maintenance industry in Egypt has long been an area of neglect, as most of buildings stakeholders restrict its role to the operation phase of the building. This attitude disregards the precautionary maintenance processes that could be achieved through the preliminary phases of the buildings. The main concern of this paper is suggesting specific guidelines that enable the integration of maintenance considerations into the whole life cycle of the buildings. The ultimate purpose is to achieve better performing buildings regarding maintenance aspects.

METHODOLOGY:
The study sheds light on the major barriers of applying efficient maintenance, through the analysis of results extracted from focused interviews that targeted a number of general and maintenance managers in a number of selected buildings.

FINDINGS:
Emphasis is made on the role and impact of maintenance considerations in guiding the decision-making process, as well as the lack of integrating maintenance into the whole building design process. This paper ends up with suggesting a framework that demonstrates the impact of integrating considerations of maintenance throughout the whole life cycle of the building.

KEYWORDS
Maintenance Considerations, Life Cycle, Building Performance Evaluation; Egypt

INTRODUCTION

The life cycle of buildings comprises six major phases shown in figure 1. Planning is the first phase where a process of producing a strategic plan occurs. It also represents the starting point of the building delivery process. The role of this phase is performing market-need analysis. The Programming or Briefing phase begins as soon as the strategic planning ends. The program is considered vital when all details about the project, including needs, aims, resources as well as the context of the project, are documented. The third phase is the design phase, where the design team develops two and three dimensional images that respond to the priorities established throughout the planning and functional programming processes. The team produces ideas and the graphic representations to communicate them.

Afterwards, in the Construction phase, the construction documents are produced for the chosen design solution. Throughout this stage all relevant information is merged with the practical instructions and requirements needed to build the facility. The Occupancy and Operation phase comes after the construction phase and is considered the longest of all phases as it might last for 30-50 years based upon the type of the building. During this phase, an adjustment of the building and its systems is done to fulfill the user’s requirements. The last phase in the design process is the Adaptive reuse of the building which is, like the planning phase, based on market and need-analysis.
The design phase, amongst all stages of the delivery of the building, has an immense impact on maintenance of the building afterwards. Vital decisions could be made at the preliminary design phases of the building delivery, which could make the application of different maintenance processes on both buildings systems and components easier. The value added is higher performance and lower operating costs of the buildings. A number of factors induce building owners to maintain their buildings to the required standards; these factors include the increase in number and variety of buildings, the increase in complexities and advance in technology and the growing concern on the health, safety and environmental issues. Nevertheless, building maintenance industry in Egypt has long been an area of neglect, as most of buildings stakeholders restrict its role to the operation phase of the building. Besides different barriers face the implementation of an effective maintenance process such as the scarcity of some spare parts in local market, lack of qualified labor, inappropriate finishing relative to the nature of building type and the local site conditions, constrained budget for the maintenance of buildings, vandalism and the inaccessibility of building spaces to apply the required maintenance work. Thus, the main concern of this paper is suggesting specific guidelines that enable the integration of maintenance considerations into the whole life cycle of the buildings.

STAGES OF DESIGN PHASE

Schematic design is considered the initial stage in the design phase. The output of this stage is a group of alternatives that translate the program of the project into building solutions. Design Development is the second stage in the building design. During this stage, one of the alternative solutions of the building is chosen and elaborated on in the next stage. The selected alternative should address the issues raised by the program in more details.

THE IMPACT OF DESIGN PHASE ON MAINTENANCE PROCESS

The process of maintenance is defined as the combination of all technical and associated administrative actions intended to retain an item in, or restore it to a state in which it can be performed its required function. As the driving line between different building types is rapidly disappearing, the problem of building maintenance is universal and the consideration of the problem at the design stage is of vital importance. It is important, however, that the essential maintenance should be carried out easily, quickly and economically.

The choice of the materials and finishing of the building, which is involved in the design phase, is considered the first step for optimizing maintenance processes throughout the life cycle of the building. Additionally, the choice of suitable types of finishes for the walls, floors and ceilings greatly affects the extent and cost of maintenance, hence the frequency of any required replacements.

Amongst the barriers that are most frequently the result of inaccurate choice of building fixtures is vandalism, which is defined as “willful destruction”. Most vandalism is based on violence; in particular, violence external to buildings. Violence can ruin equipment or portable fixtures in order to use them as weapons. The physical environment of the building, including its design detailing and fittings may encourage vandalism. In return, the term “vandal-proof” stands for the prevention of this problem by the proper selection of fittings and lights in particular, which are most vulnerable to vandals, so that they are completely imbedded into the building fabric.

The design phase can also minimize a vital barrier to maintenance process, i.e. the accessibility for maintenance. This means that the place to be maintained should be easily reached or entered for maintenance to be carried out. The design phase should work on the design alternative that fulfills the requirements of access for maintenance for different parts of the building and through the suitable methods of access, whether temporary or permanent.

GENERAL REQUIREMENTS FOR APPLYING EFFICIENT MAINTENANCE OF BUILDINGS

The process of maintenance includes all services that are required to assure that the building will perform the functions for which it was designed and constructed. Maintenance typically includes the periodical activities necessary for the building and its systems and equipment to perform their intended function.

Maintenance process involves many different requirements, including maintainability, reliability, safety and manageability. Achieving the four requirements for the maintenance process aims at effectively and efficiently supporting the life cycle of the facility by eliminating unplanned work and realizing life-cycle cost savings.

MAINTAINABILITY

Maintainability is that characteristic of design and installation which affects the amount of time and cost necessary to repair, test, calibrate, or adjust an item to a specified condition, when using defined procedures and resources.

The maintainability of the systems and components of a building includes achieving equipment access, built-in condition monitoring and other maintenance requirements. The Maintenance team should know ahead of time the types of controls, equipment and systems they will have to maintain once the facility is turned over to them.
The term maintainability also includes the accessibility, where the accesses for maintenance are places designed to allow the maintainer to perform maintenance actions on equipment or components including entrance doors, apertures, inspection windows and lubrication, pneumatic, and hydraulic servicing points 11.

The accessibility refers to the relative ease with which an assembly or component can be reached for repair, replacement, or servicing. An item is considered accessible only when it can be operated, manipulated, removed or replaced by the suitably clothed and equipped user with applicable body dimensions. Applicable body dimensions are those dimensions which are design-critical to the operation, manipulation, removal or replacement task 11.

RELIABILITY /AVAILABILITY

Reliability is the probability that an item will survive a given operating period, under specified operating conditions 12. For improving the reliability of building facilities, the most important issues requiring immediate attention are to grasp and remove the factors causing problems in all steps of the life cycle, such as building planning, design, construction and operation 13.

SAFETY

The design and construction of safe and secure buildings are one of the primary goals for building stakeholders. Security and safety measures, such as those for anti-vandalism, must be considered within a total project context, including impacts on occupants and on applying efficient maintenance processes. Human factors engineering/ergonomics in the performance of maintenance is a major factor in the design for safety of the operation. Design should reflect the safety-related human factors engineering/ergonomics criteria below. The order of precedence for satisfying system safety requirements is as follows 11:

- Design for minimum risk;
- Incorporate Safety devices;
- Provide warning devices;
- Provide procedures and training;
- Provide Personnel Protective Equipment.

MANAGEABILITY

Achieving Manageability means controlling and managing maintenance work, which is achieved through the existence of maintenance managers and setting a clear maintenance plan. The Maintenance Plan will identify the tasks required, their descriptions and schedules, troubleshooting, corrective maintenance (repair) task descriptions and spare parts identification and quantity, in addition to any unique storage requirements 10.

METHODOLOGY

Four public buildings in Egypt were chosen for the case studies. The selection of the case studies was based upon a number of factors including:

- Public Buildings with relative significance.
- Large scale type of buildings.
- Varied years of operation.
- Varied types of buildings use.
- The existence/inexistence of a maintenance management department.

Selecting the case studies with varied nature, function, scale, years of operation, and type of ownership allowed the researcher to extract a framework that could be implemented on a wide range of similar types of projects. The study involved the use of two major data collection techniques: focused interviews and observations. The interviews were conducted to the maintenance managers/general building managers that were involved in a number of selected case study buildings. The managers were asked about a number of basic issues as follows:

- The background of the buildings they worked in.
- Timing of involvement in the building.
- Types of maintenance service provided.
- Type of maintenance budget.
- The barriers and problems that hinder applying maintenance work.
- Root Causes of the barriers that hinder maintenance process.
- The impact of each specified barrier on the efficiency of applying maintenance.

The analyses of data extracted from both open interviews with CEO (Chief Executive Officer), Maintenance Managers, Deputy Project Manager and data extracted through observations provided clear data from which the findings were extracted.

SELECTION AND ANALYSES OF CASE STUDIES

The buildings under analysis were selected from among diversified patterns of public buildings in Egypt: a museum, a hotel, a library, and a commercial/recreational center. This selection aims at objectively tackling the most important problems or obstructions which face the process of public building maintenance as effectively and efficiently required. This selection of the four patterns of buildings resulted in the researcher’s ability to make clear inferences about the nature of such problems and obstructions in general, as a primary step towards achieving the main objective of the research, namely, “suggesting specific guidelines that enable the integration of maintenance considerations into the whole life cycle of the buildings,” which has a great effect on relieving the effect of the obstructions which face the process of building maintenance.

CASE (1) MUSEUM BUILDING

The Coptic Museum exists in a place called “civilizations center” in Cairo. The maintenance processes in this historical place depends on making contracts with specialized companies, only if any harm occurs in one of the different systems of the building. This is because there are no particular plans for the maintenance of the building or even for making daily cleaning processes, precautionary maintenance, renewal plans, or plans for replacing the current system, since the building lacks an administration that is responsible for the maintenance of the building. The building has been subjected to a process of complete renewal of the systems of display and lighting. This process aimed at improving the performance of the building as a whole, along with providing a welcoming and motivating atmosphere for visitors. The process of improvement faced a number of problems and obstructions which strongly affected the performance of the required maintenance processes. These obstructions are represented in the following points: 14
After its renewal and opening, the museum depended on natural ventilation, which resulted in the continuous occurrence of collision between the open windows and the display glass cases, leading to the damage of some of them. It also resulted in the accumulation of large piles of dust inside and outside the glass cases. This shows that the planning of the process of renewing the museum was poor and that the consequences of depending on natural ventilation in such dusty atmosphere were not studied, especially with some display glass cases being placed beside open windows, resulting in their being subject to collision. Figure 1a, 1b shows the glass cases which were used in the museum after the renewal processes and the glass windows from inside the museum.

The board of the building sought the assistance of a foreign company specialized in providing and setting glass cases. However, the technique used by this company in setting the glass cases, together with the policy of the company, do not allow anyone except the workers of the company to open the glass cases, and upon an advance request. This led to imposing new restrictions upon performing maintenance processes, whether the daily cleaning of glass cases from inside or the precautionary maintenance of lighting units or even replacing damaged ones.

As an attempt from the administration of the museum to overcome the previous problems a central air-conditioning system was set up in the museum as a whole to prevent the collision of windows with the glass cases and to lessen the amount of dust inside them and, in turn, the rates of periodical maintenance and cleaning. However, this solution led to the increase of the general budget of the renewal project, while, at the same time, leaving the problem of opening the cases for properly performing the maintenance processes unsolved.

CASE 2 HOTEL BUILDING

The Semiramis Intercontinental hotel overlooks River Nile in Cairo. The advantage of studying and analyzing this building is that it has already spent half of its age, since it had been opened about twenty five years ago. This makes it a rich case for studying as it has encountered varied maintenance-related problems throughout its lifetime.

The building had been subjected to entire air-conditioning system replacement, in addition to undergoing renewal processes for all systems, as well as for the internal and external facades. These processes were followed up by a specialized maintenance administration which is stationed inside the building. The most eminent problems which faced this building can be summed up as follows:

1. The project faced the problem of lack of some spare parts of high-quality materials; it also encountered the problem of lack of local trained workmen who are capable of dealing with modern techniques. Such problems clearly emerged when it was time for making precautionary maintenance for the air-conditioning system of the building. The decision of replacing the whole air conditioning system was taken after studying the costs which were provided for treating and renewing the old system. The decision of installing a new air conditioning system, which was made by the maintenance administration, led to lessening the burdens of maintaining the old system which needed many frequent maintenance cycles.

2. The building suffers from the incompatibility between the materials used for finishing and the dusty, polluted weather surrounding it as a result of its presence in a vital place in the middle of Cairo. This leads to many burdens on the performance of maintenance and cleaning processes, especially for entrances and glass facades for the purpose of keeping the good and attractive appearance of the building. Figure 2 shows the structure of the maintenance management department in the case study building.

Some machines and accessories inside the building were subjected to damage or vandalism from users, especially in public halls and lavatories. There is great difficulty in performing maintenance processes and other relevant works (especially precautionary maintenance and fixing processes) in some of the hotel halls in which guests are present.
This was the result of neglecting the accessibility for maintenance during the design of the building spaces. This problem led to obligatory evacuation of the hotel during the required maintenance processes.

CASE (3) SHOPPING MALL AND RECREATIONAL BUILDING

The City Stars project situated in Heliopolis, Cairo, includes an integrated management system, not only for the maintenance of the building, but also for facility management as a whole. Figure 3 illustrates the structure of the maintenance management departments in the building. This shows the integration between the maintenance administration and other administrations, since the maintenance administration depends on using computer techniques beside manual techniques in making maintenance schedules and issuing working order.

This resulted in great problems represented in the leakage of water inside the mall because of lack of techniques and bad implementation. Consequently, the maintenance administration resorted to periodical injection of leakage parts. On the other hand, the effect of local water and the percentage of salt in it were not studied, resulting in the obvious accumulation of salt on the façade. This in turn resulted in using filters to purify water from salts, leading to the appearance of such relatively big filters on the external façade of the building, figure (4). This problem represents a clear example of what can be caused by not integrating the maintenance considerations during the first phases of design, because solving the problem after its occurrence led to adding more unexpected burdens to performing maintenance processes for the building.

Figure 3: The structure of the Maintenance management departments in the case study 3.16.

Figure 2 : The structure of the Maintenance department in case study 2, building. 15

The administration of the building started its job after the building was implemented and shortly before starting its work. The obstacles which encountered the maintenance of the project’s halls comprised the following:16

Despite using high-quality paintings in internal corridors and public halls, the selection of such kinds of paintings disregarded some hostile manners by some users who lean with their shoes on the walls, causing damage to these paintings and making their cleaning difficult, as well as leading to the need for repainting these walls more frequently than expected.

Decision makers disregarded a very important factor related to the choice of devices and accessories which are used in lavatories, namely subjecting to vandalism. The system of selection of these devices depended on its efficiency and quality, regardless of safety measures against vandalism. This led to the subjection of most devices and accessories inside public lavatory halls to theft shortly after opening the project, which caused the administration to replace the devices with less efficient and safer ones (which cannot be removed).

The building was greatly affected by the lack of some locally modern techniques, as well as some materials with standard quality. This was clearly shown in implementing an external façade of the mall, which was planned to be made in the form of waterfalls. The administrators were forced during the implementation of the project to make use of limited local techniques to carry out the design by using pipes in hidden parts of the façade.

Figure 4: Water falls on curtain wall at city stars mall.
Source: Researcher

This project encountered another type of problems which represent an obstacle for building maintenance, which is the inability to reach some systems, especially inside the shops that do not have an outer façade facing the street. This problem led to the occurrence of limited fires inside the mall, as well as the need for eva¬cuating these shops during the maintenance process of the different control systems inside them.

CASE 4 LIBRARY BUILDING

The Bibliotheca Alexandrina library building is considered a revival of the old Alexandrian library and is situated in Alexandria, Egypt. The building has a complete administration which covers all its fields. Figure 5 shows the structure of the management department. The administration started to perform its work after the implementation of the building and before its beginning by the help of a foreign specialized management company. Then it sought the assistance of locally professional people after the foreign company had trained the local managers.
The maintenance administration of the project depends on an improved administration system which is carried out by a specialized computer program which produces both precautionary and corrective maintenance schedules, in addition to managing human resources, materials, costs and issuing work orders. It also performs an effective role in following up the performance of employees and evaluating them at the end of each maintenance cycle (3 to 12 months). Most of the problems and obstacles which confronted the implementation of maintenance processes for the building are represented in the following points:

A local specialized company was used to manufacture the internal partitions in the hall of the library with non-standard measures (as a kind of uniqueness for this building which has a symbolic importance). However, this resulted in a problem related to performing maintenance measures for these partitions and replacing damaged ones, since the manufacturing company cannot provide a small number of these partitions which were specially formed for the library building, which entails changing all the partitions at once after their hypothetical age. This problem refers to the lack of effect of maintenance considerations on the phases of building design, as well as to the existence of a mistake in selecting materials and in the used systems, since the availability and costs of such materials and systems later in local markets were not studied.

The other challenge which encountered the maintenance of this building was the shape of the building itself, since the façade of the building is extremely sloped and made of glass. This shape is incompatible with the climatic nature of Alexandria (the rainy, dusty weather), making the cleaning of the façade very difficult, especially with the lack of modern techniques and depending on manual workmanship, figure 6. Moreover, the extremely sloping nature of the building makes it impossible to use cranes and imposes on workers the need to walk over the sloping top of the library to perform maintenance.

Using some materials which are not suitable for the climatic nature and the weather changes makes them subject to damage quickly, causing the distortion of the appearance of the building in the eyes of the guests. Figure 7 shows the cracks of the façade of the conference hall annexed to the library.

1. FINDINGS OF CASE STUDIES

Through analyzing the previous case studies a group of findings were extracted and classified into a number of categories, as follows.

THE IMPACT OF THE EXISTENCE OF THE MANAGEMENT DEPARTMENT

This part of the findings was mainly based on both observations detected in each of the case studies and open interviews with managers.

Case 1: It has been shown that the lack of an administration specialized in the processes of building maintenance leads necessarily not only to the occurrence of problems which obstruct the processes of maintenance, but to a kind of randomness and hesitance in making decisions. Moreover, it adds new burdens especially on making the maintenance processes of the building with the required efficiency.

Case 2: The existence of an administration that is specialized in managing the building has helped to a great extent, in overcoming or lessening the effect of the problems that the building encounters, in addition to taking effective decisions regarding the maintenance of the building systems as a whole.

Case 3: The existence of an integrated team for maintenance administration and building administration in the project guaranteed limiting the effect of different problems which encountered it and that affected the performance of halls and different systems maintenance. Additionally, the integration between the maintenance administration and other administrations of the building also guaranteed the study of the effects of the problems on all administrations and the equal distribution of resources, resulting, in turn, in achieving efficiency in the performance of the whole building on the long run.

Case 4: The presence of a specialized, professional administration led to lessening many problems which might obstruct the effective performance of maintenance processes, in addition to the advantage provided by the applied system which is represented in its ability to evaluate the performance of employees continuously to guarantee the efficiency of carrying out the maintenance processes for the building. However, most of the problems which face this building occurred because the maintenance administration had not interfered in decision-making since the primary stages of design.
Figure 7 Cracks in the facades of the conference hall - Bibliotheca Alexandrina
Source: Researcher

Table 2: The degree of occurrence of different maintenance barriers in studied cases

<table>
<thead>
<tr>
<th>Barrier</th>
<th>A1</th>
<th>A2</th>
<th>A3</th>
<th>B1</th>
<th>B2</th>
<th>C1</th>
<th>D1</th>
<th>D2</th>
<th>D3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Case 1</td>
<td></td>
<td></td>
<td>×</td>
<td></td>
<td></td>
<td></td>
<td>×</td>
<td></td>
<td></td>
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<tr>
<td>Case 2</td>
<td>×</td>
<td></td>
<td></td>
<td>×</td>
<td></td>
<td></td>
<td></td>
<td>×</td>
<td></td>
</tr>
<tr>
<td>Case 3</td>
<td>×</td>
<td></td>
<td></td>
<td></td>
<td>×</td>
<td></td>
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<td></td>
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<tr>
<td>Case 4</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>×</td>
</tr>
</tbody>
</table>

Table 3: The degree of impact of different barriers on the effectiveness of maintenance process (According to the interview with the managers)

<table>
<thead>
<tr>
<th>Rank</th>
<th>Maintenance Barrier</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>D1</td>
</tr>
<tr>
<td>2</td>
<td>D2, D3</td>
</tr>
<tr>
<td>3</td>
<td>A1</td>
</tr>
<tr>
<td>4</td>
<td>B1, C1</td>
</tr>
<tr>
<td>5</td>
<td>A3, B1, B2</td>
</tr>
</tbody>
</table>

Table 3 shows the degree of impact of the barriers that occurred in the specified buildings on the efficiency of the maintenance process; this analysis was based on the interviews with the managers in the four case studies. The managers were asked to give a rank to the different barriers according to the severity of their impact on applying efficient maintenance in the case study buildings, from rank 1 (most severe), to rank 5 (least severe).

Table 1: Common barriers affecting maintenance of buildings in the case studies

<table>
<thead>
<tr>
<th>Requirements for Efficient maintenance</th>
<th>Area of Application</th>
<th>Type of Barrier</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. Maintainability</td>
<td>Systems</td>
<td>A1 Inaccessibility for maintenance</td>
</tr>
<tr>
<td></td>
<td>Systems</td>
<td>A2 Lack of qualified labor</td>
</tr>
<tr>
<td></td>
<td>Materials</td>
<td>A3 Lack of standard spare parts</td>
</tr>
<tr>
<td>B. Availability / Reliability</td>
<td>Materials</td>
<td>B1 Inaccurate choice</td>
</tr>
<tr>
<td></td>
<td></td>
<td>B2 Lack of efficient materials</td>
</tr>
<tr>
<td>C. Safety</td>
<td>Materials</td>
<td>C1 Vandalism</td>
</tr>
<tr>
<td>D. Manageability</td>
<td></td>
<td>D1 Lack of maintenance managment/management plan</td>
</tr>
<tr>
<td></td>
<td></td>
<td>D2 Lack of integration between different management disciplines</td>
</tr>
<tr>
<td></td>
<td></td>
<td>D3 Late involvement of maintenance managers</td>
</tr>
</tbody>
</table>
The maintenance manager should also interfere in clarifying the requirements of the selected systems and materials for maintenance processes.

MAINTAINABILITY

The maintenance manager should offer a primary evaluation for the extent to which the selected materials and systems are suitable for undergoing maintenance processes, and the appropriate rate of performing cleaning processes and periodic maintenance for them. In addition the manager should investigate the role of weather conditions in affecting both the type and frequency of maintaining the selected materials and systems of the building.

The maintenance manager also revises all the used systems of the building with respect to their accessibility for the purpose of daily maintenance and cleaning of its different parts. Accordingly, it is his responsibility to inspect the areas, service passages and the availability of entrances for the different parts of the building.

RELIABILITY

The maintenance manager is responsible of checking that the systems and materials used in the building (especially in the public halls) are vandal and theft-proof, and are highly efficient at the same time. Adopting such guidelines at the stage of design development would greatly affect both the maintainability of maintenance (A1, A2, A3), and the availability (B1, B2).

CONSTRUCTION DOCUMENTS STAGE

At this crucial stage, the building manual, which comprises all the building maintenance considerations and the rates of their applicability, should be attached to implementation documents. Also the maintenance manager should work on integrating maintenance data with all technical information about the building materials, equipment furnishings and systems. This stage should also include the process of designing the details necessary for protecting the systems and finishing from robbery and vandalism.

Adopting such guidelines at the stage of setting construction documents would greatly affect the manageability especially regarding the lack of integration between different management disciplines (D2) and achieving safety(C).

The framework in figure 8 shows the suggested guidelines integrated with, the phases of building life cycle, the suggested role of maintenance manager in each phase is highlighted, also the updated output of each phase is described after integrating the consideration of maintenance. The expected impact of such integration in either mitigating or eliminating different maintenance barriers is also highlighted on the framework.

According to this framework the maintenance manager team work in parallel with the design team to ensure that the decisions taken tackle the architecture design objectives, meanwhile have minimum negative impact on the application of maintenance processes later on. The suggested role of the maintenance manager starts with setting up a strategic maintenance plan that is based on examining the needs for maintenance of the building, either regarding the systems, the envelope, the facilities and infrastructure.

During Programming phase the maintenance management team should check the integration of maintenance needs with the design program; this includes offering enough spaces for applying maintenance requirements on each building component or system. Afterwards, during the establishment of design priorities the maintenance management team could interfere in producing modified drawings that achieves accessibility for maintenance and start working on the detailed maintenance plan for each system or component of the designed building. The role of the maintenance management through the construction of the building is limited to the Preparation of maintenance manuals, preventive and corrective maintenance plans.

During the operation of the building, the maintenance management should focus on both roles; applying different maintenance plans and monitoring the performance of the building through building performance evaluation techniques. Finally at the end of the expected building life time, maintenance management should work on extracting lessons learned and best maintenance management practices and on applying them either on, refurbished existing buildings or on new implemented buildings.

CONCLUSIONS

The top barriers that occurred in most of the case study buildings were in order as follows:

B1(Inaccurate choice of materials), C(Vandalism), D2 (Lack of integration between different management disciplines), D3(late involvement of maintenance managers).

Meanwhile, the barriers that have the most severe impacts on achieving efficient maintenance of buildings were found to be: D1(lack of maintenance management/management plan), D2 (Lack of integration between different management disciplines and D3(late involvement of maintenance managers).

The paper finally introduced suggested guidelines, in the form of a framework, that aim at integrating the considerations of maintenance into the whole design process. The suggested guidelines could be implemented throughout the whole building life cycle and ensures the achievement of efficient maintenance through minimizing the key major barriers that might face the maintenance processes. A couple of limitations could face the application of the suggested framework on different buildings as follows: The standardization of the framework might not be applicable on building types other than public buildings, where the type of ownership, the scale, the context and the surrounding services could all form variables that need to be furtherly studied.

Although the framework would resolve all the top key barriers that hinder the achievement of efficient maintenance process, or at least mitigate their negative impact, some barriers couldn’t be resolved through this framework. The unresolved barriers include the lack of qualified labor and the lack of spare parts, which are both considered as external type of barriers that could hardly be controlled or mitigated.

Finally, since the research focused on integrating maintenance considerations with the delivery phases of different public buildings, it is believed that applying this framework on other types of buildings, for example residential buildings, would imply for further investigation and modifications of the suggested framework.
Original Design Phase and updated phase after integrating maintenance (Input).  

<table>
<thead>
<tr>
<th>Type of Maintenance barrier</th>
<th>Original Design Phase</th>
<th>Updated Design Phase</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Planning and Market Need Analysis</td>
<td>Strategic Plan</td>
<td>Strategic Maintainence Plan</td>
</tr>
<tr>
<td>2. Programming (Needs, aims, resources and context)</td>
<td>Detailed Program</td>
<td>Maintenance-included detailed program</td>
</tr>
<tr>
<td>4. Construction Documents</td>
<td>Implementation of building systems and facilities</td>
<td>Setting detailed preventative maintenance plans</td>
</tr>
<tr>
<td>5. Occupation and Operation</td>
<td>Post occupancy Evaluation</td>
<td>Building performance evaluation</td>
</tr>
<tr>
<td>6. Reuse/Demolition</td>
<td>Lessons learned and market need analysis.</td>
<td>Lessons learned and best maintenance practices</td>
</tr>
</tbody>
</table>

Figure 8 a framework that shows the suggested guidelines for integrating maintenance considerations with the phases of building life cycle.

REFERENCES


[15] Head of Maintenance Management Department(2011) -Open Interview, Semeramis Intercontinental Hotel, Tahrir, Cairo, January 2011

[16] PMO and Deputy Project Manager(2012)-Open Interview, City Stars – Heliopolis, Cairo, May 2012

[17] Head of Preventive Maintenance Management Department(2010)-Open Interview, Biblioteca Alexandrina – Alexandria, July 2010
ABSTRACT

PURPOSE: Recent literature suggests that many companies are moving away from traditional costing (TC) systems in favour of activity based costing (ABC) systems which provide more accurate cost information among other benefits. The literature also reports low assimilation and abandonment of the ABC system by the companies which had adopted it owing to several weaknesses of the ABC system. These conflicting findings of high adoption of the ABC system on one hand and low assimilation on the other hand, formed the basis of this paper. The paper sought to clarify the applicability of the ABC system to the construction industry in Southern Africa. It tests whether or not the ABC system is a viable alternative to the TC systems.

METHODOLOGY: A literature survey and primary data obtained from two questionnaires; one addressed to construction companies and the other to the consultants, were used. The sample of the respondents was obtained from the register of contractors and construction industry companies. The researcher sent the links to the Lime survey by email to all the respondents.

FINDINGS: According to the respondents the use of traditional costing (TC) systems produces distorted project cost results while the ABC system produces more accurate project cost results when used in the construction industry. However, contractors had not fully adopted the ABC system but used TC systems despite producing distorted project costs.

VALUE OF THE RESEARCH: Contrary to the widely held view that TC systems have no place in modern management accounting, this research found that TC systems are still popular in the construction industry in Southern Africa, and that users of TC systems were generally satisfied with their system’s performance. However, this finding has implications in the light of the current view that TC systems are dysfunctional. The study revealed the benefits of TC systems reported by their users, such as the fact that they produce accurate costs, are simple to use, and allow real time reporting. TC systems may have been improved by computer systems to the point where they are able to provide reliable cost data and efficient reporting. This study has furthermore established that continued calls by advocates of the ABC system to implement this system because of its ability to provide more accurate product costs than TC systems may be misplaced and may not in fact increase the assimilation of ABC.

KEYWORDS: Activity-based costing, traditional costing, construction industry.

INTRODUCTION

Several researchers suggest that the current trend in accounting is that more and more companies are moving away from traditional costing (TC) systems in favour of the activity based costing (ABC) system. This is since TC systems produce inaccurate and misleading cost information to such an extent that a company using a TC system may end up trading in loss making products as a result of acting on the misleading information supplied by the system. Traditional costing entails according to Turney any of the older costing systems which use direct material where labour is consumed as the primary means of apportioning overheads.
On the other hand the ABC system is “a method for measuring the cost and performance of activities, products and customers” 7. Therefore, proponents of the ABC system 8, 9, 10 recommend that companies should implement it in order to solve the problems which arise from the application of TC systems.

However, other researchers 11, 12, 13 have found that more companies still use TC systems than the ABC system despite the cost distortions which result from their use. Furthermore, the number of companies showing interest in the ABC system has dropped as that of companies abandoning implementation has risen 14. On the other hand Stratton, Desroches, Lawson and Hatch 15 refuted the assertions that ABC is being abandoned by finding that only 2.8% of their respondents had abandoned ABC. Evidently, there is no consensus among researchers regarding the adoption of TC and ABC systems. As a result, the debate regarding which costing method is more appropriate for overhead allocation continues in the management accounting community 16.

The ABC system has been applied in many industries and business sectors of all sizes 17. This paper looked at the applicability of the system to the construction industry in Southern Africa. The objective was to determine whether the ABC system is more suitable for the accumulation of construction project costs than TC systems. It sought to establish whether the use of the ABC system would remove product cost distortions and lead to more accurate project cost in the construction industry. There are conflicting findings in the literature regarding which overhead allocation system is being used by organisations. These conflicting results therefore, justify further research since managers are confused about which costing system is more suitable to deal with overhead allocation.

This paper focuses on the construction industry since the industry is important as it accounts for a significant share of economic activity of a country and it is also a catalyst for other sectors 18. A study of overhead allocation in the construction industry helps in the determination of total costs; costs accumulation; cost management and pricing of projects 19. In a construction company an unsuitable costing system may result in management failing to measure the projects’ performance accurately which might lead to strategic decisions being made on the basis of wrong project costs. A contractor needs to maintain a proper costing system with mechanisms for the accurate allocation, apportionment of overhead costs for them for example to bid competitively for projects and furthermore during project execution (payments and final accounts). However, companies in the construction industry are failing to deal with the problem of allocating overheads leading to financial losses and bankruptcy 20. Therefore determining an appropriate costing system guarantees the survival of construction companies by improving profitability 7 and competitive advantage 21.

The rest of the paper is set out as follows: in the next section the literature is presented and this is followed by the problem statement and the research methodology. The data analysis and discussion are presented next and followed by the conclusions. The paper concludes with suggested future research.

LITERATURE REVIEW

In 1987, Johnson and Kaplan 9 disapproved traditional management accounting systems for three main weaknesses:

1. Management accounting reports are produced too late and are too distorted to be relevant for managers’ decision making;
2. It is of little importance to cost reduction and productivity improvement; and
3. The management accounting system does not provide accurate product costs.

Subsequently, researchers have found empirical evidence of product cost distortions 5, 6; product cross-subsidisation 5, 6, 22 and misinformation regarding pricing decisions 20, 21 arising from the use of TC systems. Johnson and Kaplan 9 saw the role of a management accounting system as to provide timely and accurate information in order to control costs, to measure and improve productivity and design more improved production processes.

TC systems are irrelevant for this role since they assume that indirect costs vary proportionally with direct labour 6. Therefore the ABC system fulfils the role of management accounting systems since it provides more accurate product costs and gives an insight into what drives costs 24.

Reeve, Warren and Duchan 26 define ABC as an accounting framework which is based on relating the cost of activities to final cost objects, such as products or customers. Moreover, Zawawi and Hoque 28 state that it is a modern accounting system that measures the use of resources by activities. The system assumes that products demand activities, which consume resources and the resources cost money 17. On the other hand TC systems are any of the older costing systems which use direct material and labour consumed as the primary means of apportioning overheads 7.

THE ADVENT OF THE ABC SYSTEM

The advent of ABC can be traced to global changes in technology, increased competition and rapid changes in products during the past 20 years 15, 27. These changes in the business sector rendered the design of many costing systems irrelevant 28. TC systems became invalid for facilities producing diversified products 8. However some researchers have found that ABC and TC systems are complimentary. For example, Cokins 24; and Benjamin, Muthaiyah and Marathamuthu 29 found that ABC is basically an extension of TC systems.

The system is used to supplement the company’s costing system and not as a replacement to it 30. They found that many companies which use ABC have another costing system for external reporting. De la Villarnnois 31 also established that TC systems are widely used alone or supplemented by the ABC system. Therefore the literature although in conflict, supports the continued use of TC systems supplemented by ABC and also the adoption of ABC as a replacement to TC systems.

OVERHEAD ALLOCATION AND CONSTRUCTION PRODUCTION THEORY

Construction indirect overheads are conveniently classified into two perspectives: the home office and the project perspective 6. The home office perspective deals with assigning office overheads to different projects. These overheads are incurred even if there are no projects under construction 32. The project perspective deals with assigning overheads to each section of the job. Project overheads are a factor of the project’s duration and complexity and therefore do not vary with project progress 32. According to Chao 33, these overheads are required for the running of the project as a whole.
In the construction industry, resource based costing (RBC) and volume based allocation are used to allocate indirect costs to cost objects. However, studies have shown that the ABC system produces significantly more accurate and valuable information than TC systems.

ABC principles are applicable to all types of business sectors. However, research on ABC application has concentrated more on the manufacturing sector and the service sector to a lesser extent. This is probably since the ABC system itself has its roots in the manufacturing sector and its application to other business sectors is still less significant. The construction industry is however a very important business sector since it accounts for 10 per cent of the GNP of many countries according to Bertelsen. Its impact affects the social wellbeing of human populations as evidenced by various social housing projects such as Namibia’s mass housing project and the Reconstruction Development Programme (RDP) of South Africa.

Bertelsen states that a small improvement in performance in the construction industry would greatly impact the economy. This performance may be achieved if construction companies could move away from their current costing systems to implement an ABC system. This view is supported by Zimina and Pasquire who posited that traditional arrangements do not generally comply and hamper the full exploitation of construction production techniques such as lean construction. This is important since any costing techniques to be used in the construction sector may need to align with construction production theory and not conflict with theories which have been developed to achieve efficiency in the industry.

A leading construction production theory is Lean Production which was first established by Womack and Jones. Lean Construction (LC) however, was pioneered by Koskela who founded the International Group for Lean Construction (IGLC) and developed the transformation flow view (TFV) theory of construction. According to Kramer et al., LC tries to manage and improve construction processes at low cost and maximum value through a consideration of customer value. LC emphasizes the acceleration of activities to improve productivity and cost cutting through elimination of waste. Similarly ABC determines the productivity of each activity and eliminates non-value adding or wasteful activities. Emuze argued that non-value adding activities (NVAs) need to be addressed in order to improve the performance related problems of the South African construction industry and their performance related problems. This includes waste of materials and waste is defined in LC as available costs within activities, which include reworking substandard works or delays and extended activity duration along the critical path. Womack and Jones concur that lean thinking is mostly about the elimination of waste. They define waste as any human activity which consumes resources without creating any value. Therefore, both the LC and the ABC systems focus on the elimination of non-value adding activities in the construction and production process.

LC theory and ABC systems emphasise customer value addition and product quality. According to Howell and Ballard, the primary objectives of lean thinking are the value to the customer and throughput. Lean thinking focuses on elimination of waste to improve productivity and client satisfaction according to Jyhà and Junnila. Khataie and Bulgak added that lean manufacturing focuses on the approaches that can help an organisation to reduce the waste factors in its processes.

Similarly, one of the first steps in developing an ABC system, according to Garrison et al., is Process Value Analysis (PVA) which helps the manager to eliminate non-value added activities in the company and improve quality. Therefore, the ABC system could be used effectively to reduce wastage by contractors who have implemented lean construction.

On the other hand TC systems are based on the transformation view of production which views production as a conversion of inputs to outputs. This perception of production may have led to the tracing of resources directly to outputs as if output varies with resource consumption. However, resource consumption varies with demand for activities, which is made by the products. In other words, products do not exert demand for resources but for activities which (activities) consume resources.

By taking a transformation view on resource allocation, TC methods might assume that all resources have been consumed by products. In fact not all resources are converted to output but some resources are consumed as waste. Hence, TC systems may produce distorted cost information since they are premised on the wrong view that production varies with resource consumption.

Whereas the current practice in construction is based on the transformation view, the ABC system takes the flow view of production. Production as a flow is seen as a series of value adding and non-value adding activities. He furthermore states that there is plenty of wastage in the production process as non-value adding activities exceed the value adding.

The fact that the construction process involves a lot of wastage is also confirmed by the findings of Hammerlund and Ryden who that two thirds of the Swedish plumbers’ working time on a construction site constitute waste as effort is largely directed to non-value adding activities. A way to eliminate this waste is using a fully integrated Lean Production System. Therefore, the objective of optimising the process under the flow view is to eliminate or reduce the non-value adding activities while optimising the value adding ones. The flow view of construction production, favours the use of the ABC system as it accepts that the construction process also involves waste.

**ABC/TC APPLICATION TO THE CONSTRUCTION INDUSTRY**

Kim and Ballard illustrated the typical problems associated with the use of TC systems in a construction set-up. They analysed the reports of a company constructing an industrial project of five buildings. Table 1 shows a comparison of the total job cost results reported by the resource based costing system and that produced by an ABC system for the company.

The cost disparities between the two systems show that the total costs for buildings one and two are 8% and 13% respectively, when reported by an RBC system rather than an ABC system. Whereas building three’s total costs are 41% higher under the ABC system than the RBC system. This is since an RBC system over-costs projects with a higher volume of direct labour and under-costs projects with low volume of direct labour.
The results summarised in Table 1 confirm the view of Horngren et al. 40 that TC systems cause product cross subsidisation by over-costing a product with a high resource consumption and under-costing that with a low resource consumption because of the use of an inappropriate allocation base 39.

The research summarised in Table 1 confirm the view of Horngren et al. 40 that TC systems cause product cross subsidisation by over-costing a product with a high resource consumption and under-costing that with a low resource consumption because of the use of an inappropriate allocation base 39.

Table 1: A comparison of RBC and ABC cost results D-890

<table>
<thead>
<tr>
<th></th>
<th>RBC</th>
<th>ABC</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Direct Material</td>
<td>$11,000.00</td>
</tr>
<tr>
<td>Building 01</td>
<td>Building 02</td>
<td>$6,000.00</td>
</tr>
<tr>
<td>Building 03</td>
<td>Total</td>
<td>$21,500.00</td>
</tr>
</tbody>
</table>

**Table 2: Cost reports of Small Manufacturers Ltd**

<table>
<thead>
<tr>
<th></th>
<th>Traditional Costing</th>
<th>Activity Based Costing</th>
<th>Cost Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Contract 01</td>
<td>103,899</td>
<td>107,743</td>
<td>3.7%</td>
</tr>
<tr>
<td>Contract 02</td>
<td>96,142</td>
<td>101,684</td>
<td>5.6%</td>
</tr>
<tr>
<td>Contract 03</td>
<td>234,699</td>
<td>252,406</td>
<td>7.5%</td>
</tr>
<tr>
<td>Contract 04</td>
<td>129,722</td>
<td>172,603</td>
<td>33.1%</td>
</tr>
<tr>
<td>Contract 05</td>
<td>102,974</td>
<td>118,293</td>
<td>15%</td>
</tr>
<tr>
<td>Contract 06</td>
<td>153,763</td>
<td>122,018</td>
<td>-20.7%</td>
</tr>
<tr>
<td>Contract 07</td>
<td>127,464</td>
<td>126,910</td>
<td>-0.4%</td>
</tr>
<tr>
<td>Contract 08</td>
<td>246,776</td>
<td>217,502</td>
<td>-11.9%</td>
</tr>
<tr>
<td>Contract 09</td>
<td>181,239</td>
<td>162,742</td>
<td>-10.2%</td>
</tr>
<tr>
<td>Contract 10</td>
<td>165,330</td>
<td>151,291</td>
<td>-8.5%</td>
</tr>
</tbody>
</table>

Adapted: Hicks 37

Hicks 5 further confirms the costs distortions which arise when TC systems are used for overhead allocation. This study showed disparities between total costs obtained from TC systems and from ABC of between 127% and 33%. Contracts with high volumes of assembly hours were over-costed and those with low volume under-costed. Table 2 compares the total costs obtained from the use of the two methods. Therefore, it seems that TC systems may tend to over-cost high volume labour intensive contracts and under-cost low volume machine intensive contracts.

**ABC ASSIMILATION**

Prevailing literature shows conflicting findings regarding the assimilation of the ABC system. Innes and Mitchell 53 established that more than half (97 companies) of the 187 companies in their survey had not seriously considered ABC implementation, one third (60 companies) were vetting it while four per cent (seven companies) had totally rejected it. Only six percent (11 companies) had commenced implementation of the system. Caplan 14 also found no evidence of ABC assimilation as 50 per cent of the companies used variable costing and the other 50 per cent used absorption costing for internal reporting. In the Gulf Cooperation Council (GCC) Mclellan and Moustafa 34 found that companies still relied on traditional accounting systems and not the modern tools and in South Africa Sartorius and Kamala 30 found that ABC implementation was still very low.

On the other hand Kuo and Yang 55 maintain that over the past two decades, ABC has spread across many industries among many countries. In addition Abbas and Wagdi 56 found that many Egyptian companies are adopting ABC as 56% were using the ABC system, with only 5.3% applying TC and 38% other systems. Vlijm 39 established that the hotel sector in India had implemented ABC in order to benefit from improved cost allocation, higher levels of accuracy, customer profitability analysis and cost reductions.

Moreover, it is not clear from the international literature whether the benefits of the ABC system outweigh the costs associated with its implementation. Some of the disadvantages of ABC are indicated next. The ABC system demands too much detail and a considerable amount of data collection 20, 13. Its implementation produces a cost database rendering the existing one obsolete 34. It is not easy to operate compared to other systems 59 and requires a substantial investment in the company’s resources 42. In Jordanian companies, the greatest barrier to the adoption of the ABC system was its high cost of implementation as well as the high cost of ABC consultancy and computer staff time 50 whereas the system was abandoned by many users in France because of its complexity according to Levant and Zimmovich 51. Therefore despite being more accurate in allocating overheads, the ABC system is a costly alternative to the TC system 59.

**PROBLEM STATEMENT**

The problem outlined in this paper emanates from the need to allocate indirect overheads to projects in order to determine total project costs. Traditionally, construction companies applied a single volume based allocation basis to deal with the problem of allocating indirect costs to cost objects 6.

However the use of a single volume based absorption rate (OAR) is no longer appropriate since several changes have occurred in the business sector 3, 40. For example labour intensive production has been replaced by machine intensive production to such an extent that companies have reduced their reliance on direct labour according to Ratnatunga and Waldmann 21 and Gervais, Levant and Ducrocq 30. Consequently the continued usage of direct labour produces distorted product cost results according to Ratnatunga and Waldmann 9 and Gervais, and Levent and Ducrocq 30. This paper is important since it clarifies part of the assimilation of the ABC system in which international literature shows conflicting findings and determines which costing is therefore appropriate for the construction industry in southern Africa.

**RESEARCH METHODOLOGY**

The research used two structured questionnaires for collecting data. One questionnaire was addressed to consultants who work with construction companies and the other to accountants and managers of construction companies. Structured questionnaires were used since they are simple and relatively
inexpensive to administer and analyse. The questionnaires were dominated by close ended questions and included less open ended questions. Close ended questions avoid ambiguity in the responses and are also likely to elicit responses from the interviewee who sees them as easy and less time consuming than open ended questions. Open ended questions however were used in order to obtain responses requiring expansive answers.

The questionnaires were designed to answer the following questions:

- Do TC systems produce distorted costing results when employed in the construction industry in Southern Africa?
- What are the causes of cost distortions in TC systems?
- Does the ABC system prevent cost distortions when employed in the construction industry?
- To what extent has the ABC system been adopted by construction companies in Southern Africa?
- Which costing system is most suitable for the construction industry?

The target population was the fifteen Southern Africa Development Community (SADC) member states. A sample was therefore drawn from three of the fifteen countries namely Namibia, South Africa, and Zimbabwe representing an accessible population of twenty percent of Southern Africa. The three countries were chosen since they have different development stages of the construction industry which is characteristic of the region. The sampling process is summarised in Figure 1.

The sample was randomly drawn from the three major sectors of the construction industry namely General Building works (G.B); Civil Engineering works (C.E); and Mechanical Engineering works (M.E) as shown in Figure 2. Details of contractors were obtained from the regulatory bodies such as the Construction Industry Development Board (CIDB); Master Builders Association (MBA) and the Construction Industry Federation of Zimbabwe (CIFOZ), and stratified according to their class of specialty.

Each class of contractors was further divided by size of the contractor in order to obtain responses from small, medium, and large construction companies of each class. From each stratum, a sample was randomly drawn. From every size (small, medium, and large contractors) of class of contractors were randomly drawn as shown in Figure 2.

![Figure 1: The Sampling Process](image)

**DATA ANALYSIS AND DISCUSSION**

**Distribution of contractors by size**

Table 3 shows the distribution of contractors by company size. The distribution of respondents by size was important since large companies would be expected to lead in the implementation of new costing systems rather than small companies.

<table>
<thead>
<tr>
<th>Contractor Grade</th>
<th>Common Grading</th>
<th>Number of Respondents</th>
<th>Response Rate (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-3</td>
<td>Small contractor</td>
<td>6</td>
<td>11.5</td>
</tr>
<tr>
<td>4-6</td>
<td>Medium contractor</td>
<td>11</td>
<td>21.2</td>
</tr>
<tr>
<td>7-9</td>
<td>Large contractor</td>
<td>31</td>
<td>59.6</td>
</tr>
<tr>
<td>Uncompleted</td>
<td></td>
<td>4</td>
<td>7.7</td>
</tr>
<tr>
<td>Totals</td>
<td></td>
<td>52</td>
<td>100%</td>
</tr>
</tbody>
</table>

The highest response rate (59.6%) was from large contractors followed by medium contractors (21.2%) and small contractors (11.5%). Therefore, it is implied that large contractors may have greater interest in costing systems than small and medium contractors.

**Average number of contracts**

The number of contracts a contractor executes at a given time may be important in determining the need for overhead allocation. If a contractor works on a single project at a given time, they would simply allocate the period costs for the company to that particular project.

Similarly if a contractor works on very few projects at a time, the effect of arbitrarily allocating overheads would be more negligible than if they had many projects. Figure 2 depicts the distribution of respondents by size and number of projects.
The graph shows that large contractors run more projects at a given time followed by medium size contractors and small contractors Therefore, the effect of improper allocation of overheads might be greater on large contractors than small contractors 46.

**Allocation of head office overheads to projects**

Out of the 52 respondents 28 or 53.8% stated that they allocate head office overheads to projects. 20 respondents representing 38.5% indicated that they do not allocate head office overheads to projects. Therefore, it is implied that most contractors attempt to allocate head office overheads to projects. These results contradict the findings by Cokins 16 that most companies do not make an attempt to allocate overheads to cost objects.

**System of allocating head office overheads to projects**

The responses indicated that various bases are used to allocate head office overheads to the projects. Table 4 summarises these responses.

<table>
<thead>
<tr>
<th>Table 4: Bases used to allocate head office overheads to projects</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Bases Used</strong></td>
</tr>
<tr>
<td>Value of contact basis</td>
</tr>
<tr>
<td>Administration costs incurred</td>
</tr>
<tr>
<td>Time taken on project</td>
</tr>
<tr>
<td>Value of work completed</td>
</tr>
<tr>
<td>Turnover of each contract</td>
</tr>
<tr>
<td>Direct labour hours</td>
</tr>
<tr>
<td>Activity-based system</td>
</tr>
<tr>
<td>Other (volume based) bases</td>
</tr>
<tr>
<td><strong>Total</strong></td>
</tr>
</tbody>
</table>

The responses show that most contractors (97%) use traditional volume based overheads allocation systems or some arbitrary system to allocate head office overheads to projects. These results support the findings by Kim and Ballard 16 that construction companies use resource based costing and volume based allocation and the literature that most companies still use TC systems more than ABC system 26, 54 but contradicts the findings of Cooper and Kaplan 67 that most companies have reduced their dependency on TC systems by developing ABC management systems.

**Effectiveness of the current costing system**

The research established how effective the users regard their system of allocating head office overheads to projects. The responses are summarised in Table 5.

<table>
<thead>
<tr>
<th>Table 5: Effectiveness of the current system of allocating head office overheads</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Response</strong></td>
</tr>
<tr>
<td>Poor</td>
</tr>
<tr>
<td>Satisfactory</td>
</tr>
<tr>
<td>Good</td>
</tr>
<tr>
<td>Very Good</td>
</tr>
</tbody>
</table>

Therefore, the majority of the users of TC systems are pleased with their systems as only 92% of the respondents indicated that the effectiveness is poor. This, however, contradicts the findings by Cokins 16 that managers are not satisfied with their current systems.

**Allocation of project overheads to work sections**

Examples of project indirect overheads are foremen’s salaries, health officers’ salaries, and warehouse costs. Typical project sections for a general building project would be earthworks, masonry, roofing, electrical, painting, carpentry and ceiling. The responses as summarised in Table 6 indicates that most contractors (53%) do not allocate project overheads to their works sections.

<table>
<thead>
<tr>
<th>Table 6: Allocation of project overheads to works (project) sections</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Yes</strong></td>
</tr>
<tr>
<td>Do you allocate project indirect overheads to work sections?</td>
</tr>
</tbody>
</table>

**ABC produces more accurate project costs**

Most respondents (91%) indicated that ABC produces more accurate project cost results than TC systems. Four respondents (9%) indicated that TC systems produce more accurate project cost results than the ABC system.

**Benefits of the current costing system**

Contractors gave several benefits which they are enjoying from the current costing system.

The most cited benefits were that the system helps to assess projects accurately, is simple to use and cheap to implement. These responses show that although contractors perceive the ABC system as giving more accurate project cost results, they also see several benefits in their current costing systems. These benefits are presented in Table 7 (see page 17).

Hence, contractors may be enjoying several benefits from their current system of allocating overheads and therefore they may not want or need to change.

**TC systems produce misleading project cost results**

The respondents showed that 16 contractors (34%) strongly agree that TC systems produce misleading project costs. 23 contractors (50%) agree, three contractors (6%) are neutral while five contractors (10%) disagreed that TC systems produce distorted project costs. Therefore, as found in the literature 16, 67 many contractors (84%) believe that TC systems produce misleading project costs. These results are summarised in Table 8.

<table>
<thead>
<tr>
<th>Table 8: Do TC systems produce misleading cost results?</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>TC systems produce misleading cost results?</strong></td>
</tr>
<tr>
<td>Strongly agree</td>
</tr>
<tr>
<td>Agree</td>
</tr>
<tr>
<td>Neutral</td>
</tr>
<tr>
<td>Disagree</td>
</tr>
<tr>
<td>Strongly Disagree</td>
</tr>
</tbody>
</table>

TC systems produce misleading cost results since they use a single OAR such as direct labour to allocate indirect overheads 66. However, this finding contradicts the findings above that contractors were happy with their current costing systems and that contractors were enjoying several benefits from their current costing system.

This contradiction suggests that some respondents may have improved their current costing systems to become a multiple OAR system hence they were enjoying some benefits similar to the ABC systems.
Should ABC be used supplementary to a TC system?
The responses to this statement indicated that 13 respondents (28%) strongly agree and 14 respondents (30%) agree that ABC should be used supplementary to TC systems. Seven respondents were neutral while 8 disagreed (17%) and 4 strongly (9%) to ABC being used supplementary to TC system. These results are represented in Figure 3.

These results support Cokins and Cooper and Kaplan’s observation that companies need different reporting systems: one for periodic financial statements showing the cost of activities supplied each period and an ABC system showing the quantity and actual cost of activities used in the period.

ABC and Wastage
13% of the respondents strongly agreed and 57% agreed that ABC reduces non-value adding activities. Nine respondents (20%) were neutral. Only five respondents (11%) disagree and none strongly disagreed that ABC reduces non-value adding activities. These results are summarised in Table 9. Therefore, by eliminating non-value adding activities ABC reduces wastage and improves the company’s profitability. The findings that ABC reduces non-value adding activities are consistent with the findings of Sartorius and Kamala and Horngren et al.

Can ABC be used in project pricing and bidding?
The research aimed to establish if ABC could help in project pricing and bidding.

If the ABC system is a good basis for allocating office and project level overheads, it could be useful in pricing and determining a project’s preliminaries and general fees for the contractor. Of the 47 respondents, six strongly agreed (13%) and 21 agreed (45%) that ABC can be used for competitive project pricing and bidding. Six respondents (13%) disagreed and two respondents (4%) strongly disagreed while 12 respondents (26%) were neutral. These results are summarised in Figure 4.

Most contractors (58%) believe that ABC can be used for project pricing and bidding. Only 17% of the respondents believe that ABC cannot be used for project pricing and bidding. This finding suggests that the ABC system may be useful to both accountants and quantity surveyors involved in pricing of construction projects.

Assimilation of the ABC system
Out of the 52 respondents, only 5 respondents indicated that they use an ABC system while 47 or (90%) use TC systems. 21 respondents (60%) had considered implementing ABC but abandoned it while 14 respondents (40%) never considered implementing it.

Therefore, the ABC system may not have been widely adopted in the construction industry in Southern Africa. This agrees with the findings of Sartorius and Kamala that ABC assimilation is still very low.

---

Table 7: Summary of the benefits enjoyed from the current costing system

<table>
<thead>
<tr>
<th>Benefit</th>
<th>Number of Respondents</th>
</tr>
</thead>
<tbody>
<tr>
<td>“Simple and easy to use”</td>
<td>7</td>
</tr>
<tr>
<td>“Simplicity is our current choice over one requiring detailed analysis. Less cumbersome resulting in less cost of implementation.”</td>
<td>1</td>
</tr>
<tr>
<td>“We have quick and accurate costs to compare with the revenue. The costs are not in great detail but cover the main components that need to be controlled and can direct what items need to be corrected and attended to.”</td>
<td>1</td>
</tr>
<tr>
<td>“Gives accurate assessment of project profitability”</td>
<td>1</td>
</tr>
<tr>
<td>“Accurate costing of specific projects”</td>
<td>2</td>
</tr>
<tr>
<td>“Staff can understand it and are familiar with it”</td>
<td>3</td>
</tr>
<tr>
<td>“Real time reporting”</td>
<td>1</td>
</tr>
<tr>
<td>“Very integrated system if the resources are a located up front at a click of a button you can have the following reports, histograms, programmes”</td>
<td>1</td>
</tr>
</tbody>
</table>

![Figure 3: ABC should be used in supplementary to TC systems?](image)

![Figure 4: Should ABC be used in project pricing and bidding?](image)
CONCLUSIONS

Most contractors attempt to allocate head office overheads to projects in order to establish the total cost of each project and measure supervisors’ performance. The majority of contractors who allocate head office overheads to projects use TC systems. Most contractors believe that the ABC system produces more accurate project cost results. However, the paper finds that most contractors still use TC systems rather than the ABC systems despite the cost distortions arising from their use. The most important reasons for the continued use of TC systems are that TC systems are cheaper and simpler to use. The low assimilation of the ABC was also shown by the fact that 65% of the contractors are pleased with their current systems.

However, the paper established that most contractors do not to allocate project (site) overheads to works sections. This suggests that contractors are not aware of the total cost or profitability of the individual sections of the project. The popular system of allocating both head office and site overheads in the construction industry are TC systems. Therefore, ABC assimilation is still very low, with only 10% of the respondents having adopted ABC. Contractors believe that the ABC system reduces wastage by eliminating non-value adding activities. They also find the system suitable for project pricing and bidding. This paper finds that the ABC system is a supplementary system to TC systems rather than a substitute to them. It therefore recommends that contractors should adopt a hybrid cost system which uses the ABC system for internal reporting and decision making and the TC system for external reporting.

FUTURE RESEARCH

The findings of this research have exposed some loose ends that could not be answered conclusively by the data. Therefore, further research is recommended on the following aspects:

- The cost effectiveness of employing two costing systems, namely TC and ABC, in a company.

- The extent to which improvement in computer software has enhanced the performance of TC systems.

REFERENCES


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EFFECTIVENESS OF POST CONTRACT COST MANAGEMENT PRACTICES OF CONTRACTORS IN NIGERIA

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PURPOSE: The investigation examined the effectiveness of post contract cost management practices of contractors in order to ensure profit is guaranteed and the continued achievement of the long term goals of the construction companies is realized.

ABSTRACT

PURPOSE: The investigation examined the effectiveness of post contract cost management practices of contractors in order to ensure profit is guaranteed and the continued achievement of the long term goals of the construction companies is realized.

METHODOLOGY: With the use of a self-administered semi-structured questionnaire, a survey was conducted among professionals carrying cost management functions in contracting organizations in Nigeria.

LIMITATIONS: Empirical data is limited to the views of professionals involved in cost management functions of contractors in the study area.

FINDINGS: The study reveals cost projection measure is the most frequent cost control method used by contractors, while actual versus forecast reconciliation (labour/material/plant) is regarded as the most effective control method. Expatriate and partly expatriate contractors agree on the most effective cost control methods in the construction industry.

ORIGINALITY/VALUE: This study claimed that IT integration is the only way to get quick and accurate reports to solve cost overrun and its associated problems identified by several literature and professionals.

KEYWORDS Construction project, Cost control, post contract, Cost overrun; Nigeria

INTRODUCTION

The construction industry is vital to the national economy and is an important industry worldwide, providing the infrastructure and buildings on which all sectors of economy depend. The construction industry continually is becoming more global, hence there is need for it to establish a competitive position in local, national and global markets. During the past two decades, the global marketplace has changed, and most of the engineering and construction firms have had to deal with many new competitors. The market place includes projects of dramatically different types, size, complexity, requires extensive professional and trade skill. Additionally, construction industry in the market place has created a need for understanding global dynamics and competition, developing new and innovative cost management system, and taking actions to maintain world-class leadership.

Construction projects involve several inter-related activities. The management of large projects is usually quite complicated and therefore challenging for many construction clients. Complex and interrelated activities of construction work generate problems for an effective cost control process. This is also the result even when the same set of activities is repeated on construction site. The resources used for an activity may vary depending on a number of factors, among which are weather condition, supervision of the works, late delivery of materials, rework, accidents and damages. Keeping proper record of costs incurred during the construction process is a great challenge.
Economic recession has hit the world including the construction industry very hard and fast in time past, producing a negative effect on the availability of finance by client. World recession has generally produced shortage of funds for capital expenditure and construction in general. Many projects under construction have been abruptly terminated by the client and a number of the prominent and prestigious projects delayed or scope reduced as a result of financial issues. This churns up the issue of carrying out a thorough cost planning and cost control measures during the entirety of a construction project. The financial control of any construction project commences at inception and continues until the issue of final certificate. Construction contract is hitherto separated into two major stages, namely, pre-contract and post-contract stages. The pre-contract stage is the period culminating from the inception stage to the selection of contractor. The time from signing of the contract until the final certificate is termed the post-contract phase.

The financial muscle of client has affected construction especially as a result of economic melt down and recessions in the economy at strategic periods of the year. This financial crunch leads to the suspension of construction projects, termination of contracts, construction work temporarily put on hold or to a great extent, reduction in the scope of the project. At present, contractors are struggling for survival and the continued existence of the realization of their long terms goals and objectives. There are very few building and infrastructure projects in the market for tender by majority of contractors, as the majority of the projects are been undertaken by few reputable contracting organizations. High competition among contractors forced them to get some job with reduced profit margins or even on cost price. They have resulted into cost reducing remedial measures such as cut-down of labour and staff, vacating office spaces, amongst other things. This invariably has brought up the real importance of implementing effective cost control process at the post contract stage of the procurement phase.

Cost management consists of cost estimation and cost control. Project cost estimating involves developing an approximation of the costs of the resources needed to complete project objectives. Cost control is the continuing process to keep the project within cost objectives and satisfy client’s needs. Cost control system should serve as a link between the cost estimate and the actual construction cost. Its main objective is to maintain costs within the restrictions of the cost estimate or construction budget. It is carried out to reduce to the barest minimum the deviation of the final cost from the initial cost.

Cost control is a key element of the construction management phase of a project. The contractors’ costs control system comprises the following purpose; first to provide a means of comparing actual with budgeted expenses, second to develop a database of productivity and cost performance data; third to generate data for valuing variations and changes to the contract. Cost control at the post contract stage is very important for contractors since it determines how profitable their contracts will turn out. There are several factors affecting the process of controlling cost during the construction phase of construction projects in the Nigeria construction industry. Based on the background information aforementioned, the paper seeks to assess the post contract cost control of contracting organization on construction projects in Nigeria. The aim of the study will be guided by the following specific objectives:

1) To identify the present cost monitoring and cost control methods adopted by contractors during construction phase
2) To examine the effectiveness of the cost monitoring and cost control methods used during the construction phase.

The study will examine the following hypotheses;

- There is no agreement among indigenous, expatriate and partly expatriate/partly expatriate contractors on the effectiveness of cost control methods during construction phase of project
- There is no significant relationship between the frequency of use of the cost control methods and the effectiveness of the cost control methods as used by contractors.

This paper would make a potential contribution to construction industry development in Nigeria. The study highlighted the effectiveness of the different cost controlling and monitoring methods in different construction scenarios or strategy. The study is set out to provide valuable insight to construction firms and the country at large, by promoting effective utilization of minimum available resources during construction. This study analyzed the present cost monitoring and control methods in practice among construction contractors in Nigeria. The paper is divided into four parts namely; introduction, literature review, research method, results/discussion and conclusion and recommendation respectively.

**COST CONTROL**

Cost control and cost planning appear to be the main practices of cost management. However, today the majority of people interpret the concept of cost control wrongly. It is not limited to simple monitoring of the costs and registration of financial information, planned and unplanned expenses a firm may face. Cost control can be an effective tool of gathering relevant information and making forecasts of possible threats and opportunities in hands of a skilful financial manager. Here the preventive function of the cost management practice is emphasized. By means of cost control an organization can be secured from unpleasant and unexpected surprises.

Cost control aims at ensuring that resources are used to the best advantage. In these days where the problem of cost overruns has became a serious issue. Clients are becoming more aware or cost conscious and insist on jobs being designed and executed to give maximum value for money. Cost control means the process of planning and controlling the expenditures or costs of buildings. However, cost control is considered far more than only control of expenditures of the project, but also ensuring that the timing of each transaction made is appropriate. Cost control is defined as the regulation, by executive action, of the cost of carrying out the various activities which go to make up a project or a contract. In fact, this vital process needs to take place throughout complete duration of the construction project. Good cost control during construction is closely related to the care, thoroughness and quality of the planning and decision making process during the design stages. In general, effective control systems should monitor schedule and performance as well as costs by setting budgets, measuring expenditures against budgets and then by identifying variances. This is done by ensuring that the expenditures are proper and by taking corrective action when required.
It was highlighted that changes to the design and any unexpected or unplanned works generally cost more money which always led to cost overrun of the project\textsuperscript{16}. Therefore, in order to avoid or minimize this problem of cost overrun which is the heart of this research, it is better to concentrate the design team’s efforts on making those decisions which greatly affect cost during the design stages and before construction commences. This is simply because; when cost control is well designed it helps to keep expenditure within the amount allowed by the client. Project cost control comprises the following\textsuperscript{11}:

\begin{itemize}
  \item a) Influencing the factors that create changes to the cost baseline to ensure that the changes are agreed upon;
  \item b) Managing the actual changes when and as they occur;
  \item c) Assuring that cost overruns do not exceed the authorized funding both periodically and in total for the project;
  \item d) Monitoring cost performance to detect and understand variances from the cost plan;
  \item e) Recording all appropriate changes accurately against the cost baseline;
  \item f) Preventing incorrect, inappropriate, or unauthorized changes from being included in the reported cost or resource usage;
  \item g) Informing appropriate stakeholders of authorized changes; and
  \item h) Acting to bring expected cost overruns within acceptable limits.
\end{itemize}

Project cost control, searches out the causes of both positive and negative variances and is part of integrated change control. For example, inappropriate responses to cost variances can cause quality or schedule problems, or produce an unacceptable level of risk later in the project.\textsuperscript{16} Recommended that the cost control process should be continued through the construction period to ensure the cost of the building is kept within the agreed cost limits. Also it is recommended that the professional advisor should accept cost as an element in design, and that they should ensure suitably balanced costs throughout all parts of the building, as well as an accurately forecast overall cost.

2.2 Cost control methods by contracting companies

Contractors perform some or any of the following cost control methods during the post contract stages of procurement and they include:

\begin{itemize}
  \item Standards for Costs and Variance;
  \item Cost-coding for item of works;
  \item Weekly cost reports;
  \item Earned value analysis;
  \item Monthly Profit&Loss reporting;
  \item Cost Projections;
  \item Over/under billing analysis.
\end{itemize}

All these or some of the elements should be present in all cost control methods performed by contractors. Among the cost control methods frequently used by companies are the standards methods, actual versus forecast, integration method, detailed method, weekly report amongst others. According to the standards method, a contractor organization would have to assess previous contracts and set comparative targets for costs in new projects that it undertakes.

This method, however, should imply that the projects are comparable. If two projects are not identical (which would be in most of the cases), managers of organizations should estimate the targets for unit costs. Unlike total costs, they are expenses that the company should make to produce a unit of output (e.g. this could be a square foot of building etc.). Integration method of cost control implies that the company’s managers set cost targets not only on the basis of previous experience but also in order to address other functions of the organizations such as maintaining full utilisation of plants, employment of labour force etc. Finally, a detail method of cost control can be implemented by organisations that set individual standards for each new project. Managers would have to estimate the amount that the company receives for completion of the project and prepare a budget for the project that would allocate costs and determine the profit margin of the firm\textsuperscript{12,15}.

2.2.1. Standard costs and variance

In all contractor organizations they have data collected from past projects executed basically known as standard costs. These standard costs are being premeditated from the historic performance, experiences, problems and feedback from the previous site managers and staff\textsuperscript{16}. An initial budget for a project is always prepared in a contractor organisation based on the estimated historical cost.

Furthermore, an estimated variance of the actual costs from previously projected expenses is also taken into account to forecast how far future costs will deviate from the planned values. If the actual cost exceeds the standard cost it is a negative variance, which is unfavourable for a contracting organisation. Whereas a positive variance allows for profitability and indicates that the company has managed to control the costs better than it originally planned.

Variance is estimated in terms of both the value of costs and quantity of the consumed resources. The variance is usually estimated for labour, plant, materials and overhead costs\textsuperscript{15}.

2.2.2. Cost coding for item of works.

It was argued that cost control will be performed more effectively in a contractor organisation if cost coding system is used\textsuperscript{18}. The basis of the cost coding is that each activity should be assigned a certain code (usually in the form of alphabetical letters). Cost codes are prepared by identifying activities on site that can be grouped together according to similar operations. For example, items in the Earthwork group can be titled as follows:

\begin{itemize}
  \item E. Earth work
    \begin{itemize}
      \item E321. Cut
      \item E322. Fill
      \item E332. Rock
    \end{itemize}
  \item R. Road Works
    \begin{itemize}
      \item R.111. Sub base
      \item F.121 .Road base
      \item F.131 .Wet mix
    \end{itemize}
\end{itemize}

Based on the coding system, costs will be recorded on a daily/weekly basis for all activities in a project, which will be summarized to form monthly tab sheets which are basically called cost sheets. These cost sheets help a contractor organization in preparation of the P&L reports, cost projections, etc.
It is valid to argue that cost coding may be used not only in relation to the activities but also the type of employees responsible for one or another activity. For example, accountants can be represented by letter A, Project Manager can be represented by letters PM etc. It is also argued that cost coding system may consist of numerical codes and not necessarily letters. The point is that the coding system should facilitate cost management and project management. Facilitation is achieved by making entries shorter and easier.

### 2.2.3. Weekly cost reports

Weekly cost reports are another method of cost control which allow for identifying and rectifying unfavourable variances in costs of the project. Weekly reporting of costs helps managers to control how far the actual costs have deviated from the planned values. This, in turn, allows for taking quick measures to prevent further growth of costs and reduction of profitability.

### 2.2.4. Earned value analysis

Techniques of Earned Value Analysis (EVA) and traditional value analysis may be used by organisations to forecast and plan financial information or to carry out cost control. The advantage of the EVA is that it gives the opportunity to focus on the dependence between the actual costs the company has to bear and the real physical work that is done in the context of the project. Traditional value analysis has a more simple approach of comparing the projected costs and the costs that occur in reality. Moreover, there is a number of strategic techniques, such as careful risk management, layoffs, reduction of salaries for the staff, back out of the cooperation with additional subcontractors, reduction of bonuses and initiatives for the employees, wastage control, delay in payments, etc. All the discussed techniques are effective for cost cutting. However, some of them pose particular side effects and limitations. For example, salary reduction and layoffs usually reduce productivity of the employees, which breaks the balance of costs and profits.

### 2.2.5. Monthly Profit & Loss reports

Monthly P&L reports are commonly used in standard contractor organisations all over the world. The P&L report gives an indication of the financial status of the company at a particular point in time. These reports are basically calculated where EVA techniques are used to find out the actual value of work done up to that point. They are mainly prepared on a monthly basis and are further incorporated into quarterly and annual reports.

At the end of every month, a cost sheet is produced by the contractor organisation for every project. This helps the contractor to identify overbilling and under billing for each activity in construction. Overbilling implies that more costs will have to be deducted from the revenue of the project. Underbilling is the opposite situation and it adds to the company’s earnings. So, underbilling/overbilling analysis helps the company to assess its realistic costs and compare them to the predictions of expenses.

### 2.2.6. Cost projections

Cost projections are prepared at an early stage of a project and allow contractors to foresee profitability of the contract that has been won.

As it was previously discussed, the cost projections and actual costs should be monitored on a monthly basis and are an important tool in the budgeting and cost control of all projects. Once the contract has been signed between a contractor and a client, the managers of the contractor organisation make cost forecasts and calculate the anticipated value of the project, which would be the difference between the revenue received from the client and total costs of the project completion. So, cost projections also allow the managers to make preliminary estimates of the profit margins that indicate profitability of a project. At the end of every month, the cost projection should be updated based on the actual costs incurred. The projections will then have to be revised for the remaining period of the project. It is common for construction projects to have a variance between actual and projected costs. This has already been discussed above. Revisions of cost forecasts on a monthly basis allow managers to make quick corrections and the measures to prevent further growth of costs if necessary.

### METHODOLOGY

Research design is concerned with turning the research question into a testing project. The research design has been considered as a blueprint for research, dealing with at least four problems: what questions to study, what data are relevant, what data to collect, and how to analyze the results. A survey research design was adopted in the study to achieve the outlined objectives. Specifically, a cross-sectional research design was used where samples were drawn from the population of study at one point in time.

The study was conducted in Lagos which is economically an important city in Nigeria. As the economic and commercial nerve-centre of the country, Lagos has a high volume of construction activities as well as a large concentration of building contractors of various categories and sizes.

Indigenous contracting organization are classified thus when the majority of management personnel and ownership is fully indigenous. Expatriate contractors and/or partly expatriate contractors, in contrast have majority of management personnel and ownership as foreigners. Most of the major building contractors have their head office or at least a branch/operation office in the city which also houses a rich collection of construction industry practitioners and experts.

The high demands for residential, commercial and institutional buildings, civil and heavy engineering works in the study area have necessitated the above mentioned scenarios. The target respondents included managing directors, project managers, head of estimating units, senior quantity surveyors and other key personnel involved in the planning, cost management, supervision and monitoring of construction projects.

Over eighty (80) contractors with operation offices in Lagos, Nigeria are registered with Federation of Construction Industry (FOCI). A total sample of thirty four (34) was drawn from these collections of construction contractors of various categories (small, medium and large) in Lagos. Thirty four (34) were completed and returned representing a 44% response rate. Purposive sampling, which is a non probabilistic sampling technique was adopted for the study due to the short time available for carrying out the study. Frequency, percentage, mean score, spearman rank order correlation, paired t-test and analysis of variance were used in analysing data collected for the study.
RESULT AND DISCUSSIONS

Before interpreting the findings of the study, it is important to consider general characteristics of the respondents. Descriptive statistics about the respondent and the responding organisation are presented thus; project managers constitute about 31% of the respondents, while head of estimating and/or quantity surveying unit in contracting firms have 28% representation in the total respondents used for the survey. Other designation not stated in the research instrument such as site quantity surveyors, quantity surveyors working within the commercial department of large contracting firms constitute the highest proportion (38.0%) of the respondents, indicating their high involvement in cost controlling and monitoring activities on construction project. This confirms that the fact quantity surveyors are actively involved in cost monitoring and cost control activities during the post contract stage of the procurement process. A sizeable proportion (41%) of respondents is within the age bracket of 41years and above. About 98% of the respondents received formal education, which put them in the right stead to provide valuable information. The data showed that about 52% of respondents have working experience of 11years and above which implies that they are sufficiently knowledgeable in construction matters to take active part in decision making. Most of the responding firms (70.2%) are involved in main contractor’s work, and about 79.6% of the respondents are limited liability companies. 56.0% of the contracting firms operate a fully indigenous firm, 34.0% of them partly indigenous, partly expatriate, and 10% of them are fully expatriate. It is clear that a greater percentage of contractors operating within Lagos are fully indigenous in its ownership and management system. About 51.1% of respondents are building and civil engineering contractors, 25.5% of them are both electrical and mechanical contractors;

building contractors alone constitute 14.9% of the population. It is evident that majority of contractors do not specialize in a single type of construction such as building or civil engineering. The construction activity as engaged by the respondent is given in Table 2, 75.6% of the contractors undertake general contracting, while 17.1% of them are involved in new works

FREQUENCY OF USE OF COST CONTROL METHODS ON CONSTRUCTION PROJECT

One of the objectives of the study is to identify the frequency of use of cost monitoring and control methods used by contractors in post contract stage of construction project. The study identified about twelve (12) cost control methods used in ensuring the cost budget is not exceeded. Table 1 depicted the mean score of the frequency of use of the highlighted cost control methods as adopted by the responding contracting firms in Lagos.

Cost projections, financial reports and weekly cost reports are the cost control methods used always by most contracting organization with mean score of 4.38 each. They are closely followed by actual versus forecast reconciliation and cost value reconciliation with mean score of 4.27 and 4.19 respectively. Most responding firms make use of cost projections, financial reports and weekly cost reports as their cost control methods used during construction projects in a bid to avoid excessive cost of construction, ultimately leading to reduced profit by their corresponding firms. Similarly, most contracting firms have little or nothing to do with cost control methods namely; earned value analysis, over/under billing analysis and leading parameter method. This assertion was based on the relative low mean score of the methods with mean score of 3.32, 3.22 and 2.93 respectively.

Table 1: Frequency of use of Cost Control Methods of contractors in construction projects

<table>
<thead>
<tr>
<th>Cost control methods</th>
<th>N</th>
<th>Mean score</th>
<th>Standard deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cost Projection</td>
<td>32</td>
<td>4.38</td>
<td>0.751</td>
</tr>
<tr>
<td>Financial report</td>
<td>32</td>
<td>4.38</td>
<td>0.833</td>
</tr>
<tr>
<td>Weekly cost reporting</td>
<td>32</td>
<td>4.38</td>
<td>0.942</td>
</tr>
<tr>
<td>Labour/plant/material (Actual vs Forecast reconciliation)</td>
<td>30</td>
<td>4.27</td>
<td>0.980</td>
</tr>
<tr>
<td>Cost value reconciliation</td>
<td>32</td>
<td>4.19</td>
<td>0.821</td>
</tr>
<tr>
<td>Program evaluation and review</td>
<td>32</td>
<td>4.09</td>
<td>0.777</td>
</tr>
<tr>
<td>Monthly profit and loss reporting</td>
<td>32</td>
<td>3.78</td>
<td>0.941</td>
</tr>
<tr>
<td>Standards for cost variance</td>
<td>32</td>
<td>3.66</td>
<td>0.787</td>
</tr>
<tr>
<td>Cost coding of items of work</td>
<td>32</td>
<td>3.50</td>
<td>0.880</td>
</tr>
<tr>
<td>Earned value analysis</td>
<td>31</td>
<td>3.32</td>
<td>1.077</td>
</tr>
<tr>
<td>Over/under billing analysis</td>
<td>32</td>
<td>3.22</td>
<td>0.941</td>
</tr>
<tr>
<td>Leading parameter method</td>
<td>28</td>
<td>2.93</td>
<td>1.152</td>
</tr>
</tbody>
</table>

EFFECTIVENESS OF COST CONTROL METHODS ON CONSTRUCTION PROJECT

The effectiveness of the twelve identified cost control methods highlighted in this study was examined as one of the objectives of the study. Table 2 indicated the mean score of the effectiveness of the cost control methods as used by contracting organization in Lagos state at the post contract stage of construction projects. The most effective cost control method as depicted below is the actual versus forecast reconciliation. The reconciliation approach recorded the highest mean score of 4.41 amongst the twelve methods considered in this research.

Closely following the reconciliation method as the most effective cost control methods are the weekly cost reports, financial reports and cost value reconciliation with mean score of 4.38, 4.34 and 4.22 respectively.

The following cost control methods exert the least effectiveness on cost control tendencies during post contract stage of construction projects. Standards for cost and variance, over/under billing analysis and cost coding for items of work are the least effective in cost control activities in construction projects. Leading parameter method is regarded as the least effective in the list of cost control methods during the construction phase of construction projects. It can be deduced that the least effectiveness of the standard for costs and variance, cost coding for items of work and leading parameters as methods of cost control could be as a result of their seldom use by contracting organizations or cost experts in a bid to avoid cost overrun in construction projects.
Table 2: Effectiveness of Cost Control Methods of contractors in construction projects

<table>
<thead>
<tr>
<th>Cost control methods</th>
<th>N</th>
<th>Mean score</th>
<th>Standard deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Labour/plant/material (Actual vs Forecast reconciliation)</td>
<td>32</td>
<td>4.41</td>
<td>0.911</td>
</tr>
<tr>
<td>Weekly cost reporting</td>
<td>32</td>
<td>4.38</td>
<td>0.660</td>
</tr>
<tr>
<td>Financial report</td>
<td>32</td>
<td>4.34</td>
<td>0.745</td>
</tr>
<tr>
<td>Cost value reconciliation</td>
<td>30</td>
<td>4.22</td>
<td>0.906</td>
</tr>
<tr>
<td>Cost projections</td>
<td>32</td>
<td>4.16</td>
<td>0.723</td>
</tr>
<tr>
<td>Monthly profit and loss reporting</td>
<td>32</td>
<td>4.03</td>
<td>0.836</td>
</tr>
<tr>
<td>Program evaluation and review</td>
<td>32</td>
<td>3.97</td>
<td>0.822</td>
</tr>
<tr>
<td>Earned value analysis</td>
<td>32</td>
<td>3.76</td>
<td>0.786</td>
</tr>
<tr>
<td>Standards for costs and variance</td>
<td>32</td>
<td>3.59</td>
<td>0.837</td>
</tr>
<tr>
<td>Over/under billing analysis</td>
<td>31</td>
<td>3.55</td>
<td>1.028</td>
</tr>
<tr>
<td>Cost coding for item of works</td>
<td>32</td>
<td>3.55</td>
<td>0.723</td>
</tr>
<tr>
<td>Leading parameter method</td>
<td>28</td>
<td>2.70</td>
<td>1.068</td>
</tr>
</tbody>
</table>

AGREEMENT AMONG THREE CLASSES OF CONTRACTORS ON THE MOST EFFECTIVE COST CONTROL METHODS FOR CONSTRUCTION PROJECTS

The study examined the level of agreement among indigenous, partly expatriate and expatriate contractors on the most effective cost control methods used on construction projects. The statistical tool used for analysis is the kendall’s co-efficient of concordance. Using kendall’s co-efficient of concordance, the rule for the rejection or non-rejection of the hypothesis is that when the p-value>0.05, the test fails to reject the hypothesis but when the p-value<0.05, the test rejects the hypothesis.

Table 3: Kendall’s co-efficient of concordance to test the agreement of contractors on the effective cost control methods by different contractors

<table>
<thead>
<tr>
<th>Comparison of contractors</th>
<th>W</th>
<th>X²</th>
<th>p-value</th>
<th>Remark</th>
</tr>
</thead>
<tbody>
<tr>
<td>Indigenous, expatriate and partly expatriate/party indigenous</td>
<td>0.522</td>
<td>17.226</td>
<td>&gt; 0.05</td>
<td>Accept H₀</td>
</tr>
</tbody>
</table>

Kendall’s co-efficient of concordance = W
Friedman’s chi-square = X², p = 0.418

Table 3 shows the kendall’s co-efficient of concordance and Friedman’s chi-square of the agreement of contractors on the effective cost control methods. The Kendall coefficient of concordance, W, provides an indication of the association between several rankings of different contractors. W ranges between 0 and 1, with 1 designating perfect concordance, and 0 indicating no agreement or independence of samples.

At this point, we can compute using the expression that the Kendall’s coefficient of concordance of contractors for the effective cost control method to 0.522.

The Kendall’s coefficient of concordance is considerably statistically significant. The value of the test statistic of the X² 2-test, computed using kendall’s co-efficient, amount to 17.226, while the critical value at the 0.05 per cent significance level and 11 degrees of freedom is 19.68. The p-value of the test is 0.418 which >0.05. It can then be concluded that there is no agreement among indigenous, expatriate and partly expatriate/party indigenous on the effective cost control methods used during the construction phase of construction project.

This study opines that no agreement exists between expatriate and indigenous contractors on the most effective cost control methods used on construction projects. It can be observed that the comparison of indigenous and expatriate produced t-cal = 0.547 which is less than the t-tab of 1.812 with 10 degrees of freedom (v =10) at p < 0.05 significance level.

RELATIONSHIP BETWEEN FREQUENCY OF USE AND EFFECTIVENESS OF COST CONTROL METHODS USED BY CONTRACTORS

Further investigation was carried out to determine whether or not the frequency of use of the cost control methods have positive, negative or neutral effects on the effectiveness of the cost control methods used in construction projects. This involves the test of the second research hypothesis which states that there is no significant difference between the frequency of use and effectiveness of cost control methods.

Data collected on the respondents’ assessment of the frequency of use of cost control methods and their effectiveness of the cost control methods were used for the test.

The hypothesis was tested using paired sample t-test with p-value>0.05, the test fails to reject the hypothesis but when the p-value<0.05, the test rejects the hypothesis.

Since the p-value > 0.05 for eleven (11) of the twelve (12) listed cost control methods in the study, it is safe to state that the null hypothesis that: there is no significant difference between the frequency of use and the effectiveness of cost control methods for all the cost control methods except over/under billing analysis.

Hence the null hypothesis is rejected for over/under billing analysis because p-value ≤ 0.05 as depicted in Table 4.15 above. It can be induced that either an increase or decrease in the frequency of use of cost control methods will not result in the corresponding increase or decrease in the effectiveness of the respective cost control methods.

This assertion holds for all the cost control methods except for over/under billing analysis. It can be said that a small increase in the frequency of use of over/under billing analysis will give rise to a greater increase in its effectiveness.
Table 4: Paired sample t-test of the frequency of use of cost control methods and the effectiveness of cost control methods

<table>
<thead>
<tr>
<th>Variables</th>
<th>T</th>
<th>df</th>
<th>p-value</th>
<th>Decision</th>
</tr>
</thead>
<tbody>
<tr>
<td>Actual versus forecast reconciliation</td>
<td>-0.421</td>
<td>28</td>
<td>0.677</td>
<td>Accept H0</td>
</tr>
<tr>
<td>Cost coding for items of work</td>
<td>-0.239</td>
<td>29</td>
<td>0.813</td>
<td>Accept H0</td>
</tr>
<tr>
<td>Weekly cost reports</td>
<td>0.239</td>
<td>30</td>
<td>0.813</td>
<td>Accept H0</td>
</tr>
<tr>
<td>Financial reports</td>
<td>1.000</td>
<td>30</td>
<td>0.325</td>
<td>Accept H0</td>
</tr>
<tr>
<td>Monthly profit and loss reporting</td>
<td>-1.975</td>
<td>29</td>
<td>0.058</td>
<td>Accept H0</td>
</tr>
<tr>
<td>Cost projections</td>
<td>1.650</td>
<td>30</td>
<td>0.109</td>
<td>Accept H0</td>
</tr>
<tr>
<td>Cost value reconciliation</td>
<td>0.000</td>
<td>30</td>
<td>1.000</td>
<td>Accept H0</td>
</tr>
<tr>
<td>Standard for costs and variance</td>
<td>0.891</td>
<td>30</td>
<td>0.380</td>
<td>Accept H0</td>
</tr>
<tr>
<td>Over/under billing analysis</td>
<td>-2.763</td>
<td>29</td>
<td>0.010</td>
<td>Reject H0</td>
</tr>
<tr>
<td>Program evaluation and review</td>
<td>0.849</td>
<td>30</td>
<td>0.403</td>
<td>Accept H0</td>
</tr>
<tr>
<td>Leading parameter</td>
<td>1.617</td>
<td>25</td>
<td>0.118</td>
<td>Accept H0</td>
</tr>
<tr>
<td>Earned value analysis</td>
<td>-1.613</td>
<td>27</td>
<td>0.118</td>
<td>Accept H0</td>
</tr>
</tbody>
</table>

CONCLUSIONS

The purpose of this paper is to evaluate the effectiveness of post contract cost control methods of contractors in construction projects. This paper highlighted the most effective cost control methods as adopted by contractors in the study area. Actual vs forecast reconciliation is considered as the most effective for effective cost management practices in construction projects in the industry.

This is in sharp contrast with cost projections which is considered as most used by contracting organizations in the running of construction projects. Furthermore, this paper tested the level of agreement among contractors on the most effective cost control methods adopted in the construction process. Kendal co-efficient of concordance reveals that there is no agreement among indigenous, partly expatriate and expatriate contractors on the most effective cost control methods on construction projects.

Finally, paired sample t-test was used test the association between the frequency of use and the effectiveness of cost control methods used by contractors. The result showed that there is no relationship between the frequency of use and effectiveness on the twelve cost control methods except over/under billing analysis.

From all these issues from the effectiveness of different cost control methods, the study recommends that contractors should embrace cost control methods which ensure close monitoring and reporting of work progress and cost performance.

This is very important for effective cost control process during post contract stage. This paper recommends that IT integration is the only way to get quick and accurate techniques to solve cost overrun and its associated problems identified by several literature and professionals.

REFERENCES


SUCCESSFUL DELIVERY OF GREEN BUILDING PROJECTS: A REVIEW AND FUTURE DIRECTIONS

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PURPOSE: The purpose of this paper is to furnish the understanding of how to successfully deliver green building projects.

ABSTRACT

PURPOSE: The purpose of this paper is to furnish the understanding of how to successfully deliver green building projects.

METHODOLOGY: This paper analyses the current research development of the subject area of delivery of green building projects by systematically reviewing selected articles published from 2005 to 2014.

FINDINGS: The analysis of the selected articles revealed two major research topics on the delivery of green building projects, (1) the practices for ensuring the successful delivery of green building projects, and (2), lean technique for understanding the requirements of green building projects. The implication of these findings were related to the delivery of green building projects in South Africa.

LIMITATION: The systematic review undertaken to achieve the purpose of this paper only covered the design and construction stages of the delivery of green building projects. The pre-construction and post-construction stages were not included.

ORIGINALITY/VALUE: This paper elicited further research areas that can ensure successful delivery of green building projects.

KEYWORDS: Green building projects, project delivery, literature review, lean technique, research, value

INTRODUCTION

According to Kang et al.¹ green building is a significant issue because of the impact on global environment. This is manifested in the environmental benefits of green building projects including: energy and water efficiency, saving natural resources, minimizing the impacts of projects on ecosystems, and promote increased use of environmentally friendly materials²,³,⁴. Also there are social benefits of green building projects such as improved indoor environment quality and increased health and occupant productivity⁵. Furthermore, green building projects provide economic benefits in form of lesser cost of operation during occupation⁶,⁷. Given these benefits, it is important to successfully deliver green building projects²,⁴. In essence, when green building projects are successfully delivered, the environmental, social and economic benefits are realised. Also, a successfully delivered green building project will be realistic in terms of cost, quality, time, safety, and level of sustainability performances⁸. In support, Korkmaz, Riley and Horman³ asserted that superior delivery processes in terms of planning, design and construction are required to achieve sustainable high-performance building projects.

However, it is difficult and complex to deliver green building projects. The delivery of green building projects often requires additional project players, more design iterations, advanced simulation and analysis, higher construction standards, additional site precautions, and the use of new and unfamiliar materials⁹,¹⁰,¹¹. These additional requirements demand a specialized set of competencies that differs considerably from standard practices¹. In this case, various disciplines are collaborated and coordinated towards delivering green building projects¹².
The problems arising from the difficulties and complexities in delivering green building projects are germane. For instance, to account for the additional requirements posed by green building projects, an up-front or first cost premium is commonly associated with this building type, usually to purchase better quality building components. Also, there are enormous wastes arising from the delivery of green building projects. Consequently, green building projects are pervaded with low cost performance. In terms of time, quality, and level of sustainability, green building projects are also pervaded with low performance. Also, poor delivery of green building projects may lead to non-realisation of the environmental, social, and economic benefits.

In order to successfully deliver green building projects, there is need to furnish the understanding of owners and green building project stakeholders in the construction industry. In this paper, project delivery is taken to mean the processes used to get owner needs to a green building project. To achieve successful delivery of green building projects, literature review of existing researches on the delivery of green building projects is a useful methodology to gain in-depth understanding on the research topic. Also, green building projects are extensively researched, and thus, can be relied upon to furnish the understanding of how to achieve successful green building projects. In light of these, this paper undertook an analysis of relevant articles on delivery of green building projects. The selected articles were reviewed under two themes, thus this paper focuses on (1) the practices for ensuring the successful delivery of green building projects, and (2) lean technique for understanding the requirements of green building projects. Both will contribute to the existing knowledge of how to deliver green building projects successfully. The paper begins with the background on green building practices and the delivery of green building projects, followed by an account of the research methodology. Finally, directions for further research and the implications of research outcomes for the delivery of green building projects in South Africa are suggested.

**GREEN BUILDING PRACTICES**

Green building is the construction of structures with the minimum environmental footprint, which optimizes the utilization of materials, energy, water and other resources. It is the practice of creating structures that are environmentally responsible and resource-efficient throughout a building’s life-cycle from siting to design, construction, operation, maintenance, renovation and deconstruction. In other words, green building is based on the principle of sustainable construction. According to Ojo, Mbowa and Akinlabi, sustainable construction involves creating constructed items using best-practice clean and resource-efficient techniques from the extraction of the raw materials to the demolition and disposal of its components. On the basis of this principle, green building contributes to sustainable development, or the meeting of growing human needs for natural resources, industrial products, energy, food, transportation and effective waste management while conserving and protecting environmental quality and the natural resource base essential for future life and development. In essence, green building projects simultaneously provides social, economic and environmental benefits of the present and the future.

Given its potential to positively impact environmental, economic and social issues, there is an increasing demand for green building projects from government, commercial developers, individual owners etc. For instance in the US, the number of green building projects rose from 192 to 30,068 in a period of fifteen years (2000-2014). Also in Australia, the number of green building projects has been consistently rising annually since 2004. In many other parts, including Germany, Norway, Singapore, South Africa, Brazil and United Arab Emirates, there are growths in demand for green building projects. Also, there is strong growth in green building institutional practices globally. For instance, from eight-country incorporated member organisation in 2002, the World Green Building Council, the network of national green building councils, now has over a hundred member countries. Also, many countries, particularly the developed countries, have robust assessment system used in the lifecycle of green building projects, based on certain criteria to measure the “green” level, guidance and identification of the practice of green building. Some assessment systems include LEED (USA), Green Star (Australia), BREEAM (UK), CASBEE (Japan), Green Mark (Singapore) etc. These are indicative of active and expanded green building practices in different countries.

In the same vein, green building projects have attracted a wide range of research attention and, based on this, Zuo and Zhao carried out a systematic review of these researches. It was found that the common research themes on green building projects were: definition and scope of green building projects; quantification of benefits of green building projects compared to conventional building projects and, various approaches to achieve green building projects. It was also found that majority of the researches focused on the environmental aspect of green building projects. While these remain a valuable addition to knowledge, critical is the need to understand the delivery of green building projects. As described by Lapinski et al. there is the need to understand the delivery process that enables the efficient achievement of green building goals. This understanding will provide important and enduring capabilities currently underdeveloped or missing in the delivery of green building projects. The next section describes the project delivery of green building projects, with emphasis on the stages and complexities involved.

**PROJECT DELIVERY OF GREEN BUILDING PROJECTS**

The first stage in the delivery of green building projects is the preconstruction activities, where the consideration, analysis, and implementation of sustainable alternatives, life cycle cost analysis in addition to the construction cost calculations, and, early building commissioning planning and analysis are carried out. Lee et al. described the following stages as follows, criteria design, where initial system schemes are developed, while principles and possible solutions are qualitatively and quantitatively analyzed and coordinated. The detailed design follows, where components designs are analysed, simulated, calculated, integrated and delivered to the owner in form of preliminary drawings, specifications and schedules. The next is implementation document stage, where the project team for each component design develops post-design drawings and specifications; reviews the documents; delivers the documents to the owner for final design approval. After the documentation phase, construction, occupancy and maintenance follow. Because green building projects are developed based on the principle of sustainable construction, the delivery process is difficult, complex and unfamiliar. The difficulties and complexities in green building projects stem from unique practices such design iterations, advanced simulation and analysis, additional site precautions, energy modelling, new...
construction techniques and methods etc. which are critical for the fulfillment of sustainability objectives 34-36. Another unique practice is the selection of reusable, recyclable and less energy-embodied building components and materials at the design stage of green building 34-36, which is done so as to achieve the sustainable and energy efficiency objectives of green building projects 37. In essence, the activities involved in the delivery of green building projects are not sequential, but integrated and holistic 2-12.

According to Korkmaz et al. the delivery of green building projects is not about assembling new materials, technologies and practices, but holistically optimising all considerations in an integrated and interdisciplinary collaboration. Thus the project delivery of green building projects involves the input of many disciplines such as architects, engineers, construction managers, owners, occupants, and government agencies performing various processes 2,38. Seemingly, the multiplicity of disciplines and requirements in the project delivery of green building increases the need for team interaction and intensive decision making so as to balance traditional cost, quality and schedule performance against the impacts of building features on energy efficiency, operating costs, the health and safety of building occupants and the amount of waste generated during construction 43.7.

In the delivery of green building projects, the standard traditional roles are expanded 20. For instance, an architecture firm may work mostly independently on the schematic design for a traditional project, a green building project seeking to maximize energy performance requires a schematic design effort with coordination among a variety of groups such as construction professionals, mechanical engineers, facilities managers, building occupants, and utility companies 12. Currently, many experts have concluded that the project delivery of green building is sharply different from traditional buildings 13,35, as such employing traditional approaches in green building will create inefficiencies in design and construction 4.

Taken together, these additional considerations constitute the complexities and difficulties in the project delivery of green building projects 3,43. Given the complexities, it is difficult to deliver green building projects. For instance, the increased levels of design collaboration and coordination between structural, envelopes, mechanical, electrical, and architectural systems during design of green building projects cause process waste, costly changes, unnecessary rework in design, as well as buildings that operate at levels far below optimum 3. Also, the complexities in the delivery of green building projects caused the many projects to be delivered behind schedule in Singapore 46. In fact, most green building projects are delivered at a higher first costs 2. Evidently, the delivery green building projects remains challenging.

Usually in searching for relevant publications in databases, keywords connected with Boolean operators are usually employed as search strategy (e.g. see 43). In this paper, the keywords connected with Boolean operators, and used include: “Project delivery” “Green building project”; “Project delivery” “High performance green building project”; “Project delivery” “Green building project” “Performance”; “Project delivery” “High performance green building project” “Performance”; “Project delivery” “Sustainable building project”; “Project delivery” “Sustainable building project” “Performance”. These combinations were also connected separately with the different types of green building projects in this form (Educational OR Residential OR Low-energy OR Carbon OR Commercial). The search was conducted in December 2014, and 896 publications retrieved, but only the 68 journal publications were downloaded into the EndNote.

Prior to downloading the 68 journal publications into the EndNote, their titles and abstracts were briefly reviewed so as to justify their inclusion in line with the inclusion criteria above. Still, given the possibility of irrelevant inclusion, a further filtering activity was carried out in line with 44-46. The 68 publications were subjected to content analysis of the methods used for examining and analysing the delivery of green building projects. According to Swarup et al. due to locational, participant and other variations, it is difficult to understand the delivery of green building projects from quantitative perspective. Wherefore, case studies and/or qualitative methods provide more meaningful ways of understanding green building project delivery. Thus 36 publications where qualitative methods were employed in examining and analysis of the delivery of green building projects were selected.

SEARCH STRATEGY

It is known that authors publish their researches in scholarly journals 41. Also by focusing on a specific type of publication such as journals or textbooks, there is the use of identical analytical constructs in terms of research aims and methodologies when investigating retrieved articles 17. Thus this research systematically reviews relevant journal articles on the delivery of green building projects. Initially, a comprehensive search, represented in Figure 1, was undertaken in the Google Scholar database. According to Xiong, Skitmore and Xia, known academic databases such as Scopus, Elsevier etc. are not fully inclusive as the Google Scholar. In fact the coverage of Google Scholar include those of other databases 43, and therefore all leading construction journals are included in a Google Scholar 42. In the selection of the articles of interest in the Google Scholar search, the inclusion criteria include studies that examined and analysed the delivery of green building projects through:

1) Case study of design and construction activities of real green building projects;
2) Case study and/or participant survey of experiences of stakeholders involved in identified green building projects; and
3) Case study and review of documents of identified green building projects

Eight articles that employed mixed method of research were selected. An example is 37 who performed quantitative analysis on data from 40 completed green building projects, as well as the interview of the participating stakeholders, wherefore allowing for deeper understanding of the delivery of green building projects. In exception to the inclusion criteria, four articles that employed survey research method for examining and analysing the delivery of green building projects were selected 44,46,40,45,46. The studies investigated the green building project design and construction strategies used by organisations with significant experiences in developing green building projects. In justifying their inclusion, the survey responses and results in the articles were in reference to real green building projects. The selected publications, with additional details are presented in Table 1.
Figure 2: Number of Relevant papers published yearly from 2005 to 2014

SELECTED JOURNALS ARTICLES

The selected 48 articles, in 20 different journals, for this research spanned between 2005 and 2014, which is equivalent to 10 years. Notably, 2005 is a period green building started gathering momentum in most countries, especially in terms of establishing Green Building Councils and Rating systems.

For instance, Green Mark, the Singaporean green building assessment system was established in 2005. Also in places like Australia, where green building momentum had started before 2005, it was not until 2004 that the first green building was constructed. Arguably the studies selected cover the period when green building practices started till the present.

---

Table 1: Journals and their numbers

<table>
<thead>
<tr>
<th>Journals</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>*Journal of Construction Engineering and Management</td>
<td>15</td>
</tr>
<tr>
<td>Journal of Green Building</td>
<td>11</td>
</tr>
<tr>
<td>*Journal of Management in Engineering</td>
<td>3</td>
</tr>
<tr>
<td>Structural Survey</td>
<td>2</td>
</tr>
<tr>
<td>Journal of Architectural Engineering</td>
<td>2</td>
</tr>
<tr>
<td>Lean Construction Journal</td>
<td>1</td>
</tr>
<tr>
<td>Facilities</td>
<td>1</td>
</tr>
<tr>
<td>Architectural Engineering and Design Management</td>
<td>1</td>
</tr>
<tr>
<td>*Habitat International</td>
<td>1</td>
</tr>
<tr>
<td>*Technological and Economic Development of Economy</td>
<td>1</td>
</tr>
<tr>
<td>*Building and Environment</td>
<td>1</td>
</tr>
<tr>
<td>*Sustainable Development</td>
<td>1</td>
</tr>
<tr>
<td>*Construction Management and Economics</td>
<td>1</td>
</tr>
<tr>
<td>International Journal of Sustainable Engineering</td>
<td>1</td>
</tr>
<tr>
<td>Pacific Rim Property Research Journal</td>
<td>1</td>
</tr>
<tr>
<td>*Solar Energy</td>
<td>1</td>
</tr>
<tr>
<td>KSCE Journal of Civil Engineering</td>
<td>1</td>
</tr>
<tr>
<td>*Sustainable Cities and Society</td>
<td>1</td>
</tr>
<tr>
<td>Sustainability Supply Chain</td>
<td>1</td>
</tr>
<tr>
<td>*Building Research and Information</td>
<td>1</td>
</tr>
<tr>
<td>Total</td>
<td>48</td>
</tr>
</tbody>
</table>

Figure 1: The Search Strategy Process
In Figure 2, the trend of the articles over the period is presented in 2-year interval period. It could be seen that studies on green building project delivery process had been on steady increase since 2005, except for the period of 2007 and 2008, when there was a sharp decrease. 10 of the 20 journals (50%), which are annotated with (*) sign in Table 1 have SCImago Journal Ranking (SJR) of 0.50 or greater (see 12). According to Ahmed 13, SJR is a major journal ranking system that exists in the world. The total number of articles contained in the 10 journals is 26, which is 54% of the selected articles. Also the Journal of Green Building (JGB), though with SJR of 0.267 (as at 2013), is a journal that presents the very best of practical applications together with the very best of peer-reviewed research in green building design and construction 14. The 11 articles selected from this journal is a considered a boost to this research. On these bases, the quality, quantity and relevance of articles selected contribute to the validity of the study.

UNIT OF ANALYSIS

In the delivery of green building projects, the design and construction stages of development are the most important 15.

Table 2: Distribution of publications by period and identified research themes

<table>
<thead>
<tr>
<th>Research theme</th>
<th>Period (year)</th>
<th>Total</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>The practices for ensuring the successful delivery of green building projects</td>
<td>1</td>
<td>0</td>
<td>7</td>
</tr>
<tr>
<td>Lean technique for understanding the requirements of green building projects</td>
<td>4</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>Total</td>
<td>5</td>
<td>1</td>
<td>10</td>
</tr>
</tbody>
</table>

Adapted from Mok et al. [11]  

FINDINGS

PRACTICES FOR SUCCESSFUL DELIVERY OF GREEN BUILDING PROJECTS

As indicated earlier, the delivery of green building projects are difficult, complex and unfamiliar 15,40. In order to overcome these, there are unique practices that must be implemented by project stakeholders during the delivery of green building projects. According to Klotz et al. 16 these practices will ensure the successful delivery of green building projects. The practice of pooling together of multidisciplinary knowledge and technology towards optimizing project results is notable for ensuring the successful delivery of green building projects 28,36.57,58,54,60. This is termed integration, and it delivers increased value to owners, as well as ensuring the maximization of efficiency through all phases of design, fabrication, and construction 61. In order to achieve integration, project team members and stakeholders are collocated in charrettes, meetings or pre-workshops at the early stage of green building projects so as to agree upon strategies, commitments, differences, and programmes are agreed upon 56,62.

Another notable practice is owner commitment. This describes the affective efforts and dedication of project owners towards ensuring that the goal for green building projects is achieved 62,63,64. Project owners of green building projects are considered as important stakeholders because of their decision making role 46, as such, their commitments ensures successful delivery of green building projects. An instance of owner commitment is when project owner facilitates the integration of project team members, or work packages, this foster cooperative working relationship and information sharing which can improve project cost and quality 65. Other practices that can ensure the successful delivery of green building projects include effective communication among project stakeholders, 25,66, safety practices, 9, modification of the traditional project management to suit green building, using bonus and reward in project contracting 67,68, education and early involvement of project stakeholders 67,68, sustainability programming 69, and systems design approach 70. Overarching these, these practices leading to successful delivery are carried out at the project level of development of green building projects.

At the organisational level, that is, within the parent organisations of project stakeholders, there are unique practices that must be implemented to ensure successful delivery of green building projects. According to Li et al. 70 multiple organisations are involved in the delivery of green building projects, thus, these organisations should seek to establish good and long term relationships 48. This fosters seamless communication and collaboration, which is beneficial to the success of green building projects 48. As an example, the collaboration among three international partners involved in the delivery of multiple green building projects ensured not only successful outcome, but also the capacity building of participants, as well as innovation and knowledge transfer 71. Furthermore, organisations should seek to exemplify leadership, plan strategically, emphasise on meeting owners’ and employees’ needs, implement knowledge management strategies, and develop effective operational strategies 71. Of note is the delineation in the practices that ensures the successful delivery of green building projects across project and organisational levels. This can be linked to the complexities in the delivery of green
building projects, whereby project and organisational level practices must be taken into consideration distinctly to achieve success.

In the delivery of green building projects, researchers have linked the practices for ensuring successful delivery and the performance in terms of cost, schedule, quality, and sustainability level. It is argued that the practices for ensuring the successful delivery form the guidelines towards successful execution of green building projects. The performance of green building projects is also described as the performance-at-completion, which measures the efficiency with which resources are used to attain the results. In essence, the implementation of the practices for ensuring successful delivery of green building project influences the performance-at-completion. However there is currently no empirical support for this claim. An empirical support in this regard will avail the knowledge of specific practices that lead to different performance outcomes in delivery of green building projects.

Table 3 Practices for successful delivery of green building projects

<table>
<thead>
<tr>
<th>Project level success factors</th>
<th>Sources</th>
</tr>
</thead>
<tbody>
<tr>
<td>Integrated team</td>
<td>[12,76,77]</td>
</tr>
<tr>
<td>Owners’ sustainability commitment</td>
<td>[67,78]</td>
</tr>
<tr>
<td>Effective communication among project team members</td>
<td>[25,66]</td>
</tr>
<tr>
<td>Safety consciousness</td>
<td>[9]</td>
</tr>
<tr>
<td>Greening project management</td>
<td>[25]</td>
</tr>
<tr>
<td>Bonus and reward in project contracting</td>
<td>[25]</td>
</tr>
<tr>
<td>Education and early involvement of project stakeholders</td>
<td>[67,68]</td>
</tr>
<tr>
<td>Sustainability programming</td>
<td>[28]</td>
</tr>
<tr>
<td>Systems design approach</td>
<td>[59]</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Organisational level success factors</th>
<th>Sources</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inter-organisational collaboration and communication</td>
<td>[48]</td>
</tr>
<tr>
<td>Leadership within organisations, strategic planning, focus on owners and employees, cultivation of organisation’s resources and capabilities</td>
<td>[71]</td>
</tr>
</tbody>
</table>

LEAN TECHNIQUE FOR UNDERSTANDING THE REQUIREMENTS OF GREEN BUILDING PROJECTS

Notably, the difficulties and complexities involved in the delivery of green building projects are due to the added requirements, which are beyond standard practice in the construction industry. Thus there are techniques employed by project team members to understand these requirements. Lean technique is usually employed by project team participants to understand the requirements of green building projects. In this, all the activities to be carried out in the delivery of green building projects are characterised, and the different requirements made explicit to project team members. The lean technique also ensures the minimization of wastes in resources used in the delivery of green building projects. This is often phrased as “lean and green”, where lean techniques are regarded as exemplar of greening. Koranda et al. developed a framework that integrated “lean and green” concepts in small construction projects in the construction industry. The framework indicated that both lean and green concepts ensure minimization of wastes differently. While the green concept concentrates on eliminating material waste, emissions and environmental impact, the lean concept targets the value stream of projects by focusing on minimization of material and operational wastes. Nonetheless, both add to the achievement of sustainability in green building projects.

The application of lean technique in the delivery of green building projects followed a structured methodology. The first thing is to understand owner value. These may include a built structure, space creation, economic, social and environmental needs etc., and value is generated when these needs are met. Understanding owner value is followed by process modelling or mapping to provide a pictorial representation at increasing levels of detail of the steps to be followed in delivery the owners' value, along with identifying potential barriers or opportunities. A process performance analysis is then carried out to determine the wasteful and value adding processes, which is the most important function of the lean process. The last is process validation through: capability for improvement of current practice by reducing first and/or life cycle cost; potential to improve the performance of the physical development; and, reduction of downstream process waste.

It could be seen that value is an important consideration in the delivery of green building projects. However, value in green building projects could be differently defined, wherefore value engineering could be applied to arrive at an optimum value.

Other techniques for understanding the requirements of green building projects include value engineering, which provides a structured approach to identifying project solutions that improve project performance and increase levels of sustainability, and visualisation tools (e.g. infrared cameras, Energy 10 software, CAD, eQUEST, and RADIANCE) which reduce sub-optimal decisions and costly mistakes.

FUTURE RESEARCH DIRECTIONS

The previous section is a systematic review of researches on delivery of green building projects. In doing the review, two areas have emerged in need of further research, which is illustrated in Figure 3, and explained in the following section.

ESTABLISHING EMPIRICAL SUPPORT THAT THE PRACTICES FOR SUCCESSFUL DELIVERY INFLUENCE THE PERFORMANCE-AT-COMPLETION OF GREEN BUILDING PROJECTS

The practices for ensuring the successful delivery of green building projects have been pointed. It was emphasised that these practices could influence the performance-at-completion of green building projects. It is important to verify this claim in empirical terms. According to Gultekin et al. an empirical verification of this claim will help project stakeholders to carry out detailed analysis of decisions regarding the achievement of performance-at-completion of green projects.

Further, project stakeholders will be able to predict the performance-at-completion, and take necessary corrective actions. Of note is the practice of owner commitment because of the implication for project owners. According to Robichaud and Anantatmula, the decision making role of project owners, especially in the regard of sustainability decisions, has placed them at the centre of success of the project delivery of green building projects. In future research, the empirical evidence that the practice of owner commitment ensures the successful delivery of green building projects should be provided. The knowledge will further motivate owners to adopt and successfully implement green building projects.

IMPLEMENTATION OF VALUE ENGINEERING IN THE DELIVERY OF GREEN BUILDING PROJECTS

In the delivery of green building projects, there is value when the owners’ requirements are met.
Thus value addition is an important consideration in the delivery of green building projects. However because of added requirements, it is difficult for owners and project teams to define value in green building projects. For instance, it is difficult to be specific about value in terms of social, economic or environmental considerations. Value could also be the balancing of social, economic and environmental considerations. Due to the difficulty, there has been advocacy for the implementation of value engineering in the delivery of green building projects. Value engineering is defined as an organised effort directed at analysing the functions of the system for the purpose of achieving the required function and value. It is structured problem solving process based on function analysis to improve the value of a system. Tentatively, value engineering is a methodology for defining and ensuring value in green building projects. However, there has been no research aimed at implementing value engineering in the delivery of green building projects. Consequently, future research should seek to uncover how value engineering can be implemented in the delivery of green building projects. The outcomes of such research will help owners and project team members to define, and improve value requirements in the delivery of green building projects.

FRAMEWORK FOR IMPLEMENTING “LEAN AND GREEN” CONCEPT

The “lean and green” concept ensures the minimization of wastes in the delivery of green building projects. However, the lean aspect ensures the minimization of wastes differently from the green aspect. According to Koranda, while the green aspect concentrates on eliminating material waste, emissions and environmental impact, the lean aspect targets the value stream of projects by focusing on minimizing material and operational wastes. The mutual exclusivity of the lean and green concept can be related to lack of framework of implementation. A framework of implementation will help project team participants to articulate the synergy between lean and green concept, thereby enabling the implementation of specific lean practices in achieving a corresponding level of greenness, and vice versa.

IMPLICATIONS FOR THE DELIVERY OF GREEN BUILDING PROJECTS IN SOUTH AFRICA

Better than other African countries, green building practices are thriving in South Africa. Currently, South Africa (SA) is an established member of the World Green Building Council (WGBC). This means that industry leaders in SA are operationally stable, nationally positioned and empowered to effect the transformation of the local building industry toward sustainability. The evidence of this is the development of 211 green building projects between 2007 and 2015 in SA. Thus the outcome of this research, which contributes to the existing knowledge of how to deliver green building projects successfully, is relevant in SA. These include:

1) The awareness of the stakeholders in the development of green building projects of the need for the implementation of practices such as owner commitment so as to ensure the successful delivery of green building projects

2) The awareness of the stakeholders in the development of green building projects that the practices for ensuring successful delivery of green building projects must be implemented at the project and organisational levels in order to overcome the complexities in the delivery of green building projects

3) The awareness of the stakeholders in the development of green building projects that lean techniques can be implemented in the delivery of green building projects so as to understand and balance the additional requirements

4) The availing of research opportunities that can further lead to successful delivery of green building projects to the construction management researchers. These include subjects such as value engineering implementation, performance-at-completion of green building projects, and framework for “lean and green” implementation.

CONCLUSION

It is difficult and complex to deliver green building projects. This complicates the success of green building projects. In order to deliver green building projects, there is need to furnish the understanding of owners and green building project stakeholders in the construction industry. Given that literature review is a useful methodology for gaining in-depth understanding of a subject area, this paper undertook the systematic review of articles on the delivery of green building projects, published in relevant academic journals between 2005 and 2014.

In the review, 48 relevant peer-reviewed articles were examined. It could be seen that steady increase in the research interest in this area has been growing since 2009. By content analysis of the articles, two topics were identified as key research themes in the area of delivery of green building projects, namely (1) the practices for ensuring the successful delivery of green building projects, and (2) lean technique for understanding the delivery of green building projects.

Based on the review, the practices for the ensuring the successful delivery of green building projects can be implemented at project and organisational levels. The project level emphasizes on the practices implemented during the actual execution of green building projects. The organisational level emphasizes on the practices implemented within project participants’ organisations. However, the delineation in the practices for ensuring successful delivery of green building projects between project and organisational levels is indicative of the complexities in delivery of green building projects. This means additional considerations must be taken during actual construction, and also within project participants’ organisations so as to achieve success.

Also the implementation of the practices for ensuring successful delivery of green building projects influences the performance—at-project completion, even though there is currently no empirical support for this claim. Therefore in future, researchers and practitioners should seek to establish empirical relationship for this claim. An empirical support in this regard will avail the knowledge of specific practices that lead to different performance outcomes in delivery of green building projects. The other theme is the lean technique for understanding the delivery of green building projects. The lean technique is a veritable means of understanding the
additional requirements required in the delivery of green building projects. It is notable that green building projects are have additional requirements, beyond standard practice, which makes the delivery difficult and complex. Lean technique is described as an exemplar of green practices in the delivery of green building projects. This is termed “lean and green” concept, and together they ensure the minimization of resource wastes in the delivery of green building projects. Consequently, the development of a framework of implementation is proposed. The framework will enable the implementation of specific lean practices in achieving a corresponding level of greenness, and vice versa. Also to help owners and project team participants to define value requirements, the implementation of value engineering in the delivery of green building projects has been suggested. Value is attained when the owners’ requirements are met. However due to the difficulties in defining value requirements, the implementation of value engineering will help owners and project team members to define, and improve value requirements in the delivery of green building projects.

The aim of this research is to furnish the understanding of owners and green building project stakeholders in the construction industry on how to successfully deliver green building projects. However the systematic review undertaken to achieve the aim only covered the design and construction stages of the delivery of green building projects. This is a valuable contribution considering the high importance of the design and construction stages of green building projects. However, the pre-construction and post-construction stages were not considered.

The pre-construction stage encompasses activities such as consideration, analysis, and implementation of sustainable alternatives, life cycle cost and construction cost calculations, and early building commissioning planning and analysis. The post-construction stage includes activities such as adaptive reuse, retrofitting, maintenance, and operation strategies. In essence, it could be considered inefficient to discard the preconstruction and post-construction stages in the delivery of green building projects in this research.

![Figure 3: Current status and future directions of researches on project delivery of green building projects](Adapted from [17].)

**REFERENCES**


35. Jrade, A. and F. Jalaei, Integrating building information modelling with sustainability to design building projects at the conceptual stage. Springer.


47. Swanup, L., Gultekin, P. and Horman, M., Exploring the validity of qualitative methods to analyze project delivery of sustainable, high performance buildings.


83. Shi, Q. and X. Xie. A fuzzy-QFD approach to the assessment of green construction alternatives based on value engineering. IEEE.


Purpose of this paper

What are the reason(s) for writing the paper or the aims of the research?

Design/methodology/approach

How are the objectives achieved? Include the main method(s) used for the research. What is the approach to the topic and what is the theoretical or subject scope of the paper?

Findings

What was found in the course of the work? This will refer to analysis, discussion, or results.

Research limitations/implications (if applicable)

If research is reported on in the paper this section must be completed and should include suggestions for future research and any identified limitations in the research process.

Practical implications (if applicable)

What outcomes and implications for practice, applications and consequences are identified? Not all papers will have practical implications but most will. What changes to practice should be made as a result of this research/paper? What is original/value of paper? What is new in the paper? State the value of the paper and to whom.

All headings and sub-headings should be in 10 pt bold capitals and the keywords themselves should be in 10 pt bold upper and lower case.

Introduction (page 3):

The introduction should clearly state the purpose (aims and objectives) of the paper. It should include key references to appropriate work, but is NOT the place for a comprehensive historical or literature review.

Discussion: The discussion should emphasize the implications and practical significance of research findings, their limitations, and relevance to previous studies.

Acknowledgements:

A short acknowledgement section of one paragraph is permissible at the end of the text.

Conclusions:

Conclusions should state concisely the most important propositions of the paper, as well as the recommendations of the authors based on the propositions.

Illustrations:

Illustrations must accompany the manuscript and should be included in the text. Photographs, standard forms and charts must be referred to as Figure 1, Figure 2, etc. They should be numbered in the order in which they are referred to in the text. The figure identification and accompanying description and any reference should be one line space immediately below the figure and linked to the left margin.

Illustrations should be submitted in a form ready for reproduction, preferably as high-resolution .jpg files. Diagrams and drawings should be drawn in black ink on white paper. Alternatively they should be high quality laser computer printouts from reputable computer software drawing packages.

Drawings and diagrams must not exceed 140mm in width and all dimensions must be in mm. Annotation must be in upper and lower case lettering, the capital of which should be 3 mm high. Figures will normally be reduced in size on reproduction and authors should draw with this in mind. With a reduction of 2:1 in mind the authors should use lines not less than 0.25mm thick and upper and lower case lettering, the capitals of which should be 4mm high. Typewritten annotations are not acceptable.

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Tables must be located close to the first reference to them in the text and must be referred to as Table 1, Table 2, etc. and be numbered in the order in which they are referred to in the text. The table identification and accompanying informative description and any reference should be one line space immediately above the table and linked to the left margin. The table identification should be in bold. Identify all statistical methods and sources of data.

Tables should only have horizontal lines, the heading and bottom lines being in bold. All words should be in upper and lower case lettering. The headings should be aligned to the left of their column, start with an initial capital and be in bold. Units should be included in the heading. Any explanations should be given at the foot of the table, not within the table itself.

Table 1: Component expenditures

<table>
<thead>
<tr>
<th>Component</th>
<th>Expenditure (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cleaning works</td>
<td>40.9</td>
</tr>
<tr>
<td>Mechanical services</td>
<td>37.7</td>
</tr>
<tr>
<td>Building works</td>
<td>13.6</td>
</tr>
<tr>
<td>Civil works</td>
<td>7.8</td>
</tr>
<tr>
<td>Total</td>
<td>100.0</td>
</tr>
</tbody>
</table>

(Northwood, 1995)

Symbols, abbreviations and conventions:

Symbols, abbreviations and conventions in papers must follow the recommended SI units. Where non-standard abbreviations are used, the word(s) to be abbreviated should be written out in full on the first mention in the text, followed by the abbreviation in parentheses.

References:

The numbered system must be used. References in the text should be numbered consecutively (1), etc. References should be collected at the end of the paper in alphabetical order by the first author’s surname. The style should follow the examples below:


If no person is named as the author the body should be used (for example: Royal Institution of Chartered Surveyors (1980) Report on Urban Planning Methods, London.

If no person is named as the author the body should be used (for example: Royal Institution of Chartered Surveyors (1980) Report on Urban Planning Methods, London.

Endnotes:

A limited number of explanatory notes is permissible. These should be numbered 1, 2, 3, consecutively in the text and denoted by superscripts. They should be typed on a separate sheet of paper at the end of the text. Endnotes should not be used for academic or project citations.

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