Association of Schools of Construction of Southern Africa

The Eighth Built Environment Conference
27 - 29 July 2014

Reflections on Directions in Construction
PREFACE

The ASOCSA Built Environment conference series has become the undisputed leading built environment conference on the African continent. It is one of only two construction-related conferences in South Africa that has been fully accredited by the Department of Higher Education for subsidy. Since its inception in 2006 the peer reviewed conference proceedings have been referred to by private and public sector policy and decision makers. The series produces a conference edition of the sought after Journal of Construction, which is on the list of journals approved by the South African Department of Higher Education for subsidy. The series has been underwritten by major industry stakeholders that have included the Construction Industry Development Board (CIDB), Council for the Built Environment (CBE), Master Builders South Africa (MBSA) and PPC Cement. It has been endorsed by the International Council for Research and Innovation in Building and Construction (CiB), one of the largest global built environment research organizations.

OBJECTIVES

The Eighth Built Environment Conference continued in the tradition of previous conferences in the series and provided in an ever-increasing challenging global economic environment with shrinking sponsorship budgets an international forum with a very clear industry development and sustainability focus that provides the opportunity for researchers and practitioners from developed, developing and underdeveloped nations to deliberate topical current issues that impact the Built Environment.

The broad objectives of the conference are:

- To provide a forum for multi-disciplinary interaction between academics and industry practitioners;
- To disseminate innovative and cutting edge practices that respond to the conference theme and outcomes, namely Reflections on Directions in Construction;
- To provide a world class leading internationally recognized, accredited conference for the built environment; and
- To contribute to the existing built environment body of knowledge (BEBOK) and practice.

The conference organizers brought together in a single forum a group of researchers and academics from the full range of built environment disciplines that include engineers, architects, quantity surveyors, construction and project managers. Delegates were drawn not only from South African institutions of higher education, government agencies, and other construction-related organizations but also from the African continent, United Kingdom and United States of America.
CONFERENCE OUTCOMES

This conference sought responses to questions related to selected current conversations and debates in construction namely

- Integration of professional practice
- Building Information Modeling
- Sustainable Green Building
- Inquiry-based construction education
- Infrastructure delivery
- Construction malpractices

and includes papers that address, inter alia,

- Current trends and developments
- Policies
- Legislation and regulations
- Practices
- Case studies

These internationally peer reviewed and edited proceedings were aimed at contributing significantly to the body of knowledge relative to the science and practice of construction not only in South Africa but everywhere that the products of construction are being produced.

Theo C Haupt
Durban, South Africa
July 27, 2014
ACKNOWLEDGEMENTS

The organizing committee of The Eighth Built Environment conference, held in Durban, South Africa, wish to thank the University of KwaZulu-Natal, the Council of the Association of Schools of Construction of Southern Africa and membership universities and individuals for supporting this conference through their valued contributions. Without that support this conference and the further development and growth of the Association of Schools of Construction of Southern Africa (ASOCSA) with respect to its mission in the region would not have been possible. Further, this support demonstrates the commitment to the further development of the body of knowledge relative to the science and practice of construction. This commitment is deeply valued and acknowledged.

Our thanks are extended to Professor Theo Haupt (Pinnacle Research and Development Solutions and University of KwaZulu-Natal) and Ferdinand Fester (University of Johannesburg) who worked unstintingly on every aspect of the conference. Together with the Scientific and Technical Committee and additional reviewers to whom special thanks are extended they worked hard and long to prepare refereed and edited papers and published proceedings of the highest standard that satisfy the criteria for subsidy by the South African Department of Higher Education.

Special mention is necessary for the co-ordinators of the various sub-themes, Profs. Maritz, and Du Plessis and Drs. Agumba, Anosike, Musonda and Venkatachlam for their efforts relative to this conference - often under extremely difficult and trying circumstances.

The contribution and excellent support of our webmaster, Wendal Koopman, in setting up and supporting our conference website is appreciated.

Finally, the sterling contribution and efforts of Ferial Lombardo to the success of this conference is acknowledged in her capacity as conference organizer working with the conference committee and evident in the superlative logistic coordination and attention to detail in every aspect of the conference organization.
ORGANISERS – SOUTH AFRICA

Ferdinand Fester, University of Johannesburg, South Africa, President
Prof Theodore Haupt, Academic Chair
Ms. Ferial Lombardo, Conference Organiser
PEER REVIEW PROCESS

In order to maintain and ensure the highest quality in the conference proceedings and comply with the requirements for subsidy of the South African Department of Higher Education, a rigorous two-stage system of peer review by no less than two acknowledged experts in the field has been followed. In terms of this process, each abstract received was twice blind reviewed in terms of:

- Relevance to overall conference theme and objectives;
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- Originality of material;
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- Contribution to knowledge; and
- Research methodology.

Authors whose abstracts were accepted after the review process was completed, were provided with anonymous reviewers’ comments and requested to submit their full papers noting and addressing these comments. Evidence was required relative to the action taken by authors regarding the comments received. These resubmitted papers were twice blind reviewed again in terms of:

- Relevance to overall conference theme and objectives;
- Relevance to selected sub-theme;
- Originality of material;
- Academic rigour;
- Contribution to knowledge;
- Research methodology and robustness of analysis of findings;
- Empirical research findings; and
- Critical current literature review.

Authors whose papers were accepted after this second review were provided with additional anonymous reviewers’ comments and requested to submit their revised full papers. These final papers were only included into both the conference presentation schedule and the conference proceedings after evidence was provided that all comments were appropriately responded to, having been multiple peer-reviewed for publication. At no stage was any member of the Scientific and Technical Committee or the editor of the proceedings involved in the review process relative to their own authored or co-authored papers. The role of the editor was to ensure that the final papers incorporated the reviewers’ comments and arrange the papers into the final sequence based on the conference presentation schedule as captured on the Flashdrive and Table of Contents. Of the 60 abstracts originally received, only 39 papers were
finally accepted for presentation at the conference and inclusion in these proceedings, representing an acceptance rate of 65%. To be eligible for inclusion these papers were required to receive one of three recommendations from at least two reviewers, namely

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History

ASOCSA is not the first attempt to form a body that addresses, inter alia, matters of construction education and training. In the days of the Building Industries Federation South Africa and the National Development Fund there were regular annual meetings of the Heads of Departments that offered construction-related programs. Recognizing the two-tiered higher education sector in South Africa, there were separate meetings for universities and the former technikons. In the more recent past, the Chartered Institute of Building - Africa initially convened annual educators’ forums that did not quite fulfill the same function as the previous forums. However, during 2005 the very first meeting of University Heads of Departments drawn from all higher education institutions in South Africa met for the very first time since the re-landscaping of the sector in the same venue to discuss matters affecting construction, and particularly construction education in the country. This meeting was repeated in 2006 where the need was expressed for the establishment of a formal forum / association of universities to engage in discussion / debate / collaboration / promotion of matters of mutual interest.

Broad Aims

ASOCSA aims to be the professional association for the development and advancement of construction education in Southern Africa, where the sharing of ideas and knowledge inspires, guides and promotes excellence in curriculums, teaching, research and service. To achieve this aim ASOCSA is partnering with the construction industry to find ways to effectively represent the interests of both construction academic and industry practitioners. ASOCSA will offer a variety of programs and services designed to help its members serve their customers more effectively and succeed in an increasingly challenging environment of construction information management and technology. To this end ASOCSA provides a forum for the debate and discussion of issues of mutual interest to all industry stakeholders. For example, one of the tasks of ASOCSA will be supporting the development of curriculums that address the needs of the construction sector in the Southern African region. ASOCSA convenes an annual conference that is accredited by the Department of Higher Education where construction academics and practitioners can interact relative to practical experience and the findings of relevant research. This conference series is endorsed and underwritten by the International Council for Research and Innovation in Building and Construction (CIB).
The Journal of Construction which is accredited by the Department of Higher Education presently published twice per year is the official journal of ASOCSA and more than 5,000 complimentary copies are distributed to all industry stakeholders in the Southern African region. The production and distribution of practice notes and technical papers is a further endeavor to grow the partnership between academia and industry.

With respect to the Southern African region, ASOCSA is committed to the following:

**Vision**

To drive innovative construction related higher education

**Mission Statement**

To promote, facilitate, develop and monitor the relevance and quality of construction related curricula, research and graduates in conjunction with higher education institutions, industry and government.

**Strategic objectives**

The objectives of the Association are:

- to promote and facilitate the development of curricula for construction related programmes
- to assist with the accreditation of construction related programmes
- to hold an annual conference that acts as a forum for multi-disciplinary interaction between academics and practitioners
- to publish an accredited research-based journal and contribute to the built environment body of knowledge (BEBOK)
- to disseminate information dealing with construction education and related matters
- to develop and maintain closer links with industry and government
- to represent the collective views of its members
- to liaise with other organisations and persons to promote the interests of its members
- to promote and support relevant postgraduate research
- to provide bursaries to postgraduate students in accordance with set criteria

ASOCSA continues to seek opportunities to promote both academic and industry employment opportunities. Finally, ASOCSA intends to play a significant role in the accreditation of construction-related academic programs.
Meeting of Heads of Schools and Departments of Construction

ASOCSA believes that meetings of Heads of School and Departments of Construction is a vital component of its functions and holds Heads meetings during each conference. It is still the aim of ASOCSA to bi-annual Heads meetings.

International Affiliation

ASOCSA has commenced discussions about closer collaboration with similar institutions such as the Associated Schools of Construction (ASC) in the United States, the Royal Institute of Chartered Surveyors (RICS), the Chartered Institute of Building (CIOB) and Council of the Heads of the Built Environment (CHOBE) in the United Kingdom. ASOCSA has entered into a Memorandum of Understanding with the International Council for Research and Innovation in Building and Construction (CIB).

In summary, benefits of membership of ASOCSA which are self-evident include participation in meetings of Heads of construction programs throughout the region, access to the Journal of Construction, reduced rates at all ASOCSA and CIB events, involvement at regional level with industry-academia forums, interaction and networking opportunities relative to, for example, collaborative research, curriculum development, external moderation of courses, and external examination.

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For more information on ASOCSA and its activities visit www.asocsa.org
TAX BENEFIT

ASOCSA is a registered Public Benefit Organization as defined in Section 30 of the Income Tax Act and a registered Section 21 Company as defined in the Companies Act. Therefore all donations made to ASOCSA will be fully deductible for income tax purposes and a section 18A certificate, for proof of deductibility will be issued to the donor upon receipt of the donation. The deductible donation is limited to 10% of the donors’ taxable income before providing for Section 18A and Section 18 deductions.
Introduction

CIB is the acronym of the abbreviated French (former) name: "Conseil International du Bâtiment" (in English this is: International Council for Building). In the course of 1998, the abbreviation has been kept but the full name changed into:

INTERNATIONAL COUNCIL FOR RESEARCH AND INNOVATION IN BUILDING AND CONSTRUCTION

CIB was established in 1953 as an Association whose objectives were to stimulate and facilitate international cooperation and information exchange between governmental research institutes in the building and construction sector, with an emphasis on those institutes engaged in technical fields of research.

CIB has since developed into a world wide network of over 5000 experts from about 500 member organisations active in the research community, in industry or in education, who cooperate and exchange information in over 50 CIB Commissions covering all fields in building and construction related research and innovation.

CIB Members are institutes, companies and other types of organisations involved in research or in the transfer or application of research results. Member organisations appoint experts to participate in CIB Commissions. An individual also can be a member and participate in a Commission. CIB Commissions initiate projects for R&D and information exchange, organise meetings and produce publications. These meetings can be Commission meetings for members only or international symposia and congresses open to all. Publications can be proceedings, scientific or technical analyses and international state of the art reports.

CIB Past and Present

CIB was established in 1953 with the support of the United Nations, as an association whose objectives were to stimulate and facilitate international collaboration and information exchange between governmental research institutes in the building and construction sector. At that time an implicit objective also was to help rebuild the European infrastructure for building and construction research following the ravages of the second World War.
At the start 43 research institutes were members of CIB and by far the majority of these were European. And just as in the programmes of these institutes at that time, so in the CIB programme there was a strong emphasis on technical topics.

For selected topics CIB Commissions were established to which member organisations appointed experts from their staff to participate.

Along with all types of less visible activities, this collective participation resulted in many important international symposia and congresses and in a large number of publications acknowledged as of global standing. Indeed many of these formed the factual basis for developing international standards or were themselves used as such. Others were international state-of-the-art reports that for a long time provided an indispensable input to programming new research by the participating institutes and countries.

However, CIB has come a long way since 1953.

At present about 500 organisations are members of CIB from whom about 5000 individual experts participate in over 50 CIB Commissions. These extend over the whole area of building and construction research and innovation.

Amongst the CIB member organisations we can now find almost all the major national building research institutes in the world, as well as many other types of organisations in the building and construction sector who have joined us since. And although within the CIB programme considerable attention is still given to technical topics, there are now also activities focused on topics like organisation and management, economics of building, legal and procurement practices, architecture, urban planning and human aspects.

It is no exaggeration to say that at present CIB is the world's foremost platform for international cooperation and information exchange in the area of building and construction research and innovation. And we continue to increase our membership, to expand our scope, to initiate new activities while constantly striving to improve the quality of our products and services.
27 July 2014

Dear Author

PEER REVIEW PROCESS: 8TH BUILT ENVIRONMENT CONFERENCE:
DURBAN, SOUTH AFRICA 2014

I confirm that the following peer review process was strictly followed relative to this conference.

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Dr David Edwards, Birmingham City University, UK

Regards

Ferdinand Fester (ASOCSA President)

Prof Theo C Haupt (ASOCSA Vice-President)

Ms Ferial Lombardo (ASOCSA Conference Organizer)
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ASOCSA2014-SGB1

Property developers’ perspective on the current status of green building in South Africa

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ABSTRACT AND KEYWORDS

Purpose of this paper

To determine the perspective of property developers on the current status of green building in South Africa.

Design methodology

The study evaluates the current status of cost and benefits of green building. A questionnaire investigated the experience and opinions of property developers.

Findings

Developers agreed that green building in South Africa is increasing. Most developers already had experience with green developments. Tenants are demanding more green buildings and all developers expect a cost premium for green building. Green accredited consultants have an imported role to play. Several aspects of Green Star SA have the potential to influence business decisions.

Research limitations/implications

Limited data is available in the young green building industry in South Africa. Comparison of cost is a challenge due to the diverse nature of construction projects. The study only involved a limited number of developers.
Value of paper

This study provides insights from developers on development trends, expected cost and affordability of green building. The findings will be of value to the Green Building Council of South Africa and other important stakeholders such as professional consultants and property owners.

Keywords: Current status, Green building, Property developers, South Africa, Trends.

1. INTRODUCTION

1.1. Background

The construction industry is highly resource intensive both at construction and operation phase. With sustainability now a global concern, there is an increasing focus to create sustainable buildings (Milne, 2007). Buildings may use 32% of the world's resources in construction, buildings consume approximately 40% of global energy use and generate up to 30% of global greenhouse gas emissions (World Green Building Council, 2010). This creates huge potential for the construction industry to contribute to environmental efficiency. The United Nations Environment Programme confirmed that buildings promise very cost effective potential to reduce emissions (Koepel, 2007).

Various rating systems exist internationally such as the Leadership in Energy and Environmental Design (LEED) rating system was developed by the United States green building council LEED provides a framework for the evaluation of green building design, construction, operation (USGBC, 2013).

Extensive studies have been done of LEED rated buildings and these studies serve as a benchmark in the current market with regards to green building projects (Davis Langdon, 2006). Green building offers various benefits such as including environmental factors but also other benefits such as reduced operating costs, higher asset returns, increased property value, enhanced marketability, reduced risk and liability and improved tenant demand and retention (Milne, 2007).

There are challenges and barriers related to green building which include economic barriers related to direct capital costs, split incentives, existing building stock. The construction industry is however in a strong position to deliver significant long term environmental improvements and these barriers must be brought to the surface Milner (2007).

Evaluation of previous LEED based studies as well as available South African case studies will give an indication of what premiums may be expected in the South African market. The benefits derived from green
building and whether the reported capital premiums are offset by the benefits derived from incorporating sustainable design will be evaluated.

1.2 Importance of the Study

There exist widespread opinions that green buildings are more expensive than conventional buildings. The relevant benefits of green building must be analysed but must also be translated into hard economic realities - who pays and who gains (Milne, 2007). The green building initiative and decision making in the green building environment will benefit if more information and more certainty exist regarding current trends in the industry and how the markets are reacting thereto. Aspects such as the cost premium of green building, if the claimed benefits of green building is motivating development decisions and if there exist an accelerating green building trend will be evaluated in this study.

2. THE PROBLEM

The purpose of this study is to add insight into local SA market trends and driving forcing are regarding green construction. Property developers need to make informed business decisions based on a clear understanding of the expected capital premiums related to green building practices. The study analysed property developers' perspectives on the current status, costs and benefits of green building in South Africa.

Data on developers’ perspectives was collected by means of a questionnaire completed by 16 different development professionals in Gauteng. Developers were identified as respondents because they often make investment decisions on additional capital costs for green building.

3. REVIEW OF RELATED LITERATURE

3.1 An increased trend in green

There has been a substantial increase in green buildings worldwide. Approximately 94% of built professionals, contractors, and owners are reporting that new construction projects are to achieve some level of sustainable credits. Currently about 60% of projects contain some form of green initiative. These statistics have almost doubled since 2009 (Mcgraw-Hill, 2013). This indicates that internationally the green building trend is expanding rapidly.
The Mcgraw-Hill report (2013) continues that 51% of South African firms expect significant levels of green activity by 2015, three times as much as the 16% reflected in 2012. This growth reported from South Africa is the strongest growth among all the survey respondents. This information confirms the importance for South African decision makers to make sound decisions to remain competitive.

3.2 Will green building ratings cause an increase in initial capital investment?

A substantial number of LEED rated buildings in the North American market have been analysed as case studies to make comparison to LEED rated building costs. The LEED version 2.2 rating system comprises 7 prerequisites and 69 elective points which are grouped into six categories. There are different levels of ratings from certified to platinum: certified=40-49, silver=50-59, gold=60-79, platinum=80 and above. (USGBC, 2013).

A total of 221 buildings were analysed of which 83 buildings obtained a form of LEED rating and 138 buildings were conventional. Amongst these buildings were 60 academic buildings, 57 libraries, 70 laboratory buildings, 18 community centres and 16 ambulatory care buildings. No indication was identified that there was an increase in cost per square foot for the LEED certified buildings (Davis Langdon, 2006). The following findings can be deduced from the case studies. The majority of projects did achieve sustainable goals within budget, budgets set with reference to sustainable goals achieved certification with little or no adjustment, when sustainable design was incorporated at later stages there was an increase in final cost. From this analysis we may conclude that sustainable buildings can be built with little or no supplemental funding. (Davis Langdon, 2006).

Robinchaud & Anantatmula (2011) identified construction cost as a barrier to progress in green building. A study by Issa, Rankin & Christian (2010) also named additional cost but also operations and maintenance as possible barriers that may hamper development in green building.

The South African market is relatively immature and suffers from a lack of compiled data to indicate valuable evidence of costs and financial benefits of green building (Milne, 2007). The Green Building Council of South Africa (GBCSA) developed the Green Star SA rating system. The objectives of the Green Star SA tool are to establish a common language and standard of measurement; promote integrated design; raise awareness; reduce environmental impact of development and recognize environmental leadership. The system consists of categories for management, indoor environmental quality, energy, transport, water, materials, land use and ecology, emissions and innovation. The ratings that can be achieved are: 4 star: 40-49, 5 star 60-74 and 6 star 75-100 (GBCSA, 2013).
A number of prominent buildings received Green Star SA ratings in the recent past. An analysis of the construction costs of these buildings and the capital premiums paid for green building is detailed in Table 1 (Milne 2012).

The above data confirms that South African green building follow a similar pattern as green buildings in the US and do not necessarily carry a significant cost penalty. Milne does however advise for competent and experienced sustainability consultants to be appointed (2012).

<table>
<thead>
<tr>
<th>BUILDING NAME</th>
<th>RATING</th>
<th>CAPITAL PREMIUM</th>
<th>SUBMISSION COSTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aurecon Century City</td>
<td>5 Star Design</td>
<td>5% 8%</td>
<td>1.7%</td>
</tr>
<tr>
<td>Nedbank Phase II</td>
<td>4 Star Design, 4 Star As Built</td>
<td>3.3%</td>
<td>&lt;0.5%</td>
</tr>
<tr>
<td>Mayfair-on-the-Lake</td>
<td>4 Star Design</td>
<td>5%</td>
<td>1%</td>
</tr>
<tr>
<td>24 Richefon Circle</td>
<td>4 Star Design</td>
<td>10%</td>
<td>R750,000</td>
</tr>
<tr>
<td>Falcon Building Menlyn Maine</td>
<td>4 Star Design</td>
<td>9.2%</td>
<td>0.55%</td>
</tr>
<tr>
<td>Aurecon Lynnwood Bridge</td>
<td>4 Star Design</td>
<td>2.6%</td>
<td>0.26%</td>
</tr>
<tr>
<td>Forty on Oak</td>
<td>4 Star Design</td>
<td>&lt;1%</td>
<td>Not available</td>
</tr>
<tr>
<td>ABSA Towers West</td>
<td>5 Star As Built</td>
<td>&lt;2%</td>
<td>Not available</td>
</tr>
</tbody>
</table>

Table 1-Capital Premiums of Green Star SA Rated Buildings (Milne, 2012)

3.3 Will green building benefits motivate business decision?

What are the major benefits of green building and do they motivated and influence business decisions? Reducing operating costs offers a significant potential cost benefit for building owners. Energy is a substantial and widely recognized cost of building operations that can be reduced by green design principles (Kats, 2003). LEED rated buildings consistently shows an average of 25%-30% better energy building performance compared to national averages (Turner & Frankel, 2008). Reducing operating costs by reduced water use will also have an effect as water shortages will cause increased water costs (Yahoo, 2013).
A case study in America revealed LEED certified buildings had an effective rental premium of between 5.9% and 6.6% and a transaction price premium of between 13% and 11.1% compared to non-certified buildings. Asset value increased due to tenants being secured more rapidly, higher tenant prices are commanded, lower tenant turnover, grants and subsidies are attracted, occupant productivity is improved (RICS, 2010). This serves as an indication of tenant demand as one major driving force for green building.

Enhanced marketability also serves as one of the benefits motivating business decision. Milne confirms that all Green Star SA rated buildings noted increased media coverage as a result of their Green Star certification (2012). This media coverage may also result in savings on marketing budgets to receive the same marketing value.

Reduced liability and risk serves as a benefit as building owners are incorporating sustainable design to future proof their assets against changes in the business and regulatory environments (Milne 2012).

4. METHODOLOGY

This research used qualitative research based on data obtained from a questionnaire completed by 16 developers as respondents. These developers are all active in Gauteng province, mainly in the commercial real estate industry. The questionnaires were completed during structured interviews resulting in a response rate of 100%. The questionnaire’s first section profiled the respondents. The data to answer the problem was obtained through statements that asked respondents to reply based on a 5 point Lickert scale.

5. DATA ANALYSIS

5.1. An increased trend in green

All respondents agreed that an increase in green building is prevalent with more than 93% of them strongly agreeing therewith (Figure 1). This finding corresponds with the literature that there is an increasing green building trend in South Africa.
A total of 68% of the respondents confirmed that they already had green building experience. In the context of the relatively young green building market in South Africa, such big portion of previous involvement with green developments supports indications of an increase in green building in South Africa.

5.2 Will green building ratings cause an increase in initial capital investment?

All respondents were of the opinion that obtaining a green rating will increase capital expenditure compared to conventional buildings, thus confirming the industry perception amongst developers that green building causes an increase in cost. This finding may also explain a part of the resistance to green building that exist in the industry.

When evaluating green construction cost, the bidding climate when new systems and processes are introduced should be considered. When asked to comment on the statement that contractors will mark up their bids given the above scenario, 25% strongly agree; 37.5% agree; 25% neutral; 12.5% disagreed (Figure 2)
More than 62% of respondents were of opinion that part of the increased cost of green building originates from a risk or uncertainty response from contractors when confronted with new technology. The actual direct cost of green building items is expected to only be in part responsible for green building cost premiums.

To address the nature of the expected cost premium in more detail, the respondents were asked to identify the Green Star SA categories that are most likely to increase building cost. Respondents ranked the categories from most likely as materials, energy, water, innovations, indoor environmental quality, management, emissions, land use and ecology and transport. Materials, energy and water were the categories expected to most likely to increase building cost. The same categories were however also considered the most likely categories to add value in cost savings or reducing carbon emissions.

Green building professionals employed on green developments will add to the cost. In response to the statement that green building professionals should be employed more than 81% of the respondents agreed with only 6% opposed to their appointment (Figure 3).
5.3 Will green building benefits motivate business decision?

Business decisions to invest in green building will be based on significant advantages offered by different aspects or categories of green building. It was therefore necessary to evaluate the opinion of developers on the benefit potential of the nine categories of the Green Star SA system. They were asked to indicate their opinion on the different categories’ potential to add value. Their combined opinion was energy (100%), water (93.8%), materials (93.8%), indoor environmental quality (77.6%), management (73.8%), transport (60%), emissions (55%), innovations (53.8%) and land use and ecology (47.6%).

More than 81% of respondents agreed that other green building benefits such as lifecycle cost saving, increased marketability or higher asset values may also motivate business decisions.

Business decisions are often made in response to demand from customers. All the respondents agreed with the statement that the demand for green buildings from tenants is increasing. A total of 87.5% strongly agreed with the question and 12.5% agreed.

6. FINDINGS

6.1. An increased trend in green

The findings of this study confirmed an increase in green building in South Africa. The literature review revealed that the majority of industry professionals and owners are incorporating sustainable design. This is in response to pressures on the industry to reduce its carbon footprint and be more sustainable regarding consumption of resources. More than 93% of
respondents agreed that the green building trend is increasing and 68% of them already had experience of green developments. The above findings may therefore lead to a conclusion that developers in the industry are very much aware of green building and that they will be sensitive for new developments or new opportunities to explore.

6.2 Will green building ratings cause an increase in initial capital investment?

This finding of the study confirms the perception in the industry amongst developers that green building will cause an increase in cost. All the respondents were of the opinion that green building is likely to increase building cost. This finding may in part explain the resistance to green building that exist in the industry.

The study also revealed that developers are of the opinion that contractors are likely to increase their bids in response to the inclusion of new green building technology. When new technology or concepts are introduced it will often come at a higher capital cost and be met with some industry resistance. However over time and through education and awareness new ideas takes root and becomes generally accepted and more affordable. This aspect merits further research.

Materials, energy and water were found to be the green building categories most likely to increase building cost. The same three aspects however were also revealed as the most likely aspects to make a positive difference in the green building initiative.

The study also revealed that in spite of the additional cost of green building consultants, the developers were convinced that the competence provided by such consultants will add value and that they should be employed when green building developments are considered.

6.3 Will green building benefits motivate business decision?

The study found that developers regard several aspects of green building to have the potential to positively motivate business decisions. A total of five of the nine Green Star SA categories were evaluated with a potential of higher than 70% to motivate business decisions. A green building category rated 70% and higher by developers for added value potential will probably only have to be proven practical and cost effective for such category to be able to positively influence business decisions.

The growing demand from tenants to occupy space in green buildings was also acknowledged by all respondents. This trend should provide additional support to green building initiatives and should make it more likely to get positive business decisions.
7. RECOMMENDATIONS

The study revealed several areas that merit further research to be able to more accurately describe the green building scenario as it is enfolding in South Africa. The following topics are suggested in this regard:

- The study involved a limited number of property developers in Gauteng. A more representative study involving a larger sample and or involve other stakeholders such as professional consultants will add value.
- Describe the motivation behind the current increasing trend in green building in detail – is it an own initiative to get lead on competitors, an effort to try to keep up with competitors, is it largely consultant driven, is it tenant/demand driven, may it be to follow international trends, is it expected to be a short term fad or long term momentum.
- Define the current green experience of developers in detail – did it originate from own initiatives, was it consultant driven, was it prompted by tenant demand.
- Describe the expected importance of green building in the next 5 years – a vital capability to survive, an important aspect to ensure a positive public image, necessary to keep in line with legislation, of benefit to keep up with competition, of some benefit to stay in touch with change.
- Explore the expected cost premium of green building in more detail – cost premium to introduce new technology, a tender bid premium due to uncertainty/risk for contractors, the cost premium of the actual additional time and material spent, the likelihood that SA will follow international trends where the cost premium tend to diminish over time.
- Investigate the cost versus benefit of the three most prominent categories of energy, water and materials in detail – possibilities offered, options exploited, local opportunities and challenges.
- Investigate the added value of the most prominent categories of Green Star SA over the full lifecycle of buildings.
- Describe the role of green building consultants – what are they expected to deliver, the additional demands on them compared to conventional construction, the additional cost of green consultants, are green consultants good to have or a vital necessity.
- Case study research to establish actual cost and benefits delivered by green rated buildings in SA? Business decisions need to be made on proven, hard facts and not on perceptions or opinions.
- Describe the major risks involved in incorporating green building or sustainable design.
- Investigate new initiatives or inputs necessary in South Africa to enable green building and sustainable design incorporated in property development in the local industry to close the gap compared to international market developments and trends.
8. REFERENCES


Building thermal performance and energy management: a retrofit case study in Durban

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ABSTRACT AND KEYWORDS

Purpose of this paper
This paper aims at critically analysing an existing building pre- and post-retrofit thermal data, to gauge the effectiveness of green strategies applied while discussing alternatives in line with the formulation of energy management measures.

Design/methodology/approach
The research combines a theoretical approach based on the available literature with a case study approach focused on analytical thermal data capturing and analysis, along with energy management discussion.

Findings
The window retrofit analysed, led to a decrease in temperature (1°C-1.5°C) and the daily thermal gain graph, previously showed high peaks during warm hours and flat base curves during cooler hours, now has more consistent, predictable gains and losses.

Research limitations/implications
Temperature sensors and energy usage meters are located to minimise variables which need to be investigated in further studies.

Practical implications (if applicable)
Through simple retrofit strategies and correct energy management it is possible to enhance user’s comfort and decrease operating costs.

What is original/value of paper
The results of this research will be used to formulate a “best practice approach” to building’s energy management, using real-time data and measurements, in order to better understand deficiencies in current management practices and highlight cost-effective retrofits and passive strategies able to decrease building life cycle costs.
Keywords: Green building, green retrofit, energy efficient management, measurement and verification (M&V)

1. INTRODUCTION

In South Africa currently, existing buildings are the largest users of energy, accounting for around 40% of energy usage (Lemmet, 2009). This highlights the potential for energy efficiency measures to be adopted in existing older buildings. The building’s main user of energy is the so called HVAC systems (Heating, Ventilation and Air-conditioning). The need for efficient and properly maintained and run HVAC systems is of evermore-critical importance with today’s energy security issues. The importance extends deeper than the obvious environmental impact, but with today’s energy crisis looming, it extends to providing a shift towards a focus on energy security and economic best practices. The urban energy landscape is often viewed as being a passive system of supply meeting a constant demand (Hagan, 2013). While this may hold true for large-scale city analysis, on the more micro level of a building this is often far from true.

An investigation was conducted on an existing office building, located on the University of KwaZulu-Natal Westville campus (Durban) using temperature sensors and electrical usage meters placed throughout the building, in order to capture real-time data and building operational parameters. These data were used to establish a usage and temperature base point before a retrofit phase was carried out. The first phase of the investigation was a physical retrofit of the building envelope in the form of energy efficient window installations. Further data capturing and analysis was carried out before a theoretical second phase “air flow retrofit” was analyzed and discussed. The second phase looked to take advantage of the building’s design and the fact that one face of the building is in relative shade while the other face is in direct sunlight, in order to reduce the building’s temperature using natural airflow. Based on the collected data pre- and post-retrofits consumption patterns and volumes are discussed and analyzed with effectiveness or lack thereof gauged. The results of this research will be used to formulate a “best practice approach” to building’s energy management, using real-time data and measurements, in order to better understand deficiencies in current management practices and highlight cost-effective retrofits and passive strategies able to decrease building life cycle costs.

2. BACKGROUND AND LITERATURE REVIEW

A building’s energy usage is not just determined by external factors such as weather or building façade characteristics, but has an internal ecology that is determined, on a day-to-day basis on what the user requires and how the user interacts with the building. This creates a dynamic environment for energy usage, one, which makes it hard to apply a constant, and linearly
rigid building management model for a pre-conceived set of standard operating protocols. All of these are dynamically linked so that changes in one system imply direct and indirect changes on the other systems through causality. With this in mind, any adjustments or changes to the management practices for a system cannot be seen as being an isolated or a singular issue, but must instead be looked at, in the sense of a connected array of inter-related systems. Efficiency in one system does not mean efficiency in another sub-system. Instead, a greater efficiency in one system may lead to an overall deficiency in the building, due to the inter-related nature of the buildings ecology (Keirstead et al., 2011). Current efficiency practices aim to reduce a buildings carbon footprint through lower energy consumption and demand. This can be done through adopting newer, more efficient technologies, building envelope retrofits or simply through a more stringent and hands on approach to energy management namely in the form of “rationing” or direct restrictions on user occupation usage characteristics. These, however, will all have an initial capital requirement or perceived negative user reviews and a continual need for maintenance and management (Mathieu 2011). Proper life-cycle analysis needs to be conducted in order to ensure that the systems are in fact sustainable and impart a negative or at least neutral carbon footprint on the building. There are other passive options, all viable theoretically, such as natural airflow ventilation and cooling but there is a distinct lack of data that will substantiate the theoretical benefits of a passive system (Runming et al., 2009). This lack of accurate and real world data hinders adoption of these cost-effective and natural passive systems, which could easily and readily be adapted to any existing buildings management systems. Energy efficiency needs to be looked at more as an insurance policy against future energy supply and pricing volatility for all existing buildings. A lot of the challenges faced with promoting and rolling out energy efficiency measures can be traced back to legislation and design code deficiencies. Overlooking those obstacles, the engineering challenge is doing the financial analysis, taking into account government incentives and pairing the technology with the best application, in order to suit client, user, environmental and societal requirements for the retrofit. A strong measurement and verification programme will go along way to addressing many of these concerns when it comes to investing the capital. South Africa does have current and future commitments when it comes to GHG emissions reduction under the Kyoto protocol (Van Es D. et al., 2006). This, initially, went smoothly as large pools of foreign investment was opened up for investment in energy projects through Clean development mechanisms (CDM) these CDM’s produced a sellable entity in the form of carbon credits, that were used by the investor country or company to offset their own emissions. However, in light of the current economic climate, the price of these carbon credits has plummeted (Hodes, 2013). This has further been complicated by a ruling that all future energy investments will focus on non-developed countries, meaning that as a developing country South Africa would not be able to register any new CDM’s. CDM’s registered before 2012 still stand, as well as any Programme of activities (PoA) already registered.
The economic climate of a country greatly contributes to the mind-set of a potential investor. In a developing country the need for strong economic improvement is an ever-present demand. A stagnant or linear trending economic environment, lends itself to failure of the adoption of new often, non-essential projects, albeit projects that by effect could help lift that economic zone out of stagnation. Funding and capital employed for projects, needs to clearly demonstrate tangible and real world benefits in order to help justify their use, as well as providing a basis and a launching ground for future capital and monetary requests. However, the benefits to a socio-economic system of an investment are often rated purely on the classical neo-economic parameters which often overlook benefits in a dynamic societal sense and the potential human based consequences due to lack of funding and growth. Building retrofit can act as a means for stimulating the local economic environment, and help reduce building life cycle costs for owners. However, this needs sound and accurate data capturing and analysis, pre-and post-retrofit, in order to gauge viability for investment as well as providing a platform for future investors to gauge viability for similar projects. Jaccard (2005) defined an energy system as “the combined processes of acquiring and using energy in a given society or economy.” For the purpose of this paper, a focus is placed on the latter, the usage of energy in an urban energy system and the role that retrofitting existing buildings plays in improving user comfort, decreasing building life-cycle costs along with providing energy security and societal improvements through local economic improvements. These needs to be divided into short-term goals that focus on the building itself as well as the longer-term governmental energy use targets.

3. RESEARCH CRITERIA AND METHODOLOGICAL APPROACH

The basic rationale of this paper is the analysis and dissemination of an existing buildings thermal behaviour, through thermal measurement, pre- and post-retrofit (using temperature sensors and electrical usage meters to have real-time data), with a break down and discussion on the effects of the buildings current HVAC management system. The building’s thermal conductance characteristics were evaluated and discussed pre-retrofit in order to establish a base point for current building operational parameters. This base point will be critically analysed in order to gauge building functionality characteristics for an existing building. These data will be used to formulate a best practice approach to building energy management, using real time data and measurements (temperature and energy usage) in order to better understand deficiencies in current management practices and highlight cost effective retrofits and passive strategies to decrease building life cycle costs, with the aim of improving user comfort while decreasing energy costs. Beyond just reducing load profiles, any energy management plan implemented must have the aim of reducing peak hour loads. Mitigating South African current energy crisis through this shift of peak loads to off peak periods where energy is more sustainable (in a broader economic scope) as
well as being cheaper for the consumer. This practice of shifting peak loads, reduces cooling’s costs without effecting user comfort and providing greater energy security for the building and for the national grid.

4. THE CASE STUDY: BUILDING ENVELOPE RETROFIT THROUGH LOW-E WINDOW INSTALLATIONS

Building envelope performance relies on many factors, factors such as the thermal conductivity of the envelope material. Thermal conductivity is the relation of the materials intrinsic ability for heat transfer. Thermal storage characteristics are also important, how a material gains and dissipates heat is critical to any retrofit and energy management plan. The focus for the first phase of the retrofit was on window performance. Glass/windows have much higher U-values (Thermal transmittance characteristics) than concrete or brick, meaning heat gain through windows in comparison to concrete or brick is much higher and quicker. However, unlike concrete and brick, windows do not exhibit thermal creep when exposed to a heat source. Installing windows with Low-E (emissivity) should reduce thermal transmittance during peak period of high temperatures, thus lowering room temperatures, and improving user comfort during the daily extremes. However, these installations will not prevent thermal creep later on in the evening due to the surrounding façade. These energy efficient window systems play a role in increasing the building façade performance, helping to bring existing buildings in line with current design codes as well as improving the look and value of a building. Due to variables present in an operational building, gauging a retrofits quantitative benefit is made difficult. As such actual temperature differences were not deemed as the definitive definition of success, a change in the temperature profile of the building will indicate the consequent effects of the retrofit. The aim of the first phase of the retrofit was the reduction of the high load duration, with respect to temperature profiles and volatility to the external environment. Any apparent reduction leads to lower cooling costs and a more predictable thermal gain profile, allowing easier energy management, along with a more constant and comfortable internal user environment. Thermal sensors placed throughout the building were recorded pre-retrofit in order to establish a base point. The data post-retrofit were compared to these in order to note any changes to the building’s thermal profile. Changes in this thermal profile will correlate closely with the load profile and provide evidence that the retrofit was a success or failure. For the case of this paper three office rooms were chosen through interviews on user habits and location.

- **Room 1**: Sun facing, with constant air-conditioning use and continually occupied by a single educator. This room will undergo the window retrofit.
- **Room 2**: Sun facing, with constant air-conditioning use and continually occupied by a single educator.
- **Room 3**: This room is on the protected, fully shaded side of the building.
From the above thermal profiles it is apparent that the thermal profiles of the offices mimic and closely follow that of the brick face. The shaded face hardly exhibits any change in the thermal gain profile. This shows that the external environment does have an effect on the internal environment to a larger degree than that of the internal environment.

From the graph characteristics (in Figure 4.2) it is clear to see how the chiller unit cycles, trying to combat the thermal creep from the exterior. When the exterior temperature is at a max, or constant temperature, the chiller unit cycles off and on, as the temperature in the room decreases and increases. When the external temperature decreases the chiller unit does not switch on, as it is not needed. However, the area that is of greatest interest is how the chiller behaves when the external temperature is rising. It is noted from the graphs that when the external temperature rises, the chiller unit does not cycle and instead operates constantly without being able to bring the room temperature back down to a base point. This is an area of great inefficiency and greatly contributes to an increased energy load during those rising temperature periods. The success of the retrofit needs to be gauged on how these sharp rises in thermal creep can be flattened out providing a more constant internal thermal environment that the chiller units are better suited to handle with normal cyclic operation. These characteristics are illustrated below.
These profiles help identify weak areas in the building’s performance as well as provide a base profile for gauging the effects of that energy efficient window retrofit.

Due to variables such as user habits and external temperature differences it is hard to accurately compare pre vs. post-retrofit data. However, the data do indicate a large shift in the thermal profiles post retrofit.
Previously Room 1 exhibited higher overall room temperatures than Room 2. In the post retrofit phase, this was reversed and Room 1 had a lower thermal profile than Room 2.

Table 4.1 Time vs temperature differentials.

<table>
<thead>
<tr>
<th>Time</th>
<th>Temp (°C) Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>06:00-07:00</td>
<td>0.57</td>
</tr>
<tr>
<td>07:00-08:00</td>
<td>0.70</td>
</tr>
<tr>
<td>08:00-09:00</td>
<td>0.88</td>
</tr>
<tr>
<td>09:00-10:00</td>
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<tr>
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<td>0.97</td>
</tr>
<tr>
<td>11:00-12:00</td>
<td>1.10</td>
</tr>
<tr>
<td>12:00-13:00</td>
<td>0.95</td>
</tr>
<tr>
<td>13:00-14:00</td>
<td>0.90</td>
</tr>
<tr>
<td>14:00-15:00</td>
<td>0.67</td>
</tr>
<tr>
<td>15:00-16:00</td>
<td>0.95</td>
</tr>
<tr>
<td>16:00-17:00</td>
<td>0.79</td>
</tr>
<tr>
<td>17:00-18:00</td>
<td>0.73</td>
</tr>
<tr>
<td>18:00-19:00</td>
<td>0.62</td>
</tr>
</tbody>
</table>

The average temperature per hour indicates a change in temperature between the two rooms with an average 0.85 °C of difference. This temperature difference is greater during the warmer periods, meaning that the energy efficient windows perform as expected and correlate with theoretical assumptions. Performance increases the greater the external temperatures are. This change in thermal gain should also reflect in how the chiller unit cycles. A lower and more constant thermal ingress allows the air-conditioning unit to operate in a more efficient manner, thus increasing energy efficiency as a direct result.

Figure 4.4 Chiller cycling profile: post-retrofit phase
Previous pre-retrofit data showed that the chiller unit was not cycling when external temperature was rising. In the post-retrofit phase, it is evident from the graph in Figure 4.4 that the chiller units are operating more efficiently in the retrofitted Room1 (in comparison to previous graphs, and to Room2) the chiller units show evidence of cycling while the external temperature is climbing. This would help indicate that the internal room environment has a more constant thermal profile compared to the non-retrofitted room.

5. RESULTS AND DISCUSSION

Sample Room 1 and sample Room 2 were selected for comparison due to their similar characteristics and like user habits. Thermal sensors were placed in the brick, on the window frame, and in the centre of selected rooms. Data were collected and thermal profile was established for the selected rooms. In the pre-retrofit phase thermal data indicated that Room 1 had a higher rate of heat ingress then Room 2. Moreover, data indicated at how the chiller units operate (when it comes to cycling). It was found that efficient cycling of the units was not evident when the external temperatures were climbing during the warmer hours of the day. Perceived user comfort was indicated at being comfortable; however, during the warmer hours of the day or if there was an air-conditioning fault this user comfort suffered and was aid to be noticeably less comfortable to occupy the rooms.

In a second phase, Room 1 underwent an Energy Efficient Retrofit (EER) in the form of a Low-E window installation. In this case, thermal data indicated that Room 2 now had a higher thermal profile in comparison to room 1 (this is a switch from pre-retrofit data). This indicates that the rate of heat ingress into the retrofitted room1 was substantially lower than the standard room 2. A difference in how the chiller unit operates was also evident, Room 1 showed evidence of cycling of the chiller unit during the warmer period when external temperatures were increasing, in comparison to the standard Room 2 and in comparison to previous pre-retrofit data of the same room. Perceived user comfort indicated that the room “felt” cooler and was a comfortable working environment.

5.1 Natural ventilation: Discussion on viability and benefits

Gauging a building's internal environment relies on many factors such as: temperature, air velocity, relative humidity and air quality (i.e. pollutant factors). These factors, including local climatic variations mean that designing passive based natural ventilation system is a complex procedure. For the case of this study a theoretical, best practice approach was taken, looking at the potential for a passive airflow system to be adopted (in line with the current building configuration) in order to improve internal building air quality and to enhance the building's thermal performance, thus causing a reduction in cooling loads and an enhanced internal environment. The focus being on a night time “airflow management retrofit”, aimed at cooling down the building using a purely non mechanical means, providing improved air
quality for occupants in the morning, while simultaneously improving user comfort levels and reducing cooling costs. The building has a unique attribute of having one face fully exposed to the elements while the other face is partly sheltered by trees, nearby buildings and a grass bank. This leads to the building having temperature differentials on either side of the building along with a theoretically different wind speed on either face of the building. These variations are greater during the warmer daytime hours, however between the hours of 17:00 and 6:00 the values converge before diverging due to the effects of solar heating on the exposed face. For the purpose of this research night time hours will be defined as 17:00 to 6:00 being the times when most occupants leave the building and conversely arrive at work. Below is an average representation of the temperature difference between the two buildings faces and the internal temperature (all cooling systems turned off) between those hours, for warmer summer months and for cooler winter periods.

![Figure 5.1 Temperature differentials - warm months](image)

**Figure 5.1** Temperature differentials - warm months
5.2 Role of temperature and pressure differentials in ventilation

A temperature difference between the internal and external air environments will create a “natural draft” forcing air to flow through the building. The direction depends on temperature, warmer air is less dense than cooler air, hence warmer internal air will flow up and out the upper parts of the building while cooler external air will flow into the lower parts of the building. In the case of this case building, the protected face of the building will have slower façade wind speeds; in comparison to the non-protected face this causes pressure differences. As air speeds up its pressure drops meaning the protected face has a higher pressure across its façade than the non-protected face. Since wind (drafts) is produced by differences in air pressure a naturally occurring gradient would occur between the two faces of the building. This naturally occurring effect can and should be utilized in order to naturally cool and ventilate the building at night without the addition of artificial mechanical means. There is a clear difference between the air temperatures on both sides of the building and between the outside and inside temperatures. This observation is critical in understanding the viability and the theoretical success of a natural night time ventilation strategy.

6. CONCLUSION

Energy management is the key to lowering a building’s operating costs, and with cooling accounting for a large portion of these costs an obvious focus on tracking the buildings thermal gain is critical. This study means to provide a base measurement and verification platform for the building pre and post-
retrofit, highlighting areas of inefficiency. The energy efficient window system was found to make a marked noticeable difference. The gains will be more noticeable the warmer the external environment becomes, allowing the air-conditioning system to operate more efficiently and economical. The EE window systems were seen to reduce the intensity and duration of peak temperatures. These data must now be used to better manage when and how the buildings cooling system is used. A shift to off peak use is the aim, from the thermal gain graphs a shift away from 24 hour cooling must be the basis of further experiments. This can be done through the use of a passive cooling strategy. A strategy like this would reduce costs and improve the internal environment of the building.

Further study needs to be carried out to ascertain the actual real world performance of a passive system. With energy issues currently around peak periods and the high price of peak power, this shift away from peak energy usage can reduce cooling costs substantially, while contributing to providing justification for the investment of the retrofit.

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Passive design strategies applied to office buildings in Gauteng

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ABSTRACT

Purpose: To ascertain which passive design strategies are adopted in the design of commercial office buildings in Gauteng, and whether passive strategies are viable alternatives for achieving both human comfort and energy-efficiency.

Research Design: Architects of eight Green Star rated commercial office buildings were interviewed to determine which passive strategies they had used or not used and the reasons therefore.

Delimitations: Only modern office buildings between four and eleven storeys high which had been designed according to passive principles were considered.

Empirical research findings: A key finding was that buildings are designed to achieve the aimed-for Green Star rating, rather than to be as energy-efficient as possible without negatively affecting the occupants.

Value of paper: This study contributes to the knowledge-base on the implementation of green building strategies in South Africa.

Practical implications: This study provides designers with information on the most commonly-used passive design strategies in office buildings in Gauteng.

KEY WORDS
Passive design; energy-efficient; Green Star; sustainable building; Gauteng.
1. INTRODUCTION:

There is a general trend in the world today towards leading more energy conscious lives. Whilst buildings can consume excessive amounts of energy, they can also be designed to use energy more wisely. Energy efficiency, especially in the construction industry, has recently gained popularity in South Africa, and Gauteng’s climate is one that could gain from the benefits of passive design strategies to decrease energy consumption (Holm, 1996).

This paper presents the findings of a study undertaken to research and analyse the extent to which passive strategies are applied to office buildings in Gauteng. The objective of the study was to assist Gauteng designers, in particular, in determining whether specific passive strategies are viable design strategies for achieving human comfort whilst reducing energy consumption. Primary data was derived from answers given by designers during an interview process. Secondary data was obtained from published documents and literature relevant to the study. Through the use of both interview results and published literature, the study combined both quantitative and qualitative approaches to the research.

It is well-known that the building sector is one of the largest energy consumers and greenhouse gas emitters (Biello, 2013). On the other hand, the building sector has the potential to significantly reduce primary energy use and subsequent CO\textsubscript{2} emissions (Dodoo et al., 2011).

While South Africa has a rather benign climate, our buildings, both old and new, have failed to use this advantage to its full potential. In summer the buildings are hot, while the opposite is true in winter. The need for building occupants to be comfortable has led to the installation of energy consuming heating and cooling devices. Although these devices may initially have a relatively low cost, their nature of being high energy consumers results in an on-going cost for the building owners (Holm and Viljoen, 1996).

In recent years, South Africa has experienced an increased interest in green construction. This interest may be partly due to new environmental legislation and the ever-increasing pressure from developed countries. The Department of Minerals and Energy (DME) set out energy efficient targets in 2003 and requested the industry to establish a code for energy-efficiency in buildings. This was as a result of a study put forward by the DME which revealed South Africa’s increasing need for electricity. It was clear from the study that South Africa would run out of base electricity generating capacity by 2007 if urgent steps were not taken to limit energy consumption (Barnard, 2009).

The South African National Standard (SANS) 204 was introduced with the aim of specifying design and construction standards to ensure energy-efficiency by reducing the building’s energy consumption and thus its energy use.
requirements (Hutchinson, 2011). It is important to note that the SANS 204 objective is to reduce operational energy use of new buildings without reducing comfort and convenience. At first the code was optional, but has since become mandatory (Mulholland and Matshe, 2009).

During 2004, the DME introduced the “Energy Efficiency Strategy of the Republic of South Africa” to address the topic of sustainable development and to identify the benefits of improving South Africa’s energy-efficiency (Mulholland and Matshe, 2009). The electricity regulations stated that all buildings required energy efficient fittings to be in place by 1 January 2010 and that the requirements for the supply of electricity, heating ventilation and air-conditioning (HVAC) systems, as well as the heating of water should be met by 1 January 2012 (Mulholland and Matshe, 2009).

The Green Building Council of South Africa (GBCSA), which was established in 2007, is an independent non-profit company with the aim of being the leader in “greening” South Africa’s built environment. During 2008, the company launched the Green Star South Africa Environmental Rating System for Buildings (Green Star SA) for new commercial buildings that wish to be recognised as being “green” (Mulholland and Matshe, 2009).

From the above information it is clear that South Africa has undergone some major changes in terms of building regulations and legislation in the last nine years. Several energy saving strategies related to buildings such as the use of eco-friendly building materials, the reduction of peak energy demand, and the reduction of GHG emissions both during construction and operational use of the building are available to designers now more than ever before (Leskovarv and Premrov, 2011).

South Africa is regarded by Dieter Holm as having suitable climates for the successful use of passive solar design. It has been proven that the correct application of passive design strategies has, amongst others, the direct effect of significantly reducing the energy consumption of a building, while the indirect effects of passive design include improved health and reduced environmental pollution (Holm, 1996). Designing all types of buildings according to passive principles is thus a viable and feasible option to reduce energy consumption. This will benefit all South Africans because a reduction in energy demand will assist in postponing the need for additional energy supplies (Holm, 1996).

The goal of this study was thus to determine to what extent passive principles and the appropriate strategies are applied to office buildings in Gauteng and ultimately to assist South African and, particularly, Gauteng designers in determining whether specific passive strategies are viable alternatives to active strategies as the primary design consideration for modern office buildings in the country’s emerging energy-efficient philosophy.
2. BACKGROUND TO THE STUDY

South Africa is currently Africa’s largest (Aneki, 2012), most refined and diverse economy (Gauteng Online, 2007). Over time, Gauteng’s economy has evolved from one focused on agriculture and mining, to one dominated by finance, trade and services. Johannesburg is ruled by finance and business services, while Pretoria’s economy centres on Government services, motor vehicle businesses and transport (Gauteng Online, 2007). It may be argued that Gauteng has had to construct suitable office buildings to support a growing number of financial and service-based businesses.

Just as South Africa’s economy has evolved, so have humans’ need for comfort. It has been suggested by multiple studies that people are more content and, therefore, more productive when they are in a comfortable and stress-free environment (Paul and Taylor, 2007; John, et al., 2005). It has also been found that the occupants of buildings are more frequently demanding healthier and more stimulating work environments (Gratia and De Herde, 2003; Menzies and Wherrett, 2005).

Changes in the operating environment are impacting on the building sector in a tremendous manner (John, et al., 2005). The cost of electricity in the country has risen rapidly over the last few years as the National Electricity Regulator of South Africa (NERSA) approved increases in excess of 20% each year since 2008. The price of electricity will continue to rise by 8% per year until 2017 (Botes, 2012). The questions of sustainability have also begun to impact the lives of individuals, corporations and the broader society on a daily basis, which is giving rise to increased opportunities for responsible and holistic thinking by the construction industry (John, et al., 2005). It is thus important that designers are able to design sustainable buildings which meet the client’s requirements and satisfy the demands of the building users, whilst both consuming the minimum amount of energy in the process, and considering the effects that such demands will have on the environment as a whole (Holm, 1996; van Wyk, 2009).

The concept of passive building design has been around for many years, and although there is documented evidence that supports the concept, there are still only a few dedicated practitioners who have adopted it (Peterkin, 2009). The question that remains to be answered, is whether or not passive design is being applied to its full potential in office buildings, in order to achieve optimal levels of human comfort while reducing the energy consumption?

This paper summarises the findings of a study which sought to determine the current application of passive design strategies in commercial buildings in Gauteng.
3. RESEARCH DESIGN

Research questions

The foundation of this research developed from the following general questions: Is the construction industry proactively becoming energy-efficient? Do architects design only what is appealing from the outside, or do they consider environmental aspects, comfort and energy-efficiency before they put pen to paper? Is the use of energy-efficient technology really necessary if buildings are designed correctly? Is the construction industry in South Africa adopting or rejecting the sustainable practices of past generations? Are passive strategies being used more now, or are designers moving towards active strategies, or is a combination of both being used?

From the above questions, the research question: “Which passive design strategies are commonly applied or not applied to office buildings in Gauteng, and why?” emerged. In order for the main research question to be answered, the study was broken down into three sub-questions. The sub-questions were laid out as:

- **Sub-question 1**: Which passive design strategies are applicable to the specific climatic conditions of Gauteng?
- **Sub-question 2**: Which passive design strategies are commonly applied or not applied to office buildings in Gauteng?
- **Sub-question 3**: Why are the passive design strategies identified in sub-question 2 applied or not applied to office buildings in Gauteng?

Simply put, the study looked at passive design strategies relevant to the specific climatic conditions of Gauteng. Thereafter, the study aimed to determine the extent to which passive design strategies were applied or not applied to office buildings in Gauteng, and the reasons therefore.

Research methodology

Qualitative and quantitative methods of data collection were used in order to answer the individual sub-questions, as well as the research question as a whole. The main data-gathering instruments for this study were literature-based, desktop studies and loosely structured interviews.

The question, “Which passive design strategies are applicable to the specific climatic conditions of Gauteng?” formed the theoretical basis of the study. A desktop study was conducted to determine which passive strategies were relevant to the conditions of Gauteng. The information obtained from sub-question 1 formed a basis for the development of an evaluation framework. The interview template used to collect the data for sub-
questions 2 and 3 were structured according to the layout of the evaluation framework developed in sub-question 1.

In answering the second sub-question, namely "Which passive design strategies are commonly applied or not applied to office buildings in Gauteng?", the interview template developed from the aforementioned framework was utilized during the interviews. The interview consisted of 53 building-related and 12 architect-related questions. This allowed the author, to determine the areas where passive strategies have been applied in the various designs of the buildings being investigated.

The same aforementioned interview template was used in answering the third sub-question of, "Why were the passive design strategies identified in sub-question 2 applied or not applied to office buildings in Gauteng?". The question was asked in order to gain an understanding of why designers applied certain passive strategies and not others to their designs.

A sample of nine certified buildings was drawn from the population of buildings on the GBCSA website. Three prominent architecture firms involved in the design of numerous medium-rise office buildings were identified from the sample. The architects of said buildings were then approached to take part in the study. Of the sample of nine buildings, one architect declined the request to participate in the study, resulting in a total of eight buildings being investigated. One architect designed two of the buildings in the study.

The interviews were divided into building-specific questions and architect-specific questions. The building-specific questions were asked to determine which passive strategies had been applied or not applied to which areas of the design, and the reasons behind the decisions. The architect-specific questions were asked in an attempt to gain an understanding of what the architects’ opinions on passive design were. Although quite loosely structured and flexible, the interview had a specific plan of enquiry, the basis for which was a formal set of questions. The goal of the interview was to generate a discussion surrounding the main research question. These formal interview questions were prepared in advance and were altered if it seemed appropriate as the interview progressed. While the precise wording of questions varied from time to time, certain questions were pro forma. All interviews were performed on an individual basis.

**Data Processing and Analysis**

After gathering data from the completed interviews, the responses were tabulated and analysed. This enabled the author to compare the architect’s answers in order to determine whether or not there were trends and patterns in the use of passive strategies.
Ethical Considerations

As this study required the involvement of human respondents, specifically design professionals, certain ethical issues needed to be addressed. The consideration of these ethical issues was essential for the purpose of safeguarding the confidentiality as well as the security of the respondents. The significant ethical issues that needed to be considered in the research process included permission by the respondent to use information provided by them, and confidentiality of information not relevant to the study. In order to secure the permission of the selected respondents, the researcher relayed all of the important particulars relating to the study, including its aim and purpose before the start of each interview. Each of the respondents was then given an informed consent form to read and sign before the interview commenced so that they understood the significance of their role in the achievement of the research. Respondents were not forced to participate in the research and were advised that they were entitled to withdraw from the study at any time during the interview process.

Delimitations

Gauteng was selected because it is the business and financial hub of South Africa (Gauteng Online, 2007), and many modern commercial office buildings may be found in the region. Only medium-rise, modern office buildings were considered in the research, which included buildings between four and eleven storeys high, built since 2009. Only buildings with Green Star ratings were considered in the research. This limited the author to perform the study on the most relevant office buildings that have passive design strategies incorporated in the design, and was done in an attempt to enhance the possibility of comparative analysis between the buildings. The architects of such buildings were the only respondents interviewed in relation to the buildings.

4. FINDINGS

After an analysis of the information obtained from the interviews was conducted, the following findings were reached.

Sub-question 1

Which passive design strategies are applicable to the specific climatic conditions of Gauteng?
The climatic conditions of Gauteng were the primary influence in determining which passive design strategies were relevant to Gauteng-based office buildings. The results from the desktop study indicated that passive principles and certain strategies are relevant to the climate of Gauteng. The passive design strategies which may be most successfully applied to office buildings are summarised as: orientating the building northward; designing a shallow floor plan; using skylights to provide natural light; providing openable windows; using high performance insulated windows and frames; insulating the building; using thermal mass in conjunction with insulation; providing shading to the façade, roof and interior; employing passive means of ventilation in conjunction with high performance HVAC systems; using night time ventilation; using climate appropriate materials; and using roof ponds to insulate and cool a building.

Sub-question 2

Which passive design strategies are commonly applied or not applied to office buildings in Gauteng?

The evaluation framework revealed that the most commonly applied passive strategies are: orientation; skylights; high performance insulated windows; insulating the floor and building envelope; thermal mass; shading the façade and interior; night time ventilation; reducing air infiltration; and using climate appropriate materials. The least commonly applied passive strategies are: openable windows; insulated window frames; insulation of the roof; thermal batteries; roof shading; passive means of ventilation in conjunction with high performance HVAC systems; and roof ponds.

Sub-question 3

Why are the passive design strategies identified in sub-question 2 applied or not applied to office buildings in Gauteng?

The findings presented below are of only six of the 53 building-related questions posed to architects during the interviews. These findings are presented as they are the most relevant passive strategies which represent the Gauteng climate.

<table>
<thead>
<tr>
<th>Question</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Is the building orientated according to sunlight?</td>
<td>5</td>
<td>3</td>
</tr>
<tr>
<td>2 Does the building have a shallow floor plan?</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>3 Are exterior double pane windows used?</td>
<td>7</td>
<td>1</td>
</tr>
<tr>
<td>Question</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>-------------------------------------------------------------------------</td>
<td>-----</td>
<td>----</td>
</tr>
<tr>
<td>Is the entire building insulated?</td>
<td>2</td>
<td>6</td>
</tr>
<tr>
<td>Are external shading devices used?</td>
<td>6</td>
<td>2</td>
</tr>
<tr>
<td>Is passive natural ventilation used? (Stack driven)</td>
<td>1</td>
<td>7</td>
</tr>
</tbody>
</table>

Five buildings were orientated according to the sun to take advantage of natural sunlight in the form of lighting and a reduction of solar heat gain. Three of the buildings were not orientated according to sunlight. In two instances, the reasons were that the site boundaries and bulk requirements limited the orientation of the buildings. It was fortunate, however, that the orientation was northwards. The reason for the third was that the original north-west orientation was dictated by views required from outside. This orientation is the worst orientation for the Gauteng climate.

Four of the buildings have a shallow floor plate. The reason for two of the buildings having a shallow floor plate is that the atrium used is very big. The third building is relatively small and rectangular, therefore, a shallow floor plate is to be expected while the fourth building has been specifically designed to have a shallow floor plate in order to let light enter the building. The reason behind four buildings having a deep floor plan is that they all make use of atriums to increase the amount of light entering the building. The use of atriums also adds to comfort levels as occupants are able to look outside or into the atriums.

Seven of the buildings used double glazing for its thermal insulation properties. Two of the buildings chose only to use double glazing in certain areas, where the energy model indicated it was required, as it is very costly. One of the buildings has used double glazing as part of a triple glazing system. Three of the buildings used double glazing for the acoustic insulation characteristics. One of the buildings does not make use of double glazing because of the cost associated with the type of window, the unsubstantial decrease in sound insulation, and the fact that the energy model indicated that double glazing was not a requirement for the building.

All eight of the buildings had roof insulation in one form or another. The main reason for this was to reduce solar heat gain through the roof. Three respondents stated that they had used energy models to determine the type and placement of insulation. The envelopes of seven of the buildings were insulated in some way to reduce the flow of heat through the envelope. Three buildings used insulation material on the interior walls while four buildings have some form of cavity wall. One building did not make use of any insulation in the building envelope because energy models suggested that it was not necessary. Two of the respondents chose to insulate the ground floor slab to reduce the flow of heat through the slab. Of the six buildings which did not have insulation on the floor slab; three did so because the thermal mass characteristic of the concrete slab was desired; while three saw no benefits associated with insulating the slab.
External shading devices were used on six of the buildings. All six buildings used shading in order to reduce the solar heat gain and glare through the windows. The structural building form was used by all of these buildings as a method of shading. Three of the buildings used curtain walls which extended outside from the interior; one building used automated external blinds; one building used automated louvers; while four used fixed louvers. Two buildings did not use external shading devices. The reason for this was purely aesthetics. One building had to conform to the aesthetic theme of the existing buildings on the site, while the client of the second building stipulated a building with a flush glass façade.

All eight of the buildings had been specified with HVAC systems from the initial design stage. The only 6-star rated building studied used passive natural ventilation with an advanced building management system (BMS) and HVAC system. The mixed mode system was chosen so that the building could be ventilated in an economical manner and so the users of the building had more control over their surroundings. All of the other seven respondents chose to not use passive natural ventilation because the HVAC system had already been specified and a passive system would make the pressurised HVAC system less effective. Three of the respondents included the fact that there would be too many sources of heat generated within the building for a passive system to deal with effectively, so mechanical means of temperature control had to be used. One respondent stated that it has become the norm to specify all office buildings with HVAC systems.

The responses to the 53 interview questions revealed that the most prevalent reasons for architects applying passive strategies to the designs were: to achieve the desired Green Star rating; to reduce operational energy consumption; to improve the comfort levels of occupants within the building; and because it was specified by the client. The prevalent reasons for not applying passive strategies to the designs were because: the Green Star rating being targeted did not require additional strategies; it was felt that the strategy was not necessary or beneficial; it was never a consideration during the design stage; it was not specified by the client; the architect was unaware of the product; cost constraints did not allow for high performance products; particular products are not available in South Africa; and for aesthetic reasons.

5. CONCLUSION

South African designers have, in recent years, become more aware of the issues surrounding energy-efficiency and sustainability in the construction industry, and changes have clearly been made in terms of green architecture, but there is a long way to go if the country as a whole is to become an icon of sustainable living.
This study has found that designers are currently relying heavily on energy-efficient active strategies rather than adopting more passive strategies to achieve a reduction in operational energy consumption. This may be attributable to several factors including, but not limited to: the architects and design consultants not being aware of the advantages of certain passive strategies; architects not being confident enough in their knowledge to design strictly according to passive principles; and the architect simply not wanting to apply the strategies for aesthetic or other reasons. It is therefore necessary for the design consultants and clients to demand that the architect designs according to passive principles and strategies to achieve energy-efficiency.

If, on the other hand, it is the client or design consultants who are specifying that unnecessary active systems be applied, it is up to the architect and the rest of the design team to insist that there are other, more energy-efficient approaches to building design, like passive design, that should be followed in South Africa in this day and age. It is therefore imperative that an inter-disciplinary approach is followed during the design and construction of buildings, and that all parties involved have sufficient knowledge about green design and energy-efficiency to make the most appropriate choices when designing according to the prevalent climate.

It has also become apparent from this study that buildings are being designed to achieve the Green Star rating which is being aimed for. So in terms of design, if a 4-star rating is the aim, the building may be designed in a less efficient way than a 6-star building. The inefficiency may then be corrected by a highly efficient active system, rather than the building being designed so that it does not require such active system to begin with, or that it requires a much smaller one. Alternatively, the low score achieved due to the inefficient design may be mitigated by higher scores in different sections of the rating tool, for example, if the materials chosen are procured from sources nearby the material section will receive a higher score. It also appears that because HVAC systems are being specified at the start, meaning that the buildings are being designed for HVAC systems rather than being designed to not need HVAC systems, the design of buildings is less energy-efficient than it could be. This study has found that the actual design of a 6-star building will be far superior in terms of energy-efficiency than that of a 5 and 4-star rated building. Implementation of the Green Star system is making people more aware of green building, and has improved the overall greenness of buildings wishing to be certified. It must however be noted that the rating is not specific to the actual energy-efficiency of the design, as the Green Star system takes into consideration green strategies unrelated to design, such as water usage and material transport distances.

The SANS 204 code concentrates specifically on the energy-efficiency of buildings, which will directly relate to the design strategies followed. The implementation of the SANS 204 code is therefore more of a move towards
energy-efficient buildings than the Green Star rating because it is obligatory and it is specific to the energy-efficiency of buildings. It is forcing architects, clients, engineers, tenants and the general public to reconsider the way in which buildings have been designed and constructed over the last few decades. This has sparked a review of age old passive strategies for achieving human comfort in buildings. An increase of mandatory codes such as SANS 204 will be beneficial in that obligatory provisions will require the bar to be raised, pushing for better designs.

This research has created several questions in the area of passive design and modern architecture. It is recommended that further research be undertaken to: investigate why buildings are being designed in such a way as to only obtain the targeted Green Star rating, instead of designing it to use as little energy as possible whilst maintaining comfortable internal conditions for the occupants and; determine if the increased availability of energy-efficient active strategies for managing indoor climate and comfort is resulting in the decreased use of passive design strategies and what may be the implication of this for other sustainability goals?

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Green Concrete. An investigation into the use of waste materials for concrete applications

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ABSTRACT AND KEYWORDS

Purpose: This paper aims to investigate the viability of selected waste materials for use in concrete, in terms of the impact on workability, compressive, flexural and splitting strength relative to conventional concrete.

Design/methodology/approach: An experimental analysis compared the workability, compressive flexural and splitting strength of concrete modified with varying proportions bottom ash, recycled high density polyethylene (HDPE) pellets and sugarcane bagasse fibres (SCBF) to conventional concrete.

Research limitations: The paper is part of on-going research and did not assess the effect of moisture, elastic modulus, durability, and possible long-term strength benefits of bottom ash.

Findings: The experimental analysis indicated that the selected waste materials are best used independently. Some mixes exhibited benefits such improvements to splitting strength in the case of SCBF however all selected waste modified concrete showed a decrease in compressive strength and hence any possible applications would be non-structural.

Response to conference theme: The research proposes possible alternatives to conventional concrete for potential non-structural applications in construction.

Practical implications: The proposed waste materials, if used in the recommended proportions, could be used as possible non-structural alternatives to virgin materials for applications in the South African construction industry.

Keywords: Green Materials, Concrete, Waste Materials.
1. INTRODUCTION

The increasing global population brings about an increase in resource consumption and waste production, thus rendering current practice unsustainable in the long-term if changes in consumer behavior or waste reduction measures are not employed. It is therefore necessary for each facet of society to conserve the environment in one way or another. The construction industry has played an active role in this regard producing sustainability assessment tools such as Leadership in energy and environmental design (LEED) (U.S Green Building council, 2014) and Green Star (Green building council SA, 2014), incorporating energy efficiency into buildings through codes such as SANS 204 (SABS, 2011) and using materials which are more sustainable and environmentally friendly.

This paper will be based on investigating the use of recycled high density polyethylene (HDPE), sugarcane bagasse fibres (SCBF) and coal bottom ash in concrete. By reducing virgin mineral consumption and utilizing waste this supports environmental preservation. However in order for the waste concrete alternatives to be viable they must be economically feasible whilst meeting the basic requirements of the conventional concrete or offer enhanced properties at a premium.

This study will first compare properties such as compressive strength and flexural strength for mixes using varying proportions of waste in order to find the relative best proportion. These best proportions will be combined to form mix waste variations (SCBF + HDPE, HDPE + bottom ash etc.) and results will be assessed.

Based on the outcomes of the strength experimental analysis the respective waste mixes may be potentially used in either structural or non-structural uses. The economic viability of these mixes will be evaluated using models based on their proposed structural/non-structural uses and comparing them with conventional concrete. After comparing properties and economics the waste mixes will be viable if they meet the basic strength requirements of conventional concrete and are economically beneficial or provide superior performance to conventional concrete at a premium.

2. BACKGROUND AND LITERATURE REVIEW

Concrete is traditionally a combination of water, cement, coarse aggregate and fine aggregate. Globally around 25 billion tonnes of concrete is produced every year (CSI, 2009) and the amount of annual concrete production is roughly twice as much has the total of other building materials combined (Eco smart concrete, 2000). Research in to cement and aggregate substitutes have been investigated in order to enhance concrete properties or offer a cheaper alternative to concrete. Considering the rise in global waste production, by incorporating waste into such a widely used construction material, the effect of waste reduction and reduction in virgin
mineral use can have a potentially greater significance. This paper will therefore investigate the viability of sugarcane bagasse fibre (SCBF), High density polyethylene (HDPE) and coal bottom ash as potential partial substitutes for stone and cement.

Sugarcane is produced in large volumes in KwaZulu-Natal and bagasse is a fibrous bi-product from the sugar extraction process. In 2010 South Africa produced 6746000 metric tons of bagasse fibre (UN Data, 2013). SCBF is currently utilized as fuel source by mills for power generation. Research by C&CI and showed that the minimum volume to induce an improvement in mechanical properties is roughly 3% by volume (C&CI, 2013). Sivarja et al. (2010) showed that with a lesser volume fraction of 1.5% increases in compressive, tensile and flexural strength can be noticed. Racines & Pama (1978) researched the effect of using larger substitutions of 10, 20 and 30% and showed that with these high volume substitutions, decreases in strength can be expected.

HDPE has many modern day applications such as: drainage pipes, bottle caps, chemical container bottles, milk bottles, and shopping bags etc. but unlike bagasse it takes in excess of a human lifetime to degrade. Plastic production has been on the increase and so has recycling as shown by the 2013 plastics recycling survey conducted by Plastics S.A which indicated that the amount of recycled plastic is increasing every year with HDPE being the fourth most recycled plastic in South Africa. Recycling is a more environmentally friendly alternative to the practice of burning or landfiling waste HDPE and hence recycled HDPE was chosen to be investigated as a possible virgin aggregate substitute as it is renewable to an extent and incorporating it for use in concrete can aid in promoting recycling. Past research by Al-Manseer & Dalal (1997) showed that for high volume proportions of 10%, 30% and 50% splitting strength decreased with increasing HDPE proportions and Rahman et al. (2012) concluded that concrete modified volumes of 10-40 material substitution would be best used as a non-load-bearing application at 10% substitution albeit a decrease in compressive strength was noted for all substitutions.

Coal bottom ash is a coarse sand to fine gravel grain sized, incombustible material found at the bottom of coal boilers after the coal has been burnt (Kumara & Kaya, 2007). The most common source of coal–bottom ash is electricity power-plants. Coal bottom ash from the sugar mills is usually disposed in large ash dumps. Hence an adequate performance of coal bottom ash as a cement substitute could promote its use on a large scale and therefore clear areas of land used as ash dumps. This would mean both environmental benefits and economic viability due to the lower cost of concrete by reducing cement costs. Separate research by Singh & Siddique (2013) and Andrade et al. (2006) on bottom ash as a replacement for fine aggregate showed decrease in the 28 day strength of concrete specimens with the best results being noticed from between 10-25% materials substitution. Kurama & Kaya (2007) showed that compressive and flexural strength improved up to a substitution of 10% in comparison to conventional concrete however above the 10% substitution strengths decreased relative to the control mix.
This paper will investigate a range of substitutions of HDPE, SCBF and ash in order to evaluate low volume substitution further from 2.5% - 5% and also the maximum volume at which a negative impact on strength properties occur by investigating 10%, 20% and 40% substitutions. Research onto mixing waste material is also uncommon and hence another potential knowledge gap was noticed which the paper will aim to address. The studies conducted did not add an economic analysis to put into context the viability of the waste concrete and this knowledge gap will be addressed by the paper in the form of a basic economic feasibility analysis based on industry costing rates.

3. METHODOLOGY

The research methodology comprised of experimental analysis over a range of waste material substitutions and incorporated an economic feasibility analysis to conclude the viability of the waste modified concrete and address knowledge gaps identified form the literature review.

These potential knowledge gaps were: the lack of research based on a range of material substitution (low-high percentage), comparisons between waste materials with regards to the impact on concrete and also investigation into mixed waste combinations.

Preliminary data that needed to be tested before the mix designs were: Compacted bulk modulus of stone (TMH1) (CSIR, 1986), Fineness modulus method B13 from TMH1 (CSIR, 1986) and relative density of HDPE and stone from method B14 from TMH1 (CSIR, 1986). The relative density of the bagasse was carried out in accordance with a methodology prescribed by the Sugar Mill Research Institute (SMRI) and involved the displacement of a volumetric cylinder under water load.

The mixes were then designed to the C & CI design methodology (Addis, 2008). The proportions of waste substitution were based on the percentages of volumetric substitution not covered by past research such as Al-Manseer & Dalal (1997), research into large volumes plastic substitutions of 10%, 20% and 30% only and Sivarja et al. (2010), low volume natural fibre substitution of around 1.5% only. A range of 2.5%, 5%, 10%, 20% and 40% substitutions of stone by HDPE and SCBF and cement by bottom ash respectively was selected. This filled knowledge gaps for past research and also enriched information on the topic of waste concrete by comparing wastes and investigating percentages of substitution that have not been researched.

In order to compare the effect of material substitutions compressive, flexural and splitting strengths were tested and results compared.

Compressive strength was carried out in accordance with SABS 863-1994, flexural with SABS Method 864:1994 and splitting with SABS 1253:1994.

The subsequent results from the experimental analysis prescribed whether the concrete modified with respective waste products could be used structurally or non-structurally. The economic feasibility was assessed
costing each mix in terms of cost per cubic metre of concrete and this indicated whether waste modified concrete could be used as a viable alternative to conventional concrete or offer improved properties at a premium.

The cost rates for the economic feasibility were obtained from local suppliers. The rates for SCBF however were not readily available as they are used for power co-generation feasibility studies. A method prescribed by SMRI involved relating the cost rate to that of coal in terms of mass to power generation equivalence.

The paper is part of on-going research and hence limitations to the study included the fact that at the moment the outcomes of the ongoing investigation into modulus of elasticity, effect of moisture content and durability will be available in the near future. For the economic analysis transport and handling fees were not considered as the aim was to look at purely the material cost itself due to variations in transport of materials.

4. RESULTS AND DISCUSSION

A fixed W/C (Water/Cement) ratio of 0.57 was used and the mixes were designed using the C & CI design methodology. All testing (compressive, flexural and splitting tests) were done according to SABS test methods at the university of KwaZulu-Natal lab facilities. Concrete samples were tested after 28-days of curing for compression, flexure and splitting strengths.

![Figure 4.1: Graph of 28-day compressive strength vs. percentage substitution](image)

The Compressive strength tests shown by figure 4.1 indicated that SCBF was the best waste material in terms of compression and coal ash the worst. Ash is however known to only show significant strength increase in the long-term (>90days) as discussed in research by Aggarwal et al. (2007) due to the slow rate of pozzolanic reaction. The points at which
performance peaked for each mix were 2.5%, 5% and 10% for HDPE, ash and SCBF respectively. All mixes showed a decrease in compressive strength however compared to the control (0%) strength of 32 MPa and hence this renders them only viable for non-structural use. At substitutions above 10% rapid decreases in strength were noticed and this is in line with results obtained by Racines & Pama (1978) for SCBF and Rahman et al. (2012) for HDPE. However results differed to those carried out by C & Ci and Sivarja et al. (2010) which showed increase in strength for low-volume substitutions.

The Flexural strength tests shown by figure 4.2 indicated that HDPE was the best waste material in terms of flexure and coal ash the worst. HDPE showed improved flexural strength for substitutions up to 10% and with consideration to compressive and economic results, can be a possible non-structural alternative to conventional concrete with enhanced flexural performance. The points at which performance peaked for each mix were all at 2.5%. HDPE showed an increase in flexural strength however both the SCBF and coal ash showed decreases. These results to the proportional decline in strength it can be deduced that in terms of flexure, low-volume substitutions are the better option. The HDPE should better flexural resistance than the other waste possibly to due to the smaller plastic pellets filling voids within the concrete and offering greater resistance to bending when compressed together under flexural load. The SCBF was less elastic and brittle in comparison to the plastic and hence little flexural support was noticed.

![Figure 4.2: Graph of 28-day flexural strength vs. percentage substitution](image-url)
The Splitting strength tests shown by figure 4.3 indicated that SCBF was the best waste material in terms of splitting strength. The points at which performance peaked for each mix were 2.5, 5 and 10% for HDPE, ash and SCBF respectively. SCBF showed an increase in splitting strength however both the HDPE and coal ash showed decreases. The results obtained for SCBF correlate to those by C &CI and Rahman (2010) which stated that increases in splitting strength were realised for low-volume substitutions. For SCBF, this is possibly because of the fibre strands providing additional resistance to vertical shearing. HDPE and coal ash do not offer the same resistance and hence strengths decreased.
When looking at compression (figure 4.5), flexure (Figure 4.6) and splitting strengths (Figure 4.4) for mixed combinations compared to the optimum individual materials it was noticed the waste materials are best...
used independently of each other. All strength decreased and hence only non-structural applications could possibly be viable.

4.1 Cost evaluation

The economic analysis was carried out by using industry costing rates and applying them to the respective mixes. For this, transport and handling costs were not considered. Figure 4.7 shows these results which indicate that all mixes were economically feasible in terms of cost per m$^3$ of concrete as they were less than the control mix with the mix containing all waste being the cheapest at R1017.56 compared to R1068.03 / m$^3$.

![Graph of Costs per cubic metre of concrete](image)

**Figure 4.7:** Graph of Costs per cubic metre of concrete

5. CONCLUSIONS AND RECOMMENDATIONS

From the experimental analysis it can be seen that based on strength properties the optimum percentages for each waste substitute were 2.5%, 5% and 10% for HDPE, bottom ash and sugarcane bagasse fibre respectively. The SCBF was the best material in terms of compression and was relatively strong in splitting strength. This was possibly due to the fibres entwining with each other and providing additional resistance to shear forces within the concrete. HDPE was strongest in flexural at 28 days flexure compared to the other waste materials and the loss in compressive strength was possibly due to a poor bond interface with the cement matrix. Bottom ash is recommended to be used at 5% substitution for non-load bearing applications to reduce cost, long term strength was not discussed in this paper and this is a possibility for future research. Based
on these results SCBF would be the best potential waste aggregate substitute.

It was concluded that from a strength perspective, materials are best used independently at optimum substitutions of 2.5%, 5% and 10% for HDPE, bottom ash and SCBF respectively, because mixed combinations lowered strength substantially thus rendering them not viable. All waste mixes were economically viable however strictly for non-structural applications due to the reductions in compressive strength relative to the control specimen. By using these waste materials for non-load bearing applications there can be a potential decrease in virgin material as well as a R40 decrease per cubic metre of concrete.

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An application of multi-scale green design strategies to improve the sustainability of low-cost housing in South Africa

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ABSTRACT AND KEYWORDS

Purpose of this paper.
This paper investigates how strategic multi-scale green design strategies can potentially achieve sustainability targets (environmental, social, economic) for low-cost housing in South Africa.

Design/methodology/approach.
A case study of a low-cost housing development in the KwaZulu-Natal Province was assessed. The research adopted a bottom-up approach combining participatory methods through a field audit and interviews with the local community, and a scenario analysis based on the investigation of design alternatives (evaluating densification, building typology, passive design strategies) assessed by sustainability indicators (energy, comfort, cost, social implications).

Findings.
The results demonstrated the potential benefits of multi-scale green design principles in terms of reduction of energy demand, improved indoor comfort, social implications and economic sustainability.

Research limitations/implications.
The study promotes a design approach that can contribute to drive low-cost housing sector toward sustainable living targets.

Practical implications.
The proposed approach and strategies can support planning and design phase of future initiatives of sustainable low-cost housing development in South Africa.

**What is original/value of paper.**
The study addressed a critical field for the sustainable development of the South African built environment, promoting and validating the effectiveness of strategic multi-scale green design measures.

**Keywords:** Green Buildings, Low-cost Housing, Passive Building Design.

1. **INTRODUCTION**

In developing countries the residential sector is expected to have the highest growth potential especially for electricity usage, due to the current large numbers of unelectrified households and the increased levels of urbanisation producing the demand for electricity provision (Davis, 2011).

In South Africa, the sustainable development of housing is particularly affected by the socio-economic issues of the low-cost housing sector (houses for households with income lower than ZAR 3.500 per month - US$ 328,02 at the exchange rate on the 1st of July 2014 of US$ 1 = ZAR 10.67). The common low-cost housing practice has often been characterised by low environmental quality, impeding also social interaction and community living. Rethinking and greening the low-cost housing design principles represent firstly an opportunity to striving social inequity and improve the quality of life of communities. Furthermore, the energy consumption patterns of low-income households have emerged as one of the most important factors influencing the national electricity demand (DHS, 2009), demonstrating their relevant environmental and energetic impact.

The problem motivating this study is that the traditional low-cost housing design practice has not aided low-income communities to achieve sustainable living targets. The research question is therefore oriented to understand if alternative low-cost housing design approaches and strategies could foster the sustainability of low-income communities, in terms of energy saving, better comfort, social benefits and affordability. The hypothesis investigated in this paper is that the complex environmental and social issues relating to the living conditions of low-income communities need to be addressed with a holistic and integrated bottom-up approach to low-cost housing design, combining systemic green strategies at various scales (settlement, typology, housing units, materials).

The rationale of this study is therefore to investigate how a strategic bottom-up approach and multi-scale low-cost green design principles can potentially achieve environmental and social sustainability targets for low-cost subsidised housing with economic effectiveness. The research adopted a case study method, investigating the potential benefits of optimised green scenarios for a low-cost housing development in KwaZulu-Natal. Firstly, a
participatory method through a field audit and interviews with the local community was used to understand the actual needs and main criticalities. Then, a scenario analysis was adopted to explore possible design alternatives to the common practice (based on densification, building typology, passive design criteria such as orientation, surface area to volume ratio, thermal insulation) and evaluate the potential benefits through sustainability indicators (relating to energy, environmental, social and economic impact categories).

Starting from a background study on South African low-cost housing, the paper describes the research methodology and then discusses the results of the survey and the scenario assessment. Finally, the paper summarises the potential benefits of the adopted multi-scale green design strategies towards a sustainable development of South African low-cost housing.

2. CHALLENGES FOR THE SUSTAINABILITY OF LOW COST HOUSING IN SOUTH AFRICA

Green housing and sustainable living conditions are primary targets for developing countries addressing the green Agenda, as South Africa. In 2007 low-cost housing accounted for about 36% of the number of formal units delivered in the major municipalities (Stats SA, 2007 as cited in Milford, 2009). In 2011 about 15% of South African households were living in state-subsidised low-cost houses, whereas 12% in informal units (Stats SA, 2012). Between 2011 and 2014 the Government has planned to build 220.000 subsidised low-cost houses per year (GCIS, 2011). Low-cost housing hence constitutes a critical sector of the residential stock in the country.

The Government of South Africa has undertaken many initiatives over the last decades to improve the living conditions and provide shelter to low-income communities. The low-cost housing subsidised scheme, initiated through the Reconstruction and Development Programme (RDP) policy framework and following the principles of the White Paper on Housing of 1994, aimed to provide poor households access to adequate homes and basic services, in order to face the large housing backlog in the country. In 2013, in the KwaZulu-Natal Province a subsidy of ZAR 64.666,00 (US$ 6.060,54) was allocated to subsidise the construction of the top structure of an RDP unit (DHS, 2013), traditionally based on the typology of a detached single-storey house of about 40 m² in its plot, including a separate toilet.

A research investigation in 2000 found that only thirty percent of new houses complied with building regulations (Lodge, 2003). Critics also cited poor quality of houses and infrastructures and noted that new housing schemes are often dreary in their planning and layout (Lodge, 2003).

From the first outcomes of the programme and due to the changes in the national socio-economic context, a review of the programme led to the approval in 2004 of the Comprehensive Plan for Sustainable Human Settlement, commonly referred to as “Breaking New Ground”, which should have shifted the focus towards integrating communities, providing social and economic facilities and eradicating informal settlements. Between 1994
and June 2011, the Government built over 3 million homes, giving shelter to more than 13 million people (SA Government, 2013).

Nevertheless, low-cost housing practice mostly continued to produce energy inefficient and low environmental quality houses. The new National Housing Code of 2009 marked the lack of any environmental criteria in the common low-cost housing practice and stated that energy consumption patterns of low income households have emerged as one of the most influencing factors to the national electricity demand (DHS, 2009). In fact, low-cost houses are very inefficient not only for the limited budget: the units are also designed without any consideration of basic green passive strategies (such as orientation, shading devices, window ratio to wall, etc.).

The new National Housing Code includes only some suggestions regarding non-quantitative energy saving measures for RDP housing development, risking consequently that the criteria are not implemented and verifiable.

The new national regulation on energy efficiency in buildings, SANS 204 and 10400-XA, does not provide specific requirements for low-cost housing. However, this sector should be addressed with a specific approach due to the critical socio-economic implications. This gap is still evident in the regulation, although since 2005 the Country Report of the Department of Environmental Affairs and Tourism stated that “the biggest benefits can be won by applying energy efficient design principles in low-cost housing”. “Low-cost houses have been built with no consideration to energy efficient design principles, condemning already poor and suffering households to low-quality, uncomfortable and “costly” houses.” (DEAT, 2005, p. 15).

Nowadays, international best practices have demonstrated that, through a controlled design process and materials selection method, rather than investing in costly and high-tech solutions, it is possible to meet desired environmental goals at a lower cost (Castro-Lacouture et al., 2009). With the current best green building practices, it was observed (Milford, 2009) that in South Africa energy efficiency savings between 30% and 40% could be obtained in new buildings in the residential sector.

Various projects and research studies recently addressed, sometimes successfully, the challenge of sustainable and energy efficient low-income settlements in South Africa. For example, Eicker (2008) described the 10x10 project in Freedom Park in Cape Town, addressing the issues of subsidies housing while exploring sustainable and appropriate design solutions. The two-storey timber frame and sandbag infill row houses were designed and built with successful community involvement. Also, the Cato Manor retrofit project in Durban (GBC SA, 2012) demonstrated that few strategic green retrofit interventions in existing low-cost houses can achieve environmental targets and improve the quality of life of inhabitants. However, several green strategies are often already compromised in the existing settlements due to the unsustainable design practice of the past.

Other projects failed in achieving the planned objectives: for example, the Netreg semi-detached units project (Cape Town) of 2003 scarcely contributed to the consolidation of the fragmented structure of the area. The project enlarged an enclave settlement that has one single access and is surrounded by high-speed highways. This character has given to Netreg the
aspect of a gated community (Lizarra lde and Massyn, 2008). Also in the RDP settlement of Braamfischerville, located in Soweto (Johannesburg), initiated in 1996 and followed by two further development phases, six years later than the completion of the second phase many of the basic services as running water, sewerage and electricity were still absent (Moolla et al., 2011).

Apart from the technical aspects, the education and the participation of inhabitants are integral part of a sustainable design process. The behavioural response of users has an impressive impact on energy consumption, thus great results could be achieved through a proper education stimulating behavioural adjustments in everyday life (Langevin et al., 2013).

The mentioned studies demonstrated the importance of implementing green strategies in the decision making and in the design practice of new settlements, to reach sustainability targets for the whole community with strategic and affordable solutions planned from the early design stages.

3. RESEARCH APPROACH AND METHODS

An integrated and holistic approach combining various research methods was adopted. The sustainability, in fact, must be assessed by multiple perspectives including various and conflicting viewpoints (Espinosa et al., 2008).

Previous research used methodological approaches based on the investigation of alternative planning and design strategies to adapt theories of housing to the actual needs of low-income communities. The eThekwini Municipality, for example, evaluated different low-cost housing typologies suitable for the local context (eThekwini Municipality, 2010). Other studies focused on the assessment of densification criteria to investigate the relationship between density and housing development (Zhu, 2012). However, very few studies investigated the potential implications of alternative design solutions and building typologies in terms of indoor comfort and energy saving. The studies conducted by WSP (2010) and Mathews and van Wyk (1996) demonstrated the benefits of alternative wall technologies and thermal insulation techniques, but only applied to the traditional detached RDP house.

Furthermore, alternative design criteria should be linked to a bottom-up approach investigating firstly the needs of the local communities. Several studies demonstrated the importance of the participation of the community from the early stages of the decision making, to define solutions responding to their actual needs and suitable for the social context (GBC SA, 2012).

Considering this background, this study adopted an integrated approach to the sustainability based on the synergistic interaction between the following criteria. Theoretical methods based on a literature review were combined with the results of a participatory approach to define the strategic guidelines for a scenario analysis, which assessed alternative housing typologies, densification criteria, green low-cost measures applied to the case study of the RDP settlement in the town of Bulwer (Ingwe Municipality).

The literature review investigated South African low-cost housing design practice and related policies in order to understand the main gaps to be faced.
The case study method was used to investigate the needs of a local low-income community and apply the proposed design approach and green strategies to an actual example of low-cost housing development. The RDP settlement in Bulwer was selected as representative of the common practice in the South African context. The settlement is in fact a housing development in a greenfield area using the traditional RDP detached single-storey typology, repeated indiscriminately over the land without any consideration of green criteria and social facilities for inhabitants. Between 2008 and 2011, 313 RDP units were built in the southern part of the town, allocating about 1500 people working in the surrounding area in farming, dairying and forestry sector. The climate is classified as temperate interior by SANS 204, but it is actually quite cold due to the proximity of the Drakensberg Mountains, with night winter temperatures in the coldest months dropping below 0°C.

A bottom-up approach through a field audit and interviews was used to gain feedback from the inhabitants, stimulate the participation of the community in the decisional phase and in the definition of design strategies for future green low-cost housing development, derived from their actual needs. A post-occupancy questionnaire was created using mainly closed-ended questions (multiple choice questions) regarding environmental and socio-economic impact categories (energy, water, comfort, employment, transport, health, social aspects). Using the questionnaire, a field audit and interviews (structured and semi-structured) were conducted by the research group on a sample of thirty households in the existing RDP settlement. The participatory process is integral part of the methodology as well as foundation of the following assessment of design alternatives.

Starting from the outcomes of the interviews and field audit, a scenario analysis was conducted with regards to a potential low-cost housing development in Bulwer linked to the ongoing Urban Regeneration Plan. The scenario analysis investigated and assessed multi-scale strategies, from the level of the settlement to the scale of the building and single unit, and design alternatives, through sustainability indicators. The strategies focused on densification, building typology and low-cost passive design measures. The sustainability indicators referred to land consumption, allocated units, energy impacts, indoor comfort, social implications, safety and cost.

Firstly, a study on the layout of the settlement was conducted to investigate the potential benefits of densification strategies and alternative building typologies. A qualitative housing typologies assessment compared the typology of the existing RDP settlement (common practice) with two suitable variations for the new residential development, through four rating scores. From the results, a scenario analysis was developed to quantify the potential benefits of the densification criteria using the alternative typologies. The quantitative assessment was conducted on a layout derived from a preliminary qualitative energetic assessment of the settlement, aimed at environmental and energy efficient solutions from the early design stages.

Then, the optimised scenario was investigated in terms of energetic and indoor environmental quality of the housing units, through quantitative dynamic energy and comfort performance analyses (thermal modelling - software DesignBuilder/EnergyPlus) of the buildings and the units, whose
A plan was defined according to environmental criteria. The simulations evaluated the potential benefits of optimised scenarios using low-cost passive strategies (such as orientation, surface area to volume ratio, materials and thermal insulation) compared to the common practice, in terms of energy consumption (kWh) and indoor comfort (PMV-Predicted Mean Vote).

The potential benefits achievable in terms of reduced environmental and energy impacts, improved indoor comfort and social implications were finally supported by a preliminary cost assessment comparing the common practice with the proposed green scenario. The synergy between the various research methods is oriented to an optimisation process of the design choices to meet sustainability targets with effective and affordable solutions.

This research was mainly developed within a MScEng (Civil) at the University of KwaZulu-Natal. The application for ethical clearance was logged together with the application for MScEng and the research proposal. The study was approved and the researcher was allowed to undertake this investigation. The Ingwe Municipality also approved the study and assisted the researchers in their activities.

4. RESULTS AND DISCUSSION

The most relevant results of the field audit and interviews conducted with the community are summarised as follows. Eleven (37%) of the investigated thirty houses did not have a separate sleeping place. Twenty-three households would have needed more space but they could not afford a formal extension; twenty-four households (80%) used electricity as primary energy source for domestic uses (monthly cost range for prepaid electricity: ZAR 100-350), but twenty-four houses (80%) had no ceiling and only thirteen houses (43%) had a heater, whereas the remaining households used wood or blankets to get warm in the coldest periods. 93% of the interviewed households complained very cold indoor winter conditions and half of them also experienced very hot in the summer (figure 4.1). All the families got water from a communal tap and heated it for personal use mainly with kettles or plot on the stove. All the households did not reuse rainwater and only three of them (10%) reused greywater to clean toilet. Half of the households had a private food garden and twenty-four of them (80%) were interested to establish community vegetable gardens to provide secure food to the inhabitants. All the people complained the lack of communal areas for social interaction, nineteen households (63%) would have been available and interested in living in multi-unit residential buildings sharing facilities with neighbours. Most families experienced problems with the quality of construction such as water leaks through the roof.
The survey results supported the decisional phase for proposing alternative low-cost housing scenarios for the new residential development in Bulwer. Due to the affordability criteria, the focus of the study was switched from the assessment of the single house to a broader analysis of the settlement, which included different building typologies and related schemes of land use, community shared services that could realise cost saving considering the settlement as a whole. Firstly, a housing typologies study was conducted to evaluate potential alternative schemes. A qualitative cross comparison between the existing detached layout and two different schemes suitable for the local context investigated strengths and weaknesses based on four impact categories. The matrix of typologies of table 4.1 summarises the results of the assessment. The detached typology negatively affects most categories, especially in terms of environmental and safety aspects. The row house and maisonette schemes are promoter of medium density, cost and energy saving and community interaction. The outcomes suggested a maisonette typology predominant development that reached the highest benefits for the aim of the study, considering the greater potential for social interaction, the cost savings due to the maximum number of shared building components between the units and the limited engineering services, the energetic and environmental benefits.

Table 4.1: Matrix of typologies (++ highly positive, + positive, – negative, — highly negative)

<table>
<thead>
<tr>
<th>Economy</th>
<th>Typology 1 - Detached house (Common practice-single storey)</th>
<th>Typology 2 – Row house (two-storey units, with private internal stair)</th>
<th>Typology 3 – Maisonette (two-storey building with single storey units, shared balcony every two first floor units)</th>
</tr>
</thead>
<tbody>
<tr>
<td>++</td>
<td>No cost for communal areas (only private plots)</td>
<td>++ High cost savings for limited land consumption, roads area, engineering services</td>
<td>++ High cost savings for limited land consumption, roads area, engineering services</td>
</tr>
<tr>
<td>—</td>
<td>Max number of building components per house</td>
<td>++ Medium cost saving due to shared building walls</td>
<td>+ High cost saving due to maximum number of shared building components (walls, stairs)</td>
</tr>
<tr>
<td>—</td>
<td>Low cost-effective subsidy utilisation</td>
<td>+ Efficient subsidy utilisation for public areas and external works</td>
<td>+ Suitable to slope terrain</td>
</tr>
<tr>
<td>—</td>
<td>Maximum land consumption, roads and engineerin</td>
<td>— High cost for internal stairs (one per unit)</td>
<td>+ Efficient subsidy utilisation for public areas/external works</td>
</tr>
<tr>
<td></td>
<td>services areas</td>
<td></td>
<td>— Cost for shared external stairs and balconies</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Social implications</th>
<th>Typology 1 - Detached house (Common practice-single storey)</th>
<th>Typology 2 – Row house (two-storey units, with private internal stair)</th>
<th>Typology 3 – Maisonette (two-storey building with single storey units, shared balcony every two first floor units)</th>
</tr>
</thead>
<tbody>
<tr>
<td>++</td>
<td>Maximum potential extension of the house</td>
<td>++ Communal areas for social interaction</td>
<td>++ Communal areas for social interaction</td>
</tr>
<tr>
<td>++</td>
<td>Better sense of privacy</td>
<td>Potential for job creation in the communal areas (i.e. vegetable gardens, gardening)</td>
<td>High level of social interaction at the building level</td>
</tr>
<tr>
<td>—</td>
<td>No communal areas</td>
<td>+ Limited potential extension of the house</td>
<td>+ Potential for job creation in the communal areas (i.e. vegetable gardens, gardening)</td>
</tr>
<tr>
<td>—</td>
<td>Low social interaction</td>
<td>— Diminished privacy</td>
<td>Sense of communal/shared space</td>
</tr>
<tr>
<td>—</td>
<td></td>
<td></td>
<td>No potential extension of the houses</td>
</tr>
<tr>
<td>—</td>
<td></td>
<td></td>
<td>Low privacy</td>
</tr>
</tbody>
</table>
The subsequent step compared the existing low-density layout with medium-density scenarios (figure 4.2 and table 4.2), firstly applied to the same land of the existing settlement as hypothetical scenario to investigate the densification potential using a maisonette/row house mixed development. The densification strategy was hence applied to the new residential development area, using the maisonette typology to minimise the land consumption, demonstrating that the total allocated households could be doubled compared to the existing settlement, but utilising in the new development half the land area of the current RDP settlement. The layout of the new settlement was based on environmental and climatic considerations, using preliminary qualitative energetic assessments (i.e. overshadowing analyses) to define appropriate distances between the blocks to maximise winter solar gains for each units and strategize the most suitable location of the communal areas and food gardens. Communal vegetable gardens were considered an important feature of the development and a potential resource in terms of food cultivation and security, job creation and social interaction.

Figure 4.2: Layouts of the existing RDP settlement (left), hypothetical scenario (middle), new development scenario (right)

Table 4.2: Density indicators for the different scenarios

<table>
<thead>
<tr>
<th></th>
<th>Existing settlement layout</th>
<th>Hypothetical scenario with densification strategy (same land)</th>
<th>Development scenario with densification strategy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Land area occupied [ha]</td>
<td>12.7</td>
<td>12.7</td>
<td>5.4</td>
</tr>
<tr>
<td>Number of units</td>
<td>313</td>
<td>660</td>
<td>312</td>
</tr>
<tr>
<td>Unit gross area [m²]</td>
<td>40</td>
<td>47.5</td>
<td>47.5</td>
</tr>
<tr>
<td>Gross density (n. of units/land area) [n. units/ha]</td>
<td>24.6</td>
<td>52</td>
<td>57.8</td>
</tr>
<tr>
<td>Roads area [ha]</td>
<td>1.6</td>
<td>1.3</td>
<td>0.8</td>
</tr>
<tr>
<td>Population allocated (5 people per household)</td>
<td>1565</td>
<td>3300</td>
<td>1560</td>
</tr>
</tbody>
</table>
Each two-storey block of maisonettes comprised 6 units (47,50 m² gross floor area) per floor. The plan of the block and the units was designed to be climatic sensitive to the local context (figure 4.3), in terms of orientation, layout and window to wall ratio, which is parametrically calibrated to the opposite facing sides through energy simulations to maximise heat gains on the northern side (avoiding summer overheating through the shading effect of the roof overhang) and reduce heat loss on the south facade.

![Figure 4.3: Plan of the first floor and 3D view of the maisonette typology](image)

Dynamic energy and comfort performance analyses were conducted to evaluate the potential benefits of the proposed green scenario in terms of energy saving and indoor comfort, compared with the existing detached house scheme. Assumptions had to be made due to the unavailability of comprehensive climatic data for the weather stations close to Bulwer. The representative hourly weather data of the climatic zone 1 (Johannesburg) of South African energy efficiency regulation was used as a valuable reference for the energetic prediction. The hourly operation of appliances, occupation, lighting and cooking was based on the operational schedules provided by the software, customised to the assessed target group, considering a seven-day operation. Heating was supposed to be provided by an electrical heater (Coefficient of Performance = 1) operating principally during the occupation of the rooms. The infiltration rate was set to 0.8 ach/hour. The detached house was simulated with its traditional materials (concrete block walls, profiled metal roof on purlin rafters, metal frame with single glazing). The maisonette units were assessed firstly with the traditional materials and later with some low-cost green additional measures (double-leaf clay brick plastered walls and thermal insulation ceiling for the upper units with 40 mm of expanded polystyrene). The simulation of the maisonette units was conducted in the worst condition, assuming that only the unit assessed was heated whereas all the other units were considered with free running temperature, only with internal and solar gains (which is a likely condition for low-cost houses). Even under this condition, the results (figure 4.4) showed that just the alternative maisonette typology, characterised by a lower surface area to volume ratio, and the green design principles of correct orientation and calibrated window to wall ratio, allow for a reduction of the annual heating energy consumption of 550-650 kWh compared with the detached typology. This result was validated also in terms of improved comfort (PMV values closer to the acceptable...
range). The two additional green construction measures produced a further relevant reduction of heating consumption, especially for the upper floor unit in which the ceiling is highly effective (energy saving of 48% if compared with the traditional construction assumption). This further energy saving demonstrated the benefits of insulation ceiling and clay brick walls, confirmed also by other research (WSP, 2010; Mathews and van Wyk, 1996).

![Graph showing annual heating consumption of detached unit and maisonette units](image)

**Figure 4.4:** Annual heating consumption of the detached unit and the maisonette units; Predicted Mean Vote for the detached unit and the maisonette first floor unit in two winter weeks

Finally, a preliminary cost comparison assessment (table 4.3) was conducted to understand the economic implications of the adopted densification strategy and alternative typologies, which could produce cost savings due to the shared building components between the units and the limited municipal engineering services (roads, water and sewer system, electrical reticulation, etc.). These savings were considered to be invested in the above mentioned additional green construction measures for each unit (thermal insulation ceiling, improved material for the walls), further green implementation for the blocks (rain water harvesting, solar water heating) and for the settlement (vegetable gardens, communal areas). The green scenario could allow a better housing quality with an extra cost per unit (top structure + external and infrastructure works + green implementation) of only 3% compared with the detached house layout. However, the scenario would use more effectively the subsidy (ZAR 64,666.00 for the top structure, also in consideration of ZAR 25,696.00 = US$ 2.408.25 for municipal engineering services) to provide an improved quality of living, a better built and community environment for the low-income community.

**Table 4.3:** Cost comparison of the proposed maisonette unit and the traditional RDP house

<table>
<thead>
<tr>
<th>Top structure</th>
<th>External and infrastructure works</th>
<th>Further green implementation</th>
<th>Total unit cost</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Detached house</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unit gross area 40 m²</td>
<td>Roads</td>
<td>Storm water reticulation</td>
<td>ZAR 66,033.00 (US$ 6,188.66)</td>
</tr>
<tr>
<td>Walls: 140 mm concrete block walls</td>
<td>Sewer reticulation</td>
<td>Electrical reticulation</td>
<td>ZAR 30,693.00 (US$ 2,876.60)</td>
</tr>
<tr>
<td>Internal partitions only for the separate toilet</td>
<td>Water reticulation</td>
<td>Street lighting</td>
<td>ZAR 0.00 (US$ 0.00)</td>
</tr>
<tr>
<td><strong>Maisonette</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>First floor unit</td>
<td>Roads</td>
<td>Storm water reticulation</td>
<td>ZAR 73,247.00 (US$ 6,864.76)</td>
</tr>
<tr>
<td>Walls: 230 mm clay brick plastered walls</td>
<td>Pavements</td>
<td>Electrical reticulation</td>
<td>ZAR 14,946.00 (US$ 1,400.75)</td>
</tr>
<tr>
<td>Internal partitions for toilet and two bedrooms</td>
<td>Kerbs</td>
<td>Street lighting</td>
<td>ZAR 11,455.00 (US$ 1,073.57)</td>
</tr>
<tr>
<td>Thermal insulation ceiling</td>
<td>Water reticulation</td>
<td></td>
<td>ZAR 99,648.00 (US$ 9,330.08)</td>
</tr>
</tbody>
</table>

**Note:** The detached house and maisonette units were compared as follows: detached house (Detached house) and maisonette (Maisonette).
5. CONCLUSIONS

This study investigated how strategic multi-scale green design measures, supported by a bottom-up approach, could contribute to lead low-cost housing sector towards sustainable living targets, combining environmental and social aims with cost effectiveness. Assessing a case study of the low-income settlement in Bulwer (KwaZulu-Natal), the research adopted a participatory approach to define design alternatives and green strategies firstly responding to the needs expressed by the local community.

Strategic low-cost green strategies at the scale of the settlement, block and unit were hence assessed through a scenario analysis of a potential low-cost housing development. The results demonstrated the potential energetic, environmental and social benefits of multi-scale green strategies that combined densification criteria, building typology assessment, passive design measures, showing that it would be possible to provide higher housing quality through affordable solutions.

6. ACKNOWLEDGEMENTS

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Factors limiting Green Developments in South Africa – architects’ comments

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ABSTRACT AND KEYWORDS

Purpose of this paper
To evaluate the perspectives and experience of architects regarding aspects limiting the progress of Green Building projects in South Africa.

Design/methodology/approach
The findings were based on a questionnaire completed by a total of 18 commercially active architects based in Gauteng.

Findings
Respondents agreed with the merit and potential of green building, that the green building process is gaining momentum, that consultants should embrace green building, but that the SA Green Star process is cumbersome. More than 26% of respondents have not been involved in green projects. Almost half of the respondents disagreed that professional consultants are generally aware of green building requirements.

Research limitations/implications
- Only Gauteng architects were included in the study
- Other consultants and developers were excluded
- The study suggested solutions but did not test such solutions

Value of paper
The study describes possible challenges and problems from the perspective of architects that may be limiting the development of new Green Building initiatives in South Africa. Industry professions, the GBCSA and tertiary institutions may be able to better devise and focus action plans to address the situation based on these findings.

Keywords: Green Building, Architects, Limiting factors, South Africa
1. INTRODUCTION

1.1. Background

Global warming and the associated negative consequences thereof have been widely published. Predictions are that by the year 2040 the world will experience its first ice free winter. The planet is also on average 0.7°C warmer than in 1860 (UNEP, 2007). This scenario has led to calls for drastic measures to be introduced to address current live styles and business practises including construction practises.

The construction industry is guilty of many practices that are in part to blame for this dilemma. The construction industry is responsible for approximately 50% of the world’s waste generation, 40% of the world’s air pollution as well as a significant portion of water pollution (GBCSA, 2013).

The building industry responded with initiatives towards the design and construction of green buildings that are more energy efficient, reduce the emission of greenhouse gasses and are more environmentally sustainable. However green buildings are often perceived to be more costly than conventional buildings. Industry beliefs of increase green buildings cost and decrease return on investment for owners will make green developments less attractive as future investment alternatives.

The additional skills that may be required from consultants involved in green projects and the complications involved with the application and certification of green buildings may also hamper or limit the number of new green developments.

1.2 Importance of the Study

The research should provide some insight as to why the construction of green and sustainable buildings in South Africa has not been as rapid as elsewhere in the world. The research may indicate reasons why developers may still be uncertain about green building construction. This research may also suggest how to support and advance the implementation the design and construction of new green buildings.

This research used qualitative research based on data obtained from a questionnaire completed by practising architects as respondents. Architects are important industry stakeholders with considerable responsibility towards green building decision making on design and specification of new buildings and they will often be approached first by developers when new developments are being considered.

2. THE PROBLEM STATEMENT
The uptake of new green building developments in South Africa was relatively slow and since the establishment of the GBCSA in 2008 and the end of February 2014 only 47 buildings had been certified as Green Star SA by GBCSA, most of them being commercial offices (GBCSA, 2014). Information about industry challenges that may slow down the progress of green developments in South Africa will be of benefit to the green industry. Such information may typically be provided by important industry stakeholders. This study therefore did an analysis of the experience and perceptions of architects involved with commercial office and retail developments in Gauteng to identify possible limiting factors that may hamper new green building initiatives.

This research used qualitative research based on data obtained from a questionnaire completed by respondents. A total of 42 architects were contacted of which 19 responded by completing the questionnaire giving a reasonable response rate of 45%. Architects were targeted as respondents as architects are primarily responsible for the design and specification of the building. The industry norm is for clients and developers to first approach the architect when new developments are being considered.

3. REVIEW OF RELATED LITERATURE

3.1 Green building overview

In 1972 in Stockholm, Sweden the first Earth Summit was held to evaluate environmental effects of the modern industrial era – arguably the first event to define environmental issues on an international stage (Korkman et al, 2009). United States Green Building Council (USGBC) was formed in 1993. In 1998 The World Green Building Council (WGBC) (2013) was formed with nine founding countries, namely Australia, Spain, Brazil, Canada, Japan, Mexico, India, Korea and the USA (Green Building Council Australia, 2014). Many other countries since joined the green building drive and are now part of the World Green Building Council (World Green Building Council, 2014).

The different national green building councils have developed different programmes to regulate and support green building standards, rating and certification in their countries (GBCSA, 2013a).

The evaluation, analysis and certification of green buildings in the USA is controlled by the USGBC through the Leadership in Energy and Environmental Design (LEED) programme (USGBC, 2013). LEED provides an operating framework for the identification and implementation of measurable green building design, construction, operation as well as green measurable maintenance systems for the building owners, operators and occupants of buildings.

In Australia the Green Building Council of Australia (GBCA) was launched in 2002. The GBCA uses the Australian Green Star rating system
Factors limiting Green Developments in South Africa

3.2 The South African Green Building Council

The Green Building Council of South Africa (GBCSA) was established in 2008. The GBCSA also uses a Green Star rating and certification system, based on the Australian Green Star rating system but adapted for South African conditions (GBCSA, 2014). The Green Star SA system allows for different types of properties such as office buildings, retail properties or educational buildings. The system has nine different categories with points or credits awarded for design initiatives in the different categories.

Categories and credits include Management (14 points), Indoor Environmental Quality (28 points), Energy (30 points), Transport (14 points), Water (15 points), Materials (22 points), Land Use and Ecology (9 points), Emissions (17 points) and Innovation (5 points). Weightings are applied to each category score to reach an overall score out of 100. Projects are awarded a Green Star SA certification based on the following rating of 4 Stars = 45-59 Points (Best Practice); 5 Stars = 60-74 Points (South African Excellence) and 6 Stars = 75-100 Points (World Leadership)

3.3 US green buildings

Cullen (2011) states that there are approximately 81 million buildings in the United States, most of which use energy inefficiently, generate large amounts of waste in their construction and operation and emit large quantities of pollutants and greenhouse gases. By November 2006 the USGBC had awarded LEED certification to 623 buildings. This number rose to 2400 buildings in 2009 and excludes 35 000 buildings in process of certification. Cullen (2011) also states that green buildings differ from traditional buildings by seeking to use land and energy efficiently; to conserve water and resources, to improve in/outdoor air quality as well as aiming to increase the use of recycled and renewable resources.

3.4 Merit of green buildings

The basic intent of green building is to protect the environment by addressing unsustainable consumption of raw materials and energy and exploiting of the natural environment by current construction practices. Green and sustainable buildings aim to drastically reduce the current rate of consumption by new and sustainable products and practises.

In 2008 the Public Building Service (U.S General Services Administration found that green buildings consume 26% less energy, have 13% lower maintenance costs, have 27% higher occupancy satisfaction and emit 33% less greenhouse gas emissions (GSA 2008).
3.5 Barriers limiting green building construction

South Africa’s traditionally low energy cost due to abundant coal supplies over many years hides the effect of energy inefficient buildings. However, Eskom, the main electricity utility company in South Africa has recently raised tariffs by nearly 32% with another 16% increase per year for the next 5 years being proposed (Engineering news 2012). Wafula & Talukhaba (2010) also agree that South Africa is at the end of a cheap energy era.

Construction cost (Robinchaud & Anantatmula, 2011) and operations and maintenance (Issa, Rankin & Christian, 2010) has often been identified by recent studies as barriers to progress in green building.

A study by Benson et al (2011) also identified direct financial benefits of green building and of retrofitting existing building stock as the primary motivation to both property owners and tenants. Increased property values, reduced electricity costs, and rent premiums were named as financially appealing aspects. However the perceived high up-front costs of green initiatives often cause stakeholders to decide on conventional options (Davis Langdon & Morris, 2007). Delhagen et al (2009) also named initial cost as an important barriers to investing in energy efficiency in existing buildings. Up-front cost investments barriers are deep, inescapable, and difficult to overcome.

Funding is another barrier to green building and is often perceived as difficult by building owners. Brown et al (2012) confirmed that lenders often lack the skill and knowledge to perform audits to support development of reasonable rates or contract terms.

Lack of knowledge about green building amongst tenants may also be a factor hampering green building development. Deuble and De Dear (2012) found a positive correlation between Australian tenant’s occupancy satisfaction of green buildings and their knowledge of and attitude towards environmental concerns. Communication and education may address this.

The split incentive problem is another key issue that is a barrier to commercial green developments and originates from the lease agreement between the lessor and lessee. The owner wants to minimize the capital cost of the building and has little incentive to minimise utility costs that are paid for by the tenant on a net lease. The tenant’s however may be unable to control overall energy consumption (Benson et al, 2011).

4. METHODOLOGY

This research used qualitative research based on data obtained from a questionnaire completed by 42 architects as respondents. These architects
are all active professional consultants in Gauteng province, working mainly in the commercial real estate industry. A total of 19 responses gave a reasonable response rate of 45%. The questionnaire’s first section profiled the respondents. The data to answer the problem was obtained through statements that asked respondents to reply based on a 5 point Lickert scale.

5. DATA ANALYSIS

5.1 Respondents’ profile

The first section of the questionnaire serves to describe a profile of the respondents. The data is detailed if figures 1 to 3. Figure 1 indicates that all the firms of respondents are older than 10 years. Firms that have survived for more than a decade can be assumed to have a sound understanding of the industry they operate in.

![Company Age](image-url)

**Figure 1:** Company Age

Figure 2 details a well-balanced spread of industry experience amongst the respondent. More than a third has relatively little experience, but 47% of the respondents have been practising for more than 10 years. The experience and opinions of respondents may therefore be assumed to be a fair reflection of the full experience spectrum of architects in Gauteng.
Figure 2: Respondents Experience

Figure 3 indicates that a large majority of more than 73% of firms have been involved with development of green buildings. However a sizable section of 26.3% has to date not been active with green developments. The sample profile may be summarized as to comprise of relatively experienced firms most of which have been involved with green buildings and who employ architects over a wide spectrum of industry experience.

5.2 Growth trend

The respondent opinions on a growing trend in green developments detailed in Figure 4 indicates that 95% of them agreed that green building is expanding with 37% in absolute agreement with the question. The 5% of respondents disagreeing with growth in green building are from older firms without green building involvement.
Consideration of the respondents’ profile revealed significant additional information. Respondents with less than 5 years of experience were 78% more inclined to absolutely agree with the question (57% vs 32%). They are also more than three times as likely to agree compared to the respondents with more than 5 years of experience (57% vs 18%).

Respondents from firms who have no green building involvement are 60% less inclined to absolutely agree that green building is expanding (20% vs 32%). Respondents from firms who were most positive about their green building involvement were 100% in agreement that green building is expanding.

5.3 Owners as the green building driving force

A total of 58% of the respondents agreed with the question that owners are the driving force behind green building while the other 42% did not agree as detailed in figure 5.

Respondents’ profile again added insight into the above finding. Respondents from the oldest firms were 52% more inclined to not agree that owners are the driving force in green developments (64% vs 42%). Previous involvement with green building was found to be positively correlated with the likely hood of respondents to disagree that owners are driving green building.

Figure 4: Industry trends

Figure 5: Owners as the driving force behind green building.
Figure 5: The owner is usually the driving force behind developing green buildings?

Only 16% of respondents from firms with no previous green involvement disagreed that owners are driving green developments. More than 55% of respondents from firms with some green experience disagreed with the question while 75% of respondents from firms most committed to green building disagreed with the question.

5.4 Consultants should embrace green building

All respondents agreed that professional consultants should embrace and encourage green building. As indicated in figure 6 a total of 53% of respondents strongly agreed with the statement. The respondents’ profile indicated that respondents with less than 5 years of experience was 70% more inclined to strongly agree with the statement compared to respondents with more than 5 years of experience (71% vs 42%).

![Figure 6: Consultant should embrace green building](image)

5.5 Consultants are aware of green building requirements

The data indicate that 47% of respondents do not agree that professional consultants are aware of green building requirements while 53% of them did agree with the statement (see figure 7)
The profile of respondents added additional insight into the above finding. Respondents from firms younger than 16 years indicated a 178% higher inclination to agree that consultants are not aware of green building requirements than respondents from firms older than 16 years (75% vs 27%). Respondents from firms with previous green building experience were 51% more inclined to agree that consultants are indeed aware of green building requirements (80% vs 53%).

5.6 Green Star rating process is complicated

An alarming 85% of respondents agreed that the Green Star rating process is complicated and cumbersome (see figure 8). All respondents with less than 5 years of experience agreed while only 60% of respondents from firms with previous green building experience agreed therewith.

Figure 7: Consultant are aware of green building requirements

Figure 8: The Green Star Rating process is complicated and cumbersome
5.7 Green Building Council can do more to create awareness

The last question required the respondents to respond to the SA Green Building Council’s (SAGBC) efforts to create awareness of green building amongst professional consultants. The result largely corresponded with the finding that the Green Star rating process is considered to be complicated. Figure 9 indicates that a total of 84% of the respondents were of the opinion that the SAGBC can do more to create awareness amongst professional consultants with 26% strongly agreeing with the statement.

Even 60% of the respondents from firms with previous green building experience agreed with the statement.

![Figure 9: SAGBC can do to create green building awareness](image)

6. FINDINGS

The study evaluated the experience and perceptions of architects involved with commercial office and retail developments in Gauteng to identify possible limiting factors that may hamper new green building initiatives.

The data indicated that more than 73% of respondents have participated in green projects (figure 3), that 95% are aware that the trend towards green developments is growing (figure 4) and that all respondents are positive to embrace green building.

The data further suggest that younger architects are significantly much more aware and positive towards green developments. Younger professionals will typically have longer career expectancies than their older colleagues and may therefore be more inclined to keep abreast of new developments.

This scenario may create valuable opportunities for professional organisations, the SAGBC and academic institutions to presents continued professional development events that informs and educate older industry professionals.

A total of 58% of the respondents agreed that owners are the principle driving force behind green buildings (figure 5). They therefore accept
that consultants such as the architect play a more passive role and follow the lead of the owner. This is however not the opinion of all respondents. The majority (64%) of architects from older firms and those with experience of green developments disagreed with the statement. There was also a positive correlation between architect’s involvement with green buildings and their disagreement that the owner should initiate and drive the green process.

As much as 47% of respondents are not convinced that South African built environment professionals are aware about the green development requirements (figure 7). This is a worrying statistic as professionals are important participants in the green development process. Respondents from younger firms were much more inclined to agree to this lack of awareness that their colleagues from older firms. Respondents with previous green experience were also much more positive about professionals’ abilities and knowledge.

The previously identified need for further education and training of industry professionals are again highlighted.

The study concluded two alarming findings. A total of 85% of respondents regard the SAGBC Green Star rating system as complicated and cumbersome while 84% of the respondents were of the opinion that the SAGBC can do more to make industry professionals aware of the Green Star rating process.

7. RECOMMENDATIONS

The study evaluated the experience and perceptions of architects involved with commercial office and retail developments in Gauteng and identified certain limiting factors that may be hampering new green building initiatives.

The study revealed a number of substantial indications that the South African green building process may indeed be hampered by factors limiting progress. It will be in the best interest of the green building initiative if the SAGBC, industry professionals and possible the academic institutions can address these issues in a combined and coordinated manner.

To expand this study, to confirm the findings made and to develop possible suggestions and alternatives, the following topics for further research are suggested:

- Undertake a larger and more representative study and also involve architects from the other provinces;
- Repeat the study, but to evaluate the experience and opinions of engineers, quantity surveyors and project managers;
- Test the experience of developers and property owners;
- Develop and test possible alternatives and solutions to problems identified in the study;
- Involve the SAGBC, industry professional organisations and academic institutions to suggest continued professional development initiatives.
8. REFERENCES


Optimizing the usage of fly ash in concrete

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KEYWORDS: Concrete, compressive strength, durability, environment, fly ash.

1. ABSTRACT

1.1 Purpose of this paper

This research paper is a study to determine an optimum amount of fly ash that could
partially replace cement in concrete to obtain comparable or better results
than the universal specification of about 30%, without compromising the
integrity of concrete structures.

1.2 Design/methodology/approach

Four concrete mixtures of grade 35MPa were designed with fly ash partially
substituting cement at four levels, 30%, 40%, 50% and 60%. These mixes
were tested at the laboratories for compressive strength, durability, workability
and a cost analysis was done.
1.3 Findings

Results show that although 30% fly ash concrete has higher compressive strength results, the 40%, 50% and 60% mixtures still yielded good acceptable results. The durability index results show that all the mixtures obtain acceptable and comparable results while the higher fly ash mixtures prove to reduce costs considerably.

1.4 Research limitations/implications

The testing done looks only on the major considerations of concrete specifications in practice, i.e. slump, compressive strength and durability.

1.5 Practical implications

The study showed that the industry standard specifications can be adjusted to accommodate more usage of fly ash in concrete and contribute to sustainable development.

1.6 What is original/value of paper?

The result obtained in the study show that the specifications regarding the usage of fly ash as a cement extender should allow for higher fly ash content. This could have positive effects on the environment and lowering carbon footprint.

2. INTRODUCTION

The construction industry is the main creator of our never-ending growing infrastructure which in-turn contributes greatly in emission of carbon dioxide which is associated with the growing environmental problems of global warming. From the production of construction materials such as aggregates and cement products to the completion of infrastructure developments, there is a lot of carbon footprint associated with the construction industry. With so much construction happening around our world, every initiative to help reduce the carbon footprint is greatly welcomed.

To reduce the CO₂ emissions related to the cement production, the use of Portland Cement (PO) could be reduced without compromising the performance of concrete structures (Camoës et al., 2003). Fly ash (FA) is one of the popular cement extenders used in concrete and each ton of fly ash used in cement, or
blended into the concrete mix, saves approximately one ton of CO$_2$ emitted during the production of Portland (Bold, 2005).

Fly ash is an industrial by-product that can be blended with cement in concrete. Its content in the concrete is regulated by global specifications to just over 30% by volume, but this can be increased considerable and still obtain acceptable concrete. In some projects like the Madera project in Florida, USA, the fly ash content was increased up to 60% (PATH, 2005), with positive results.

In this study we compared the concrete properties of concrete mixes with different fly ash content, from 30% up to 60%. The aim is to obtain an optimum fly ash amount that could produce concrete that is comparable or better to a standard 30% fly ash content concrete. This was done by producing four grade 35MPa concrete mixes and testing them for workability, concrete strength and durability over 28-day period.

The use of fly ash in concrete provides improved concrete properties such as workability, compressive strength and durability. Since the fly ash is already cheap to acquire, it also can result in much cheaper concrete.

3. LITERATURE REVIEW

3.1 Background

Fly ash is an industrial by-product collected from the coal-powered power stations and consigned into landfills for disposal. The re-use of this by-product provides great relief in the environment and can result in welcomed added benefits in the concrete without compromising the concrete and structural integrity.

The use of fly ash in concrete mixtures as a partial cement substitute has been done for many years. It has been proven in different studies around the world that the fly ash blended cements in concrete perform better than pure cement in providing impermeability, workability and durability (which is considered the most attractive property). Specifications of fly ash content as an extender limits the use to 30% (Kearsley and Wainwright, 2003). An increase of this amount can go a long way in contributing to sustainable development. In some areas of construction, fly ash is used extensively with positive results. Some projects have used an increased amount of fly ash of up to 60%.

3.2 Effects of fly ash on concrete properties

3.2.1 Concrete compressive strength

The compressive strength is the most common performance measure used by engineers in designing structures. The use of fly ash as a partial replacement in concrete has been proven to reduce the early strength up to 28 days, but
improve the ultimate strength (after more than a year). It is believed that the strength gain at later stages is due to the pozzolanic reaction, causing pore refinement and replacing the calcium hydroxide.

Pozzolan is a siliceous or siliceous/aluminous material which, in itself, possesses little or no cementitious value but when mixed with lime (Calcium Hydroxide) and water, form cementitious compounds. The usage of pozzolanic materials dates back to the Roman times in structures such as the Pantheon and Pont du Gard and they are still standing today.

3.2.2 Concrete durability

Fly ash improves more than the compressive strength of concrete, also the durability can be improved. Durability of concrete can be defined as its ability to resist weathering action, chemical attack, abrasion, or any other process of deterioration. The use of fly ash as a partial cement substitute in concrete has proven to produce concrete that is more durable. Fly ash reacts with lime to create more CSH produced during hydration of cement and water, thereby closing the capillaries that allow the movement of moisture through the concrete, resulting in a less permeable concrete (Crouch et al., 2007). By decreasing permeability, the corrosion (caused by ingress of moisture corrosive chemicals and oxygen) protection is improved and results in a more durable structure.

The increase in the fly ash content could prove not only to be beneficial environmentally but also economically as more durable structures cost less to repair.

3.2.3 Concrete workability

Due to its pozzolanic properties (spherical shape), the use of fly ash in concrete can result in more workable concrete, with less water demand. The less water demand enables higher strength gain of concrete without increasing the cement content.

4. SCOPE

4.1 Methodology

In this study, we looked at how the concrete properties such as the workability, compressive strength and the durability are affected by the increased amount of fly ash in the same concrete mixture. This work is part of a dissertation for
an M-Tech degree undertaken at Durban University of Technology (DUT) and was done by the author at the University laboratory as well as at Contest Laboratory in Pinetown, Durban, South Africa.

Four concrete mixes of grade 35MPa were designed, with fly ash as cement substitute at four levels of 30%, 40%, 50% and 60%. All the other constituencies of the mixes remained the same and the total binder content remained the same for all twelve mixing proportions.

Slump tests, compressive tests and durability index tests were performed on the mixtures to determine an optimum amount of fly ash substitution to use and still obtain concrete with acceptable standards.

4.2 Materials

Ordinary Portland Cement (OPC) Surebuild 52,5N from PPC was used in this project as it does not contain any cement substitutes.

In South Africa, SANS 1491 Part 2 specifies that fly ash with typical fineness on a 45 micron sieve is 5%. Unclassified fly ash obtained from Lafarge Ash Resources at Matla Power station was used in this project. Table 4.1, obtained from the Ash Resources catalogue, shows the typical chemical analysis of Ash Resources fly ash compared to OPC.

Table 4.1 Typical chemical analysis comparison between fly ash and OPC.

<table>
<thead>
<tr>
<th>Product</th>
<th>CaO</th>
<th>SiO2</th>
<th>Al2O</th>
<th>Fe2O3</th>
<th>MgO</th>
</tr>
</thead>
<tbody>
<tr>
<td>OPC</td>
<td>66</td>
<td>21</td>
<td>5</td>
<td>2,5</td>
<td>1,5</td>
</tr>
<tr>
<td>Fly ash</td>
<td>4-7</td>
<td>47-55</td>
<td>30-34</td>
<td>3-4</td>
<td>1-2</td>
</tr>
</tbody>
</table>

All the aggregates used in the experiment were locally available. 9,5mm Tilite coarse aggregates sourced from local Lafarge quarry were used. River sand from the local suppliers was utilized. A grading of three samples of the fine aggregates was done and resulted in a Fineness Modulus of 2. 2. Normal tap water from the university was used for mixing.

No admixtures were used in the mixes as the results required should not be influenced by varying agents like plasticisers which can depend on the site location and temperature.

The material proportions for the four concrete mixtures as shown in Table 4.2. For each grade of concrete the aggregates and the total binder quantities remained the same with only the cement/fly ash content changing, to control the effect on the concrete due to the fly ash content only.
Table 4.2 Concrete mix proportions.

<table>
<thead>
<tr>
<th>Concrete Mix (MPa/FA%)</th>
<th>W/C</th>
<th>Water (litres/m3)</th>
<th>Total Binder (kg/m3)</th>
<th>Cement (kg/m3)</th>
<th>Fly Ash (kg/m3)</th>
<th>Stone (kg/m3)</th>
<th>Sand (kg/m3)</th>
</tr>
</thead>
<tbody>
<tr>
<td>35/30</td>
<td>0,5</td>
<td>210</td>
<td>420</td>
<td>294</td>
<td>126</td>
<td>850</td>
<td>800</td>
</tr>
<tr>
<td>35/40</td>
<td>0,5</td>
<td>210</td>
<td>420</td>
<td>252</td>
<td>168</td>
<td>850</td>
<td>800</td>
</tr>
<tr>
<td>35/50</td>
<td>0,5</td>
<td>210</td>
<td>420</td>
<td>210</td>
<td>210</td>
<td>850</td>
<td>800</td>
</tr>
<tr>
<td>35/60</td>
<td>0,5</td>
<td>210</td>
<td>420</td>
<td>168</td>
<td>252</td>
<td>850</td>
<td>800</td>
</tr>
</tbody>
</table>

5. PROCEDURE

For this study, the compressive strength and the durability tests were done to determine an optimum or comparable concrete mix to a standard 30% fly ash concrete mix. Also slump tests were performed to compare the workability of concrete. The compressive strength of concrete is the most common performance measure used by engineers in designing structures, and the durability of concrete is vital to ensure that structures can withstand most environmental and chemical attacks for a prolonged period.

5.1 Compressive strength testing

For compressive strength testing, four mixes of grade 35MPa FA concrete were designed for a compressive strength at 28 days were. The fly ash partially replaced cement at four levels of 30%, 40%, 50% and 60%. Cubes specimens were made, then cast into 100mm x 100mm x 100mm cube moulds and removed the following day and kept in water for curing until the test date. The cubes were tested under the Displacement-controlled Universal machine at 1, 7, 14, 28 and 56 days periods. As per the procedure, three specimens were tested on each occasion for the individual mixes and the average results recorded as the compressive strength for the mix.

5.2 Durability index testing

The durability index testing was performed on the 35MPa concrete mixes at 30%, 40%, 50% and 60% fly ash levels. The durability index tests were done at the Contest Laboratory as they are reputable industry specialists in the tests. In South Africa the durability index of concrete is commonly determined by performing the Oxygen Permeability Index (OPI) test, Water Sorptivity test and Chloride Conductivity test (The Concrete Portal, n.d.). The tests give a relative
indication of the resistance of the cover concrete to the ingress of chlorides and/or carbon dioxide.

The durability specifications currently used in South Africa are shown in Table 5.1 (Raath, 2001) cited by The Concrete Portal, n.d.

<table>
<thead>
<tr>
<th>Acceptance Criteria</th>
<th>OPI (Log scale)</th>
<th>Sorptivity (mm/√h)</th>
<th>Cl Conductivity (mS/cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Laboratory concrete</td>
<td>&gt;10</td>
<td>&lt;6</td>
<td>&lt;0.75</td>
</tr>
<tr>
<td>As-built Structures</td>
<td>Full acceptance</td>
<td>&gt;9.4</td>
<td>&lt;9</td>
</tr>
<tr>
<td></td>
<td>9.0 to 9.4</td>
<td>9 to 12</td>
<td>1.00 to 1.50</td>
</tr>
<tr>
<td>Remedial measures</td>
<td>8.75 to 9.0</td>
<td>12 to 15</td>
<td>1.50 to 2.50</td>
</tr>
<tr>
<td>Rejection</td>
<td>&lt;8.75</td>
<td>&gt;15</td>
<td>&gt;2.50</td>
</tr>
</tbody>
</table>

5.3 Concrete workability testing

There are a few types of testing that can be done to determine the workability of concrete but the slump test is the most common performance measure as it can be easily performed even on construction sites. The slump test for the 35MPa concrete mix was performed to determine the workability. Also the density of the mixes was determined.

6. RESULTS AND DISCUSSION

6.1 Workability

As it has been mentioned in the literature, fly ash improves the workability of concrete. The increase in fly ash content does provide even more workable concrete as it can be seen in the slump tests done on the four 35MPa mixes. Table 6.1 shows the plastic properties of the 35MPa concrete mixes done at the Contest Laboratory. The mixes were mixed using an electric pan mixer.
Table 6.1 Plastic properties of 35MPa concrete.

<table>
<thead>
<tr>
<th>Description</th>
<th>35/9,5-30</th>
<th>35/9,5-40</th>
<th>35/9,5-50</th>
<th>35/9,5-60</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fly Ash %</td>
<td>30</td>
<td>40</td>
<td>50</td>
<td>60</td>
</tr>
<tr>
<td>Slump (mm)</td>
<td>150</td>
<td>168</td>
<td>185</td>
<td>205</td>
</tr>
<tr>
<td>Density (kg/m³)</td>
<td>2319</td>
<td>2314</td>
<td>2284</td>
<td>2286</td>
</tr>
</tbody>
</table>

As it can be noticed, the concrete density seems to decrease as the fly ash content increases which simply means, the higher the fly ash content the lighter is the concrete. Lighter concrete can be a benefit to structures as it means lesser loads on the structures due to less self weight.

6.2 Compressive strength

The compressive strength of four Grade 35MPa mixes, with fly ash content of 30%, 40%, 50% and 60%, were done at the DUT laboratory in a Displacement-controlled Universal machine as per ASTM C1231 specifications. The 100mm cubes for each mix were tested for 1, 7, 14, 28 and 56 days strengths and the results are presented in Figure 6.1.
It is evident from the results that the lower fly ash content (30%) concrete mix gained higher compressive strength than the mixes with higher fly ash content. The 40% FA concrete gained considerable similar compressive strength around 41MPa after 28 days, compared to 43MPa for the 30% FA concrete mix. The 50% and 60% FA mixes obtained around 35MPa after 28 days which is acceptable.

All the mixes obtained even higher compressive strengths after 56 days which is a great benefit for structures. The results obtained in the compressive strength testing were acceptable in terms of strength specification.

6.3 Durability

Three types of durability index tests were performed for the 35MPa concrete. Four grade 35MPa mixes with FA substituted at 30%, 40%, 50% and 60% levels were made at the Contest Laboratory and a total of thirty-two 100mm cubes were made for performing these tests. The tests were done after 28 days to determine how the durability index of concrete is affected with the increase in fly ash content.

6.3.1 Oxygen Permeability Index (OPI) Test

The South African oxygen permeability index (OPI) test method comprises measuring the pressure decay of oxygen passed through a concrete disk (typically 70 mm diameter by 25 mm thick) placed in a falling head permeameter.
Figure 6.4 shows a graphical illustration of the OPI results for the 35MPa concrete mixes. From the graph it is observed that after 28 days curing period, the 30% FA mix has the highest OPI value at 10.11 and the 60% FA mix has the lowest value at 9.84. The 40% FA mix obtained similar results as the 30% FA mix. From the results it is observed that all the mixes have very good and acceptable impermeability properties as the OPI values are way above 9.5.

![Figure 6.1 Oxygen Permeability Index test results of 35MPa concrete after 28 days](image)

6.3.2 Water Sorptivity Test

Sorptivity can be defined as the rate of movement of a wetting front through a porous material. The water sorptivity test involves the uni-directional absorption of water into one face of a pre-conditioned concrete disc sample. The four test specimens used for the OPI were used for the Water Sorptivity Test. The sorptivity test results for the 35MPa/9.5mm mixes with different fly ash percentage after 28 days of curing in water are illustrated in the Figure 6.5.
The results illustrated in Figure 6.5 show the increase of fly ash content in the concrete can increase the water sorptivity of the concrete. The 30% FA mix achieved the best results at $9.68\text{mm/}\sqrt{\text{hr}}$, while the other mixes obtained higher results above $10\text{mm/}\sqrt{\text{hr}}$. Even with these sorptivity results, all the mixes have fairly good and acceptable results after 28 days. Due to the continuing pozzolanic reaction of fly ash in concrete, it is expected that the concrete sorptivity can improve with time.

6.3.3 Chloride Conductivity Test

The Chloride Conductivity test involves the measurement of a sample's electric conductivity. Typical chloride conductivity index values range from $> 3 \text{ mS/cm}$ for M20 – M30 OPC concretes, to $< 0.75 \text{ mS/cm}$ for M40 – M50 slag or fly ash concretes. The lower the index, the better is the potential durability of the concrete.

Figure 6.6 shows after 28 days the higher fly ash content concrete mixes have better results than the lower fly ash concrete mixes, with the 50% FA mix having the lowest results at $1.25\text{mS/cm}$. While the 40% FA mix having the highest index. According to specifications, all these concrete mixes have good chloride conductivity results.
6.4 Cost analysis

When comparing the cost of the concrete mixes, the main differences are related to the total binder content as well as the quantities of cement replaced by substitutes such as fly ash.

For each grade on concrete mixture the cost variation is relatively proportional to the amount of cement substitution by fly ash. The cost of fly ash is approximately about 10% to 15% of the cost of cement.

From the materials used in the experiment the cost of the OPC was R90,00 per 50kg bag and the cost of unclassified fly ash from the supplier is estimated at R100,00 per Ton. Figure 6.7 illustrates the cost comparison between all the concrete mixtures at different levels of cement substitutions for unclassified fly ash.

The illustration shows the increase in the fly ash content relatively decreases the total cost of the mixture per cubic meter, in terms of the binder. In higher W/C mixtures, the savings due to using fly ash as a partial substitute can range from about 26% to about 46% per cubic meter of concrete, depending on the substituted amount of cement. Where in lower W/C mixtures savings can range from 30% to 55% per cubic meter of concrete.

Figure 6.3 Chloride Conductivity test results of 35MPa concrete mixes after 28 days
7. CONCLUSION

After undertaking the various testing of concrete workability, compressive strength, durability index and cost analysis, the following conclusions can be drawn:

1. Due to the pozzolanic properties of fly ash, the increase in fly ash content resulted in more workable concrete with slump tests results of up to 205mm for the 60% FA mix. This means the water demand in the mix decreases as the fly ash content is increased. This can lead to a stronger concrete.

2. The content of fly ash as a partial substitute of cement can be increased in concrete mixes without compromising the concrete strength. The compressive strength results of the 30% FA mix were higher than the 40%, 50% and 60% mixes in all concrete grades. At 28 days all the mixes gained acceptable compressive strength and after 56 days, most mixes gained around 10MPa or more than the design strength.

3. The Oxygen Permeability Index results showed that the 40% FA mix has similar properties as the 30% FA mix, while the Chloride Conductivity results showed that the higher fly ash content concrete mixes (50% FA and 60% FA) have better qualities than the lower fly ash mixes. The durability index tests showed that the increase in fly ash content has positive effects on the concrete durability.

Figure 6.4 Cost comparison of concrete mixes with different binder and unclassified fly ash contents.
4. Using higher volumes of fly ash in concrete can result in cheaper concrete products. Fly ash can cost about 10 to 15 percent of cement cost which can result in considerable savings in big concrete projects.

The increase in fly ash content in concrete can be very beneficial for the environment and promotes sustainable development.

8. RECOMMENDATIONS

There has not been much work done locally to ascertain the adjustment of the specification regarding the amount of fly ash that can be added to concrete as a partial cement substitute, but the results obtained in this study show that the change specification from 30% can yield positive results. Also the usage of higher fly ash contents on certain projects opens up the way to explore widely this practice.

9. ACKNOWLEDGMENT

The author gratefully acknowledges the assistance from the staff of Contest laboratory and their input regarding testing concrete for durability, and also Mr E. Makhathini from Durban University of Technology with regard to preparation and making of tests specimen. The guidance provided by the Supervisor, Professor D. Allopi from DUT enabled this paper to be successful.

10. REFERENCES


ATTITUDE AND ACTION OF BUILT ENVIRONMENT PROFESSIONALS TOWARDS SUSTAINABLE BUILT ENVIRONMENT: A Case Study of Architects

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ABSTRACT

Purpose of the paper
The purpose of this paper is to present findings of a study on the attitude of professionals in the built environment regarding sustainable built environment.

Methodology
A questionnaire survey was conducted on construction projects to determine the current trend relative to professionals’ involvement on sustainable built environment.

Findings
Findings from the study include: sustainable built environment is being driven by rising energy cost, client demand and climate change as a result of carbon emission. Recommendations include: the mitigation of the effects of climate change and the benefits of sustainable built environment should be publicized.

Value
The identification of the impact of not embracing the culture of sustainable development relative to the built environment will afford the re-engineering of traditional practice relative to building project delivery.
Practical Implication

Stemming from the findings of the study, mitigations were drawn relative to the effects of lack of re-engineering professionals on sustainable built environment pursuit.

**KEYWORDS:** Sustainability, attitude, action, built environment

## 1. INTRODUCTION

Sustainable development is inevitable relative to the existence and comfort of man. In terms of existence, it refers to safety of life from loss resulting from destruction, and comfort with regards to being free from diseases. Koroneos and Rokos (2012); Brandtland (1987), and United Nations (1987) define sustainable development as a ‘development that meets the needs of the present without compromising the ability of the future generations to meet their own needs’. This definition is premised on the fact that resources are limited. The way and manner which they are consumed should be controlled. The facilities and items consuming these resources will be in continual use, therefore there is a need to use it moderately in order that there will be left for future generations’ usage. In order to achieve this goal regarding the definition of sustainable development, the attitudes and actions of professional developers, which could be referred to as the Construction Team, must be such that is skewed towards parameters that will achieve this goal. The sustainability of constructed facilities is very important relative to their maintenance cost. The reduction of maintenance cost of constructed facilities affects directly the natural resources, which is scarce and limited and will not compromise the ability for future needs. Designs that integrates sustainable feature on them should be the focus now with respect of achieving sustainability. Based on these, the study was initiated to ascertain the right attitude and actions of professionals (Architects) for sustainable built environment. A questionnaire survey on the perceptions of Architects was conducted to ascertain current design practices.

## 2. LITERATURE REVIEW

The City of Cape Town (2012); Fiocchi *et al.* (2011); Kientzel, and Kok (2011) declare that attitudes and actions of professionals, should be, such that, at the design stage, takes into consideration (starting from the planning, design, operation, management and maintenance) of any building project the following factors, be locally appropriate, conserve the natural environment, use resources efficiently and effectively, be appropriate on a life-cycle basis, minimize waste, use renewable resources, implement sustainable
procurement, utilize locally sourced materials and skills, maximize the health and well-being of users, allow real-time monitoring and evaluation, and leave a positive legacy, in order to ensure sustainability of resources and sustainable development. The construction of facilities starts from its design; it is very likely that what is contained in the design will be that which will be built. Therefore, these factors stated by the City of Cape Town reflect attitudes to ensure sustainable environment. The abovementioned factors could be classified as guiding principles that influence attitude and actions towards sustainability, and are discussed as follow:

Be locally appropriate – professionals should integrate in design the use materials that are locally sourced and involve the community in the procurement of materials and the facility. Material that will create benefits for the community in the long term, these are in terms of mastering the sourcing for the material and technology for their production, and engaging the community to obtain feedback relative to the performance of the materials and subsequent usage of the community of such materials to enhance sustainability.

Conserve the natural environment – professionals design should be such that conserve the natural resources. The construction phase should utilize materials that will conserve natural resources and ecosystems that sustain life in the area.

Use resources efficiently and effectively – Designs should be such that maximizes the efficiency of energy, water, wind and sun for electrical energy supply and other needs. Building projects should take the advantage of emerging technologies, management systems and behavioural change to effective and efficient resource use throughout planning, design, construction and operation.

Apply a full life-cycle approach – A full life-cycle approach should be integrated in the design of structures. This is relative to deciding the design of a building and the specific materials from which it is to be made; consideration must be given to the entire life-cycle of the products regarding selection of the best option. In doing this life-cycle costing should be employed relative to selecting design solutions for optimization of cost over the life of the structure.

Minimise waste – Designs must be such that minimizes waste during construction and also during maintenance. Designs should be void of complex elements, while reusability or recyclability is considered of high priority. The utilisation of systems-thinking approach should be employed to the planning and design phases.
Use renewable resources – Designs should integrate to a large extent resources and materials that can be sustainably renewed through natural processes and sustainable cultivation e.g. Solar or wind energy, harvested rainwater and sustainable timber. The use of non-renewable resources will defeat the aim of green buildings and environment.

Implement sustainable procurement – Consideration should be given to the environment regarding sustainability. This consideration should reflect on the integration in design low-toxicity and renewable materials, local product and services as a mechanism for local job creation, and the selection of materials and equipment based on life-cycle assessments. This leads to prescribing procurement criteria for every project.

Utilise locally sourced material and skills – The use of local materials boosts the local economy and promotes job security for people living in the area. This affords opportunity to develop and improve skills and materials locally for future use, and this have positive influence on sustainability.

Maximise the health and well-being of users – The use of low-toxic materials create a healthy environment for people to live, work, and play. This should be a primary goal while designing facilities. Attention should be given regarding adequate provision of the following: natural light, indoor air quality, visual comfort and thermal comfort in the built environment with respect to sustainable environment.

Allow real-time monitoring and evaluation – Monitoring and evaluation should be considered adequately relative to obtaining information on performance of materials and subsequent recommendation for use in the future. Real-time feedback on building performance is the only way for facilities managers to be alerted to poorly performing systems and their probable discontinued use relative to the future.

Leave a positive legacy – The threats of climate change, food security and fresh water availability will become increasingly real, therefore the decisions we take about the design inputs of facilities will have great impact on the facility being built. Facilities life-span exceeds that of the developers; therefore, the selection of materials as input for the facility to be constructed should not impact on resource efficiency and availability for the future.

2.1 sustainable Technology/Measures
Walker (2010), Nagel; Pappas, and Pierrakos (2012) and Rosen (2013) identify ten (10) factors concerning sustainable technology/measure to ensure sustainable environment.

Design that reduces energy use or emission – This is relative to natural lighting and renewable energy. The use of sunray, wind and water for the generation of electric energy to lighten home to reduce dependency on non-renewable energy is advocated. The orientation (North-West) of the building and the amount of opening in a building is critical to the achievement of this factor of buildings.

Designs complying with environmental standards and regulations – These are regulations specified either by the Federal or Local government.

Designs using renewable / recyclable / recycled materials – This is referring to the construction and maintenance stages. The use of bamboo in the place of timber props and forms for floor decks, steel props and so on.

Design that reduces materials waste in manufacturing – The elimination of excessive curves and projections in building will ensure the minimisation of waste.

Designs with non-toxic materials – This will afford the well-being of people in the environment. Materials such as asbestos and those in the same family non-specification in design will ensure the well-being of occupants in built spaces.

Designs with low carbon footprints - Carbon emission has grave effect to the environment, which could lead to flooding and a resultant negative effect of damage to built spaces, loss of life and property due to global warming. According to Dutil et al. (2011), in order to mitigate climate change, CO₂ emission must be reduced by 50% of the current level by 2050.

Manufacturing with less energy and natural resources - The use of less energy will conserve energy for the need of the future generations and non-depletion of scarce natural resources. This will ensure compliance to regulations on the use and of resources, in order to minimize the negative effect it may have to meet the need for the future use.

Manufacturing process that pollute less – In the manufacturing industry carbon dioxide is emitted which result in the depletion of the ozone layer and result in global warming and its effect could be catastrophic on the built environment. The use of processes that pollute less will ensure sustainability.

Products that can be disposed of safely – The use of products that can be disposed of safely with no harm to the environment should be encourage, such as
Products that require less packaging – This will reduce waste by means of limiting the use of scarce materials.

2.2 Attitude of Engineers towards Sustainability (Report of Rosen, 2013)

Below is documented a report from the study of Rosen pertaining to practicing engineers and students.

Relative to Engineers: The personal attitude of practicing engineers on sustainability is positive. Over 80% indicate involvement in sustainable information and causes outside of work. A breakdown of this reveals that 29% are extremely involved personally, 55% are somewhat involved, 11% are neutral and 5% are not interested. Respondents are of the opinion that most of the practicing engineers feels that the use of sustainable and/or green design principles in design, production, and operation of manufactured products is gaining interest with colleagues (60%), as a result, it leads to practical innovation (66%). Regarding cost, 69% of practicing engineers are of the view that sustainable and/or green design principles have higher design cost, and 19% of respondents indicate that incorporating sustainable and/or green design practices is too complex for her/his company.

Relative to students: The students have higher positive attitudes towards sustainability as compared to practicing engineers. 89% are personally involved in green and sustainable information and causes. 2% are not interested and 9% are neutral. Most engineering students are of the opinion that the use of sustainable and/or green designs principles in the design, production, and operation of manufactured products is of increasing interest to fellow students (74%) and cause high product innovation (86%). 56% indicate that their school has a sustainable design class, programme or assignment. 13% reveal that incorporating sustainable and/or green design practices is too complex for their educational institutions. On the issue of cost, 77% are of the opinion that sustainable and/or green design principles have high design cost.

2.3 Attitudes and actions of engineering corporations towards sustainability

The involvement of practicing engineers with sustainability or sustainable technology is encouraging. Those involved with sustainability technologies is about 67% and can be broken down as 24% extremely involved, 43% somewhat involved. Those that are somewhat uninvolved, extremely involved
or not at all involved are 20%. About 13% of the engineers are neither involved nor uninvolved. Engineering students relative to involvement with sustainable technology is significant. 48% are involved with sustainable technology, while 26% are either involved or uninvolved. Regarding involvement with projects of sustainable and/or green design principles beyond those mandated by regulations, 14% revealed that more than half of their projects included specifications that were based on sustainable and/or green design principles beyond those mandated by regulations.

2.4 Factors influencing an organisation’s use of green design practices and procedures

There are factors that compel organisations to engage in green design practices (Waas et al., 2011); (Gibson 2000); (Gibson et al., 2005), and (Rosen, 2013). These factors range from governmental and organisational policies, to clients demands. The overall aim is to achieve a sustainable built environment, with minimal impact on natural resources, while putting into consideration the use of natural resource by future generations in order not to compromising their rights to the availability of these resources in the future. These factors are, regulatory requirements, client demand, rising energy cost, ability to gain a market advantage, long-term returns on investment, personal sense of environmental responsibility, government/industry incentives, and none of the above.

2.5 Challenges of Sustainable Designs

There is hardly a system that does not have one challenge or the other in the running of it. Regarding challenges associated with sustainable design, Rosen, (2013) identify the following: economic cost, competitiveness, market forces and customer demand, corporate culture and commitment, inadequate incentives from government, short term focus relative to benefits, confidentiality, regulations and laws, lack of codes and standards for sustainable designs, and lack of laws to enhance the practice of sustainable design.

3. RESEARCH METHOD

Random sampling method was employed in the selection of samples for the study. The sample consisted of Architects in the Free State of South Africa. The questionnaire survey approach was employed in this study. Sixty-five (65) questionnaires were administered via e-mails and 20 were
returned completed and included in the analysis of the data, which equates to a 30.8% response rate.

The following describes the characteristics of the professionals surveyed, which include their academic and professional qualifications, years of experience and number of projects handled by the respondents. Based on these, it can be inferred that the data obtained from the respondents can be deemed reliable. 58% of the respondents were involved in private practice, and 42% in the public sector. The average years of respondents experience is 16 years, and the average years of organisation existence is 29 years. Respondents within the years of 41-50 predominate (48.5%), next is 31-40 years age bracket (25.5%), and next is 26-30 years age bracket (16.8%) and over 50 years 9.2%. MSc / MTech level (71.3%) qualifications predominate in terms of qualifications followed by Honours (24.5%), and BSc (4.2%). Respondents have undertaken various types of projects: 86.4% of had undertaken residential projects, 65.7% of had undertaken commercial – office projects, 48.7.9% of had undertaken commercial - retail projects, 51.6% of had undertaken commercial - recreational projects, 35.1% of had undertaken hotel/motel projects, 60.2% of had undertaken parking garage projects, 65.4% of had undertaken industrial projects, 62.9% of had undertaken institutional - education projects, 30.2% of had undertaken institutional – health projects, and 36.7% of had undertaken institutional – other types of projects.

3.1 Data Presentation and Discussion of Results

Table 1 Extent of integration in design sustainable technology/measures

<table>
<thead>
<tr>
<th>Sustainable Technology/Measures</th>
<th>MS</th>
<th>Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>Designs that reduces energy use or emission</td>
<td>4.5</td>
<td>1</td>
</tr>
<tr>
<td>Designs that reduce material waste in manufacture</td>
<td>4.2</td>
<td>2</td>
</tr>
<tr>
<td>Designs with low carbon footprint</td>
<td>4.0</td>
<td>3</td>
</tr>
<tr>
<td>Designs with non-toxic material</td>
<td>3.8</td>
<td>4</td>
</tr>
<tr>
<td>Designs using renewable/recyclable and recycled materials</td>
<td>3.5</td>
<td>5</td>
</tr>
<tr>
<td>Designs complying with environmental standards and regulations</td>
<td>3.3</td>
<td>6</td>
</tr>
<tr>
<td>Manufacturing with less energy and natural resource</td>
<td>3.1</td>
<td>7</td>
</tr>
<tr>
<td>Manufacturing processes that pollute less</td>
<td>3.0</td>
<td>8</td>
</tr>
<tr>
<td>Products that can be disposed of safely</td>
<td>1.8</td>
<td>9</td>
</tr>
</tbody>
</table>
Table 1 presents extent of integration in design sustainable technologies/measures in terms of a mean score ranging between 1.00 and 5.00 based upon a percentage response to a scale of 1(minor) to 5(major). It is notable that 8/10 (80%) of the factors have MSs > 2.5, which indicate that the factors have major influence on respondents design. The factor with the most influence is designs that reduces energy use or emission (MS=4.5). Design that reduces energy use will drastically reduce energy cost throughout the life span of the facility and hence, ensure its sustainability. Next in designs that reduces waste in manufacture (MS=4.2). Sustainability is the meeting of present and future needs of scarce resource. Design that reduces waste in manufacturing is reducing the extent of usage /waste of natural resources against future needs. Next is design with low carbon footprint (MS=4.0). The emission of carbon depletes the ozone layer and leads to global warming, with a resultant effect of destruction of property and loss of life’s stemming from flooding and also ill health. Designs with low carbon emission will eliminate these adverse effects and lead to sustainability of development/environment. The factor with the least influence relative to its integration in design is products that require less packaging (MS=1.2). Packing of product is a process that takes no considerable time to be done. Hence, the amount of energy used is insignificant. Therefore, this factor has less influence relative to its integration in design.

Table 3 Factors that enhance the design and production of green environment

<table>
<thead>
<tr>
<th>Factors</th>
<th>Mean score</th>
<th>Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rising energy costs</td>
<td>4.3</td>
<td>1</td>
</tr>
<tr>
<td>Personal sense of environmental responsibility</td>
<td>4.1</td>
<td>2</td>
</tr>
<tr>
<td>Client demand</td>
<td>3.8</td>
<td>3</td>
</tr>
<tr>
<td>Ability to gain market advantage</td>
<td>3.6</td>
<td>4</td>
</tr>
<tr>
<td>Long-term return on investment</td>
<td>3.4</td>
<td>5</td>
</tr>
<tr>
<td>Regulation requirements</td>
<td>3.0</td>
<td>6</td>
</tr>
<tr>
<td>Government / industry incentives</td>
<td>2.8</td>
<td>7</td>
</tr>
</tbody>
</table>
Table 3 reveals the respondents rating of the factors that enhance the design and production of green environment, in terms of MS ranging between 1.00 and 5.00, based upon percentage responses to a scale of 1 (Minor) to 5 (Major). Rising energy costs (MS = 4.3) is the most factor that enhance the design and production of green environment. Rising energy cost has led to the development of alternative sources of energy with reference to renewable energy. This will afford the non-compromising of future generations usage of the limited resources. Next is personal sense of environmental responsibility (MS = 4.1) Resources are limited and the rate of their depletion should allow for future generation usage, this should reflect on designs. Client demand (MS=3.8) is third in rating. When most of the clients demand designs that incorporate features that will ensure green environment, it will encourage designers to always integrate in the designs aspects of green environment. This will lead to designers researching into better means of green devices and thus their constant incorporation in designs. Next is ability to gain market advantage (MS = 3.6). It is not all clients that are aware of the importance of green environment. The concept is new and just gaining increasing awareness. Next is long-term return on investment (MS = 3.4) is third in rating. The concept of green environment is new and clients are just beginning to enjoy the benefits that accrue from it. Greater awareness of the long-term benefits of low maintenance cost and high saving cost of a green environment will lead to higher demand of clients for green environment. It is notable that all the factors that enhance the design and production of green environment except one, that have MSs equal to 1.0, which suggest that with the right attitude and action our environment could be green in a short time.

<table>
<thead>
<tr>
<th>Barriers and challenges</th>
<th>Mean score</th>
<th>Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corporate culture and commitment</td>
<td>4.5</td>
<td>1</td>
</tr>
<tr>
<td>Economic cost</td>
<td>4.2</td>
<td>2</td>
</tr>
<tr>
<td>Market forces and customer demand</td>
<td>3.9</td>
<td>3</td>
</tr>
<tr>
<td>Competitiveness</td>
<td>3.3</td>
<td>4</td>
</tr>
</tbody>
</table>
### Table 4: Respondents' Perception of Barriers and Challenges to Sustainable Designs

<table>
<thead>
<tr>
<th>Barriers and Challenges</th>
<th>MS</th>
<th>Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lack of laws to enhance the practice of sustainable designs</td>
<td>3.0</td>
<td>5</td>
</tr>
<tr>
<td>Regulations and laws (policies to favour sustainability)</td>
<td>2.7</td>
<td>6</td>
</tr>
<tr>
<td>Lack of codes and standards for sustainable designs</td>
<td>2.4</td>
<td>7</td>
</tr>
<tr>
<td>Inadequate incentives from the government</td>
<td>2.2</td>
<td>8</td>
</tr>
<tr>
<td>Confidentiality (the hindering of sharing of knowledge to promote sustainable practices)</td>
<td>1.9</td>
<td>9</td>
</tr>
<tr>
<td>Short term focus relative to benefits</td>
<td>1.6</td>
<td>10</td>
</tr>
</tbody>
</table>

Table 4 presents the respondents' perception with respect to the barriers and challenges to sustainable designs in terms of MS ranging between 1.00 and 5.00, based upon percentages responses to a scale of 1(Minor) to 5(Major). Corporate culture and commitment (MS=4.5) is rated the main challenge to sustainable design. Organisation's believes and commitment could be a challenge to the promotion of sustainable designs. Organisations that are not committed to sustainable infrastructure designs are inclined towards active design. Therefore, the sharing of ideas with respect to sustainability will not be practiced among colleagues in an organisation. Based on this, there will be little done to promote sustainable designs. Economic cost (MS=4.2) rated as the second challenge to sustainable design. Client's consideration of the initial high installing cost of the various insulating materials and equipment for renewable energy, and lack of experts for maintenance of alternative sources devices. Next to economic cost is Next is market forces and customer demand (MS=3.9). The weakness of market forces and customer low demand will adversely impact on the practice of design incorporating sustainable aspects in them. This will result in the production of built environment that are not sustainable. Next to market forces and customer demand is competitiveness (MS=3.3). Patronage with respect to sustainable design may greatly influence designer (Architects) regarding sustainable design. A low patronage could be a challenge to sustainable designing.

The least factor relative to challenges to sustainable design is short term focus relative to benefits (MS=1.6). The problem of awareness of the long term benefits of having a facility possessing features of sustainability in...
them is gradually being bridged, this could be the reason this factor having the least influence on designs made relative to them being sustainable.

4. Conclusions and Recommendations

4.1 Conclusions

Based on the analysis of data, the following conclusions were reached: Factors that influence the extent of integration of sustainable technology in designs include designs that reduce energy use, materials waste in manufacture and designs with low carbon footprint. Factors that enhance the design and production of green environment are, rising energy cost, personal sense of environmental responsibility and culture demand. The factors of challenges to sustainable designs are, corporate culture and commitment, economic cost and market forces and customers demand.

4.2 Recommendation

Based on the conclusions reached, the following recommendations were made. Greater awareness on the benefits of sustainable facility should be made. The awareness of the long term benefit of sustainable design will mitigate the high initial cost of such designs. Design organisations should be more committed towards designs incorporating sustainable technology. Design organisations commit to the culture of sustainable design technology and advocacy will increase clients’ interest on sustainable designs.

5. REFERENCES


Gibson, R. 2000, Specification of Sustainability-Based Environmental Assessment Decision Criteria and Implications For Determining “Significance” in Environmental Assessment; Canadian Environmental Assessment Agency—Research and Development Monograph Series: Quebec, Canada.


Rosen, N. A. 2013, Engineering and Sustainability; Attitudes and Actions. Sustainability, 3, 372-386.


THE CONVERSION OF EXISTING OFFICE BUILDINGS INTO GREEN RATED OFFICE BUILDINGS: OFFICE TENANTS VIEWS

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ABSTRACT AND KEYWORDS

Purpose of this paper
To evaluate the perspectives and opinions of office tenants in Gauteng province, South Africa regarding the conversion of existing office buildings to Green Star SA certified office buildings.

Design/methodology/approach
The findings were based on a questionnaire completed by a total of 32 commercial office tenants based in Gauteng.

Findings
More than 40% of respondents are not aware of the Green Building Council of South Africa’s (GBCSA) initiatives. Almost 60% of respondents agree with having green credentials, but only 34% are currently applying green aspects in their operational strategies. The large majority of respondents are in favour of various suggested initiatives to support the GBCSA.

Research limitations/implications
• Only Gauteng based office tenants were included in the study
• The study only referred to the conversion of existing buildings

Value of paper
The conversion of the large stock of existing South African office buildings into Green Star rated buildings has gained very little momentum since 2008. This study describes the knowledge and opinions of office tenants regarding this important subject and will assist the GBCSA and other industry stakeholders to approach the challenge of this conversion process with more certainty and better focus.
Keywords: Green Building, Conversion, Existing office buildings, Office tenants, South Africa.
1. INTRODUCTION

1.1. Background

There has been an ever-increasing trend in the last decade pushing towards a greener world and more specifically a greener built environment. For commercial tenants in South Africa the need to keep abreast with the current trends in green building techniques and knowledge is increasing. It is expected that in the near future these green building techniques and initiatives will become standards and not voluntary or participative actions.

In analysing the above challenge the study aims to determine the views of a cross section of office tenants regarding the conversion of existing office buildings into Green Star SA certified office buildings.

Knowledge of this information will facilitate the decision-making process of property owners and developers when considering the redevelopment, conversion and upgrade of existing conventional buildings into state-of-the-art, cost-effective and, efficient Green Star SA certified office buildings, whilst allowing for a clearer perspective and better understanding of the views of office tenants, when considering their needs, preferences and concerns when selecting office space to occupy.

1.2 Importance of the Study

The study will provide the real estate industry with a better understanding and insight into tenants’ perceptions about the GBCSA. It will also help the real estate industry to establish any shortcomings we currently have in South Africa with regards to how tenants perceive the conversion of existing office buildings into Green Star SA certified office buildings and how best those issues can be resolved.

Academics can use the findings to give new graduates a better understanding of how tenants in the greater market perceive the GBCSA and will facilitate a better understanding of tenant’s views on the conversion or redevelopment of existing office buildings into Green Star SA certified office buildings.

2. THE PROBLEM STATEMENT

The uptake of conversion of existing buildings into Green Star SA certified office-building developments in South Africa is very slow. Since the establishment of the GBCSA in 2008 only 2 existing buildings have been converted to Green Star SA certified buildings.
The Millennia Park office building achieved a 5 star Green Star SA Office v1 ‘Design’ certification from the GBCSA. (SA Commercial Property News, 2013) The other building refurbished to Green Star SA certification is Pretoria’s old Agrivaal building, (IOL Property, 2013)

The broader spectrum of office tenants in South Africa may lack an understanding and knowledge on the initiatives being implemented by government and the GBCSA to facilitate the conversion of existing office buildings into Green Star SA certified office buildings.

The purpose of this study is to address part of the above problem by determining the views of office tenants regarding the GBCSA and the conversion of existing office buildings into Green Star SA certified office buildings.

3. REVIEW OF RELATED LITERATURE

3.1 Green building overview

3.1.1 Pre 20th century

The history of green building techniques dates back millennia, with the most common so called green building techniques being used by tribesmen and traditional tribal peoples all around the world.

The Inuit people used to build igloos that were insulators and would keep them protected and warm from temperatures as cold as -45°C (Cornell University, 2013).

Native American tribal people used the tepee. It was durable, provided warmth in winter, stayed dry during heavy rains and was cool in the heat of summer (Yue, D & Yue, C. 1894). Tepees could be disassembled and packed away quickly when a tribe decided to move and could be reconstructed quickly when the tribe settled in a new area (Dellenbaugh. 1900. p, 204).

In South Africa, Swaziland, Botswana and Lesotho the traditional building is known as a rondavel. (Rosenthal, 1961, p. 35) It is made from a mixture of mud and clay for the circular walls and the roof is made of thatch. Traditional African rondavels range in size depending on the availability of building and construction materials.

3.1.2 Post 20th century and 21st century

The first Earth Summit was held in 1972 in Stockholm, Sweden. It is generally accepted as the primary defining event in international environmentalism and was initiated by the developed world to address the environmental effects of industrialization (Korkman et al, 2009).
In 1998 The World Green Building Council (WGBC) was launched by David Gottfried who was also one of the founders and first president of the United States Green Building Council. (GBCSA, 2014) The nine founding countries of the WGBC namely Australia, Spain, Brazil, Canada, Japan, Mexico, India, Korea and the USA "officially" launched the World Green Building Council in November 2002 (Green Building Council Australia, 2014). The Green Building Council of South Africa was established in 2008 and is the only established member on the African continent. Ghana, Kenya, Mauritius, Namibia and Nigeria are prospective Green Building Council members, whilst Botswana and Mauritania are associated groups (WGBC, 2013).

The GBCSA uses the Green Star rating and certification systems that were based on the Australian system and customised for the South African landscape and context (GBCSA, 2014).

The objectives of Green Star SA rating and certification tools are to: establish a common language and standard of measurement for green buildings in South Africa; promote an integrated and whole-building design; raise awareness of the benefits and advantages of green building; recognise environmental leadership through Green Star ratings and certification and reduce the environmental impact of developments, building and construction (GBCSA, 2014).

3.2 Green Building Council of South Africa

The GBCSA defines a green building as: “A building which is energy efficient, resource efficient and environmentally responsible. It incorporates design, construction and operational practices that significantly reduce or eliminate the negative impact of development on the environment and occupants.” (GBCSA, 2013)

Green Star SA certification is a points-based system, with points awarded for design initiatives that are known as credits within each category. Categories and credits include:

- Management (14 Points)
- Indoor Environmental Quality (28 Points)
- Energy (30 Points)
- Transport (14 Points)
- Water (15 Points)
- Materials (22 Points)
- Land Use and Ecology (9 Points)
- Emissions (17 Points)
- Innovation (5 Points)
-
Weightings are applied to each category score to reach an overall score out of 100. Each individual project/property must submit the required documentation for each of the relevant credits for review by GBCSA assessors. Projects are awarded a Green Star SA certification based on the following rating:

- 4 Stars = 45-59 Points (Best Practice)
- 5 Stars = 60-74 Points (South African Excellence)
- 6 Stars = 75-100 Points (World Leadership)

The vision of the GBCSA is to lead the transformation of the South African property industry to ensure that all buildings are designed, built and operated in an environmentally sustainable way, to allow South Africans to work and live in healthy, efficient and productive environments (GBCSA, 2013).

### 3.3 Conversion of existing office buildings into Green Star SA certified office buildings

During 2013 at the Green Building Convention held in Cape Town from the 16th to the 18th of October the GBCSA released a tool and rating/certification system for existing buildings. This tool is known as the Existing Buildings Performance Tool and is currently in pilot form. The Green Star SA Existing Building Performance Tool covers the same environmental categories addressed in the Green Star SA Design / As Built tools, but rather than design attributes it focuses on measurable performance indicators such as energy and water, management policies and plans required to achieve environmental performance, and lease agreements with building tenants. (GBCSA, 2013) The rating tool has been developed to cater for a broad range of commercial buildings including office buildings (GBCSA, 2013).

The objective of the Green Star SA Existing Building Performance Tool is to develop a tool that assesses the environmental sustainability of existing buildings and their operations. The Existing Buildings Performance Tool will provide the foundation for a significant change in sustainability practices of the broader South African property market (GBCSA, 2014). It will also allow for existing private and institutional building owners to have environmental design initiatives for existing building stock to be fairly and independently benchmarked, rated and certified (GBCSA, 2014).

### 4. METHODOLOGY

This research used qualitative research based on data obtained from a questionnaire completed during structured interviews with 32 commercial
office tenants based in Gauteng as respondents. The respondents are all based in Gauteng province. The questionnaire’s first section profiled the respondents. The data to answer the problem was obtained through statements that asked respondents to reply based on a 5 point Lickert scale.

The study only includes opinions of office tenants in Gauteng about the conversion of existing buildings to the Green Star SA certificated buildings awarded by the GBCSA and was undertaken from 01 October 2013 to 31 November 2013.

5. DATA ANALYSIS

5.1 Introduction

The study was designed to analyse and determine the views of a cross-section of office tenants in Gauteng South Africa regarding the conversion of existing office buildings into Green Star SA certified office buildings.

In order for the study to draw statistical conclusions from the sample, the data has been assigned abbreviations and values. Table 1, gives a description of the response, its abbreviation and its assigned value:

<table>
<thead>
<tr>
<th>Response</th>
<th>Abbreviation</th>
<th>Assigned Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strongly Disagree</td>
<td>SD</td>
<td>1</td>
</tr>
<tr>
<td>Disagree</td>
<td>D</td>
<td>2</td>
</tr>
<tr>
<td>Neutral</td>
<td>N</td>
<td>3</td>
</tr>
<tr>
<td>Agree</td>
<td>A</td>
<td>4</td>
</tr>
<tr>
<td>Strongly Agree</td>
<td>SA</td>
<td>5</td>
</tr>
</tbody>
</table>

Table 1: Response, response abbreviation, response number

5.2 Respondents profile

Figure 1 gives a graphical representation of the types of office tenants (respondents) to the study. The respondents can be further broken down per category:
Figure 1: Types of organisations

Figure 2 indicates as a percentage of the total responses, the size of office space occupied by respondents in meters squared.

Figure 2: Size of office space in meters squared occupied

Figure 3 indicates the overall age of organisations (respondents)
5.3 Data and statistical results

Question 6 (Q6):
Your organisation is aware of the GBCSA and its initiatives?

Question 7 (Q7):
It is important for your organisation to be seen as having green credentials?

Question 8 (Q8):
Your organisation incorporates green credentials into its current operational strategy?

<table>
<thead>
<tr>
<th>Question</th>
<th>Count</th>
<th>SD &amp; D</th>
<th>N</th>
<th>SA &amp; A</th>
<th>(%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q6</td>
<td>32</td>
<td>40,60%</td>
<td>12,50%</td>
<td>46,90%</td>
<td>100.00%</td>
</tr>
<tr>
<td>Q7</td>
<td>32</td>
<td>21,90%</td>
<td>18,80%</td>
<td>59,40%</td>
<td>100.00%</td>
</tr>
<tr>
<td>Q8</td>
<td>32</td>
<td>43,80%</td>
<td>21,90%</td>
<td>34,40%</td>
<td>100.00%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Question</th>
<th>Mean</th>
<th>Variance</th>
<th>Standard Deviation</th>
<th>Mode</th>
<th>Skewness</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q6</td>
<td>2.96875</td>
<td>1,57964</td>
<td>1,25684</td>
<td>4</td>
<td>-0,23785</td>
</tr>
<tr>
<td>Q7</td>
<td>3,5</td>
<td>1,16129</td>
<td>1,07763</td>
<td>4</td>
<td>-0,4714</td>
</tr>
<tr>
<td>Q8</td>
<td>2.90625</td>
<td>1,37802</td>
<td>1,17389</td>
<td>2</td>
<td>0,18317</td>
</tr>
</tbody>
</table>

Table 2: Presentation of results all respondents (Q6, Q7, Q8)
The summarized table indicates responses to Questions 6, 7 and 8. It also indicates the mean, variance, standard deviation, mode and skewness for each respective question.

When asked how in their opinion the GBCSA can garner more support for its initiatives from the general public, whilst also motivating and educating the wider market, tenants and their employees as to its endeavours and initiatives, the following suggestions were put to the respondents:

Q16a - Free Seminars
Q16b - Increased advertising and exposure
Q16c - Resources available through the GBCSA website
Q16d - Affiliation with professional bodies

<table>
<thead>
<tr>
<th>Question</th>
<th>Count</th>
<th>SD &amp; D</th>
<th>N</th>
<th>SA &amp; A</th>
<th>(%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q16a</td>
<td>32</td>
<td>3.10%</td>
<td>12.50%</td>
<td>84.40%</td>
<td>100.00%</td>
</tr>
<tr>
<td>Q16b</td>
<td>32</td>
<td>0.00%</td>
<td>6.30%</td>
<td>93.80%</td>
<td>100.00%</td>
</tr>
<tr>
<td>Q16c</td>
<td>32</td>
<td>6.30%</td>
<td>18.80%</td>
<td>75.00%</td>
<td>100.00%</td>
</tr>
<tr>
<td>Q16d</td>
<td>32</td>
<td>0.00%</td>
<td>6.30%</td>
<td>93.80%</td>
<td>100.00%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Question</th>
<th>Mean</th>
<th>Variance</th>
<th>Standard Deviation</th>
<th>Mode</th>
<th>Skewness</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q16a</td>
<td>4.03125</td>
<td>0.67641</td>
<td>0.82244</td>
<td>4</td>
<td>-1.47089</td>
</tr>
<tr>
<td>Q16b</td>
<td>4.46875</td>
<td>0.38609</td>
<td>0.62136</td>
<td>5</td>
<td>-0.70042</td>
</tr>
<tr>
<td>Q16c</td>
<td>3.9375</td>
<td>0.89919</td>
<td>0.94826</td>
<td>4</td>
<td>-1.0288</td>
</tr>
<tr>
<td>Q16d</td>
<td>4.46875</td>
<td>0.38609</td>
<td>0.62136</td>
<td>5</td>
<td>-0.70042</td>
</tr>
</tbody>
</table>

Table 3: Presentation of results all respondents (Q16a, Q16b, Q16c, Q16d)

The summarized table indicates responses to Questions 16a, 16b, 16c and 16d. It also indicates the mean, variance, standard deviation, mode and skewness for each respective question.

6. FINDINGS

A total of 46.9% of respondents agreed that they are aware of the GBCSA’s initiatives, while 12.5% of respondents were neutral and 40.6% of respondents disagreed. This indicates a substantial number of respondents were unaware of the GBCSA’s initiatives.

In Question 7, where respondents were asked about the importance for their organisations to be seen as having green credentials, 59.4% of
respondents agreed, a little over 20% of respondents disagreed, with the remainder of respondents being neutral.

Question 8 evaluated whether respondents incorporated green initiatives into their current operating strategies. Only 34.4% of respondents agreed that they are incorporating green initiatives in their operational strategies, whilst 43.8% of respondents disagreed.

When comparing responses from Question 7 and 8 it was found that 72.7% more respondents are positive about green strategies compared to those who are already applying green strategies (59.4% vs 34.4%). This could be due to inadequate knowledge by the respondents as to how one could implement green initiatives and where they could source the technical resources, experts and relevant bodies to assist them with this initiative.

Question 16a, 16b, 16c, and 16d were asked in order to determine methods that the GBCSA could utilise to garner more support for its initiatives from the general public, whilst also educating tenants and their employees as to its endeavours and initiatives.

All four responses; free seminars (84.4%), increased advertising and exposure (93.8%), resources available for tenants on the GBCSA website (75.0%) and professional body association (93.8%) were favourably received by respondents.

Preference was displayed for increased advertising and exposure along with professional body association, both with agreement rates in excess of 90%.

With due consideration being given to financial constraints, increased advertising and exposure, and free seminars may be too costly to implement at this stage and would probably be more viable in the long term when the GBCSA has established a greater market presence leading to an increased demand from tenants for Green Star SA certified office space.

This being said, resources made available to tenants via the GBCSA website, could be implemented with relative ease, representing a cost-effective method to substantially increase tenants’ understanding of the benefits that can be derived from tenancy in a Green Star SA certified building and the initiatives that are being implemented by the GBCSA with regard to green building education.

Professional body association is another method that could substantially increase the GBCSA’s market presence and could be implemented in the medium to long-term future. Affiliation with professional bodies may also promote mutually beneficial relationships that have advantages for all parties involved.

7. RECOMMENDATIONS

Recommendations to further this research:

Proceedings 8th Built Environment Conference
The conversion of existing office buildings into green rated office buildings: Durban, South Africa
Office Tenant views
ISBN 978-0-620-60356-0

27-29 July 2014
• It is recommended that this study be repeated in Cape Town and Durban. This will enable the adoption of inferential statistics and provide information that is relevant to the general population of South Africa.
• Further research should be carried out as to why nearly 20% of respondents to Question 7 did not think that it was important for their respective organisations to be seen as having green credentials.
• Further research should be carried out for Questions 8 of the study as to why more than 20% of respondents did not incorporate green initiatives into their current operational strategies.
• Research should be conducted into a tenant rating tool and the implementation of said tool in the future.
• Further research and investigation should be carried out regarding affiliation with professional bodies.
• Further research into other methods that the GBCSA can use to garner more support for its initiatives.

8. REFERENCES


Whole-life cost planning of green buildings in Singapore with price index and BIM

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ABSTRACT

Purpose:
The new research initiatives proposed are centred on cost planning. They have a common purpose which is to shift the traditional practice of ‘designing to a cost’ to ‘designing to a whole-life cost’ during the early stages of design where cost planning the client’s brief is carried out.

Design and Empirical Findings:
The first research looks at constructing a non-residential whole-life cost index that measures the relative change in total ownership costs over time to guide building owners on aspects of cost efficiency of their assets. Data from Singapore’s Green Mark certified projects is collected for analysing the proportions of building costs incurred in development and construction, as well as operation and maintenance, to construct an ‘integrated’ whole-life building cost index. The second one involves creating a fuzzy decision support tool that can interface with BIM to facilitate project stakeholders, especially the client, in participating in collaborative green building design and cost planning. The Green Mark Scheme’s assessment criteria are mapped onto key building elements and based on experts’ opinion transformed into fuzzy logic if-then rules to develop the tool.

Research Implications:
While traditional cost planning has little consideration of costs beyond the production of a building, the research outcomes demonstrate that the client’s objective can be broadened to encompass sustainability through applying...
whole-life thinking to designing and cost planning to best achieve value for the asset over its entire life span.

Keywords:
Cost planning, whole-life costing, price index, decision support, BIM collaborative design

1. INTRODUCTION

Driven by a greater interest in green buildings from the start of 2000, there have been increasing research on applying whole life costing approaches as tools that can provide supporting evidence of the significant operating benefits derivable from green designs which typically have low occupancy costs as a result of less energy and water usage, and lower maintenance costs because of more robust designs applying green materials, systems and strategies (Aye et al., 2000; Bartlett and Howard, 2000; Bogenstatter, 2000; Cole and Sterner, 2000; Gluch and Baumann, 2004; Hasan et al., 2004; Pellegrini-Masini et al., 2010; Wong et al., 2010; Konig and De Cristofaro, 2012; Sesana and Salvalai, 2013). Among the most important drivers of change for construction, the use of whole life costing in the assessment of project proposals has been identified as one of them (Winch and Courtney, 2001). Incidentally, Kirkham (2005) has been witnessing a rapid increase in the application of whole life costing within the construction industry. He viewed this change as the industry having largely acknowledged the benefits that decision-making based on life cycle costs can bring to the design and operation of building assets. He thinks it could be indicative of the wider desire of the industry to aim for sustainable design.

Traditionally, the broad objectives of cost planning are to ensure that the client receives an economical and efficient project in accordance with the agreed brief and budget, make the design process more efficient thus reducing the time needed to produce a successful design and ensure that all work arising from the client’s brief to the design team is included in the cost planning process. Therefore, designing to the budget begins with the important task of cost planning the client’s brief (or ideas). It is during this stage where the big cost decisions are made, consciously or unconsciously, and design work should not begin until the brief is established properly according to the client’s needs (Ferry et al., 1999). Specifically, elemental cost planning is often described as ‘designing to a cost’. The intention is to produce a building that satisfies all the requirements of the client at an agreed expenditure.

In traditional cost planning, there is little consideration of costs beyond the production of a building which concern its operation and maintenance. However, when the client’s objective is broadened to encompass sustainability, applying whole-life costing becomes a logical means to assessing and achieving best value for the development over its entire life span.
span. In essence, it is the client who makes the initial decision to develop and the way in which design and procurement takes place. This influences the amount of environmentally-friendly (or sustainable) products and practices that will be used in a project. For most developers, decisions are guided by cost and most of these decisions are made during the preparation of the budget at the project feasibility stage. Therefore, increasingly, clients who are owner-occupiers of buildings are requiring environmental sustainability issues be formally considered when developing the design to ensure that buildings are designed and built to operate at optimum whole-life costs.

Ideally, having a whole-life building cost index that measures the actual costs incurred by the building owner over the long term and a software tool that supports the client and his consultants in decision-making on aspects of sustainable cost and design during feasibility studies can indeed bring real benefits to the overall performance of the project because they enable the assessment of environmental impacts as well. In the end, the client benefits most as the whole-life cost index and decision support tool which is integrated with the BIM design process can allow making of informed environmental decisions about the project to effect timely cost and design changes as appropriate. In addition, the client and his consultants are conscious of the extent of their project achieving long-term cost efficiency and meeting green building rating requirements over the entire development of the scheme beginning from a concept to detailed design.

2. AIM OF THE PAPER

The paper sets out to describe two research initiatives (Study 1 and Study 2) that aim to achieve the outcome of ‘designing to a whole-life cost’ during the early stages of design where cost planning the client’s brief is carried out. The main objective of the first study was to design a whole-life building cost index that could facilitate the measure of relative change in total ownership costs over time when compared to a base period and would be useful to green policymakers and building owners. The main objective of the second study was to integrate Singapore’s Green Mark rating system with BIM via a decision support tool to facilitate the creation of (whole-life) cost effective building designs that could meet key assessment criteria concerning environmental impact and performance. A fuzzy rule-based system was designed and developed to achieve the objective.

3. A WHOLE-LIFE COST INDEX (STUDY 1)

Construction industries in the advanced countries, such as the UK, USA and Australia, have been over the years advocating whole-life costing practices and have developed detailed standards and guidelines to assist industry stakeholders to apply the technique to manage the total costs of building projects. For instance, the internationally well-established Building Cost...
Information Service (BCIS) owned by the Royal Institution of Chartered Surveyors in the UK has developed and maintained a database of costs pertaining to building operations and maintenance since the 1990s. The National Institute of Building Sciences (NIBS) in the US has produced a standard for life-cycle cost analysis as part of its Whole Building Design Guide to educate industry stakeholders on how to use the technique in order to manage whole-life costs of building assets. In Australia, the New South Wales Treasury has developed a guideline for ‘Life Cycle Costing’ as part of advocating total asset management in the light of growing pressures to achieve better outcomes from building assets.

However, in Singapore, while there is a national ‘Building Tender Price Index’ series to guide industry stakeholders on tender prices of public and private-sector building projects, it still lacks a body of knowledge (in terms of a centralised database) concerning whole-life costs, specifically the costs of operating/running a building. Having a ‘Whole-Life Cost Index’ essentially creates the body of knowledge of how to manage total costs of a typical building which must encompass operating and maintenance costs because it is during the asset’s service life that more resources are consumed.

3.1 Approach and Methodology

Data was mainly collected from Green Mark certified building projects starting from 2005. Non-Green Mark buildings were also used if good/complete data is available. Only non-residential building projects were considered – commercial, industrial and institutional types – because the data of operating costs of these types can be more easily obtained from a centralised source. On the other hand, for residential developments, collecting such data might not be too feasible as it would involve obtaining it from many different households. The SS CP80: 1999 (Singapore Productivity and Standards Board, 1999) was used to classify the group building elements, while the American NIBS’ Classification of Life Cycle Cost Components (NIBS, 2010) to classify the various cost components. Statistical analysis was performed on the collected data to generate the information required to build the database.

The approach of the study can be presented in two parts. The first part was to study the average cost percentages of the group building elements and to generate ratios of ‘Cost of Building Services’ to ‘Total Cost of Building’ for commercial, industrial and institutional building types (see Figure 3.1). The second part looked at constructing the ‘Whole-Life Cost Index’ using the Paasche Price Index method which produced a weighted composite index. The weights that were applied are calculated from the average proportions of the Green Mark certified buildings for the three non-residential project types between 2005 and 2009 (see Figure 3.2). The buildings must have at least been running for 6 years in order to contain sufficient data on operating costs. The completed index series would begin in 2005 (i.e. the base year).
The proposed ‘Whole-Life Cost Index’ is a weighted composite index and is constructed using the *Paasche* Price Index Method. The formulation of the *Paasche* Price Index is expressed as:

\[
\frac{\sum P_i \times Q_i}{\sum P_0 \times Q_i} \times 100 \%
\]

where, \( P_i \) = current year price; \( P_0 \) = base year price; and \( Q_i \) = current year quantity.

**Figure 3.1** Components of Total Initial Capital Costs of a Building

**Figure 3.2** Components of the Proposed Non-Residential Whole-Life Cost Index
In the first stage of constructing the proposed Index, the weights of the two main components of whole-life costs had to be established for each of the three types of non-residential buildings (i.e. Commercial, Industrial & Institutional types). The two components are:

i) Total initial capital costs.

ii) Total operating costs.

A sample of Green Mark certified buildings between 2005 and 2009 was used for this purpose to obtain their average proportions. Establishing the weights for each building type is based on the following formula:

Whole-Life Cost (C) = Initial capital costs (C1) + Operating costs (C2)

The ratios of C1:C and C2:C were calculated for each sample project. The average ratios were calculated from the sum of ratios for all sample projects divided by the number of sample projects. The derived weight for each building type was applied to each Paasche index to generate the respective whole-life cost indexes, WCI1, WCI2 and WCI3 in this manner.

Whole-Life Cost Index (WCI1) = \[\frac{\text{Average ratio C1:C}}{Q} \times \sum Pi x Qi \] + \[\frac{\text{Average ratio C2:C}}{Q} \times \sum Pi x Qi \]  
(Commercial Buildings)  
\[\sum P_0 x Qi \]  
\[\sum P_0 x Qi \]

Whole-Life Cost Index (WCI2) = \[\frac{\text{Average ratio C1:C}}{Q} \times \sum Pi x Qi \] + \[\frac{\text{Average ratio C2:C}}{Q} \times \sum Pi x Qi \]  
(Industrial Buildings)  
\[\sum P_0 x Qi \]  
\[\sum P_0 x Qi \]

Whole-Life Cost Index (WCI3) = \[\frac{\text{Average ratio C1:C}}{Q} \times \sum Pi x Qi \] + \[\frac{\text{Average ratio C2:C}}{Q} \times \sum Pi x Qi \]  
(Institutional Buildings)  
\[\sum P_0 x Qi \]  
\[\sum P_0 x Qi \]

In the second stage, the weights of the three types of non-residential buildings were established based on the following formula:

Total No. of Non-Residential Buildings (N) = Total No. of Commercial Buildings (N1) + Total No. of Industrial Buildings (N2) + Total No. of Institutional Buildings (N3)

The number of contracts awarded for the three types of buildings between 1996 and 2005 was used for this purpose to obtain their average proportions. The ratios of N1:N, N2:N and N3:N were calculated and the derived weights applied in this manner to generate the overall 'Whole-Life Cost Index' for non-residential buildings:

Whole-Life Cost Index (All Types) = [(Ratio N1:N) x WCI1] + [(Ratio N2:N) x WCI2]
+ [(\text{Ratio N3:N}) \times \text{WCI3}]

The derived weights for commercial buildings (N1), industrial buildings (N2) and institutional buildings (N3), respectively, are shown in Table 3.1.

<table>
<thead>
<tr>
<th>Type of Building</th>
<th>Total Value of Contracts Awarded (1996 to 2005) in \text{S$} million</th>
<th>Ratio/Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Commercial</td>
<td>13151.18</td>
<td>0.195592</td>
</tr>
<tr>
<td>Industrial</td>
<td>28954.43</td>
<td>0.430626</td>
</tr>
<tr>
<td>Institutional</td>
<td>25132.37</td>
<td>0.373782</td>
</tr>
<tr>
<td>Total</td>
<td>67237.98</td>
<td>1</td>
</tr>
</tbody>
</table>

4. A BIM-BASED DECISION SUPPORT TOOL FOR COST PLANNING (STUDY 2)

Building information modelling (BIM) aims to accurately generate a virtual model of a building digitally and when completed, the model should contain precise geometry and relevant data needed to support the construction, fabrication and procurement activities needed to realise the building (Eastman \textit{et al.}, 2008). In applying BIM technology, it has to involve the functions needed to model the lifecycle of a building and when implemented appropriately, BIM facilitates a more integrated design and construction process that results in time and cost benefits for projects, and in better quality buildings that require lower operational and maintenance costs.

The potential of green building rating systems supporting the development of building designs has been stated (Hakkinen and Kiviniemi, 2008). In essence, such rating systems can be integrated with BIM to achieve sustainable building designs that meet assessment criteria relating to environmental impact and performance. For most clients, decisions are guided by cost and most of these decisions are made during the preparation of the budget at the project feasibility stage (see Figure 4.1). When clients adopt a rule-based decision support approach to arriving at the budget, project consultants would have better confidence knowing that the budget had been set in a systematic and knowledgeable manner. In other words, the possibility of any change to be made to the budget, as well as the design that follows, will be relatively low. In the context of using BIM for creating sustainable designs, the proposed tool can interface with CAD applications.
(Design and Green BIM software) to facilitate designers with the task of designing to a better ascertained budget or cost plan (Goh, 2009).

4.1 Approach and Methodology

The research methodology was designed to involve the stages as follows:

i) Develop a framework of Green Mark Scheme elective requirements using the elemental classification in the Singapore Standard’s Code of Practice for construction cost information classification (SS CP80: 1999). In essence, a classification based on building elements achieves standardisation across all types of buildings.

ii) Develop logical rules with fuzzy variables as the decision rules from each of the Green Mark Scheme elective requirements. The concept of designing these rules is based on the cost implications of satisfying the elective requirements. The logic applicable for creating the rules is that as compared to the normal situation, an increase in initial capital cost would cause a corresponding decrease in operating cost. The fuzzy variables used are ‘High’, ‘Low’, ‘Very High’
and ‘Very Low’. See the examples of RETV and artificial lighting system.

Example 1:

If your company plans to meet the pre-requisite requirement of RETV of 22W/m² or 20W/m², what are the corresponding percentages (%) as higher initial capital cost of the building envelope and lower operating cost per year of energy consumption that are considered as acceptable for a typical residential development?

a) For Green Mark GoldPlus Rating, where RETV is set at 22 W/m² or lower:
   
   High Initial Capital Cost _______%
   Low Operating Cost per year _______%

b) For Green Mark Platinum Rating, where RETV is set at 20 W/m² or lower:

   Very High Initial Capital Cost _______%
   Very Low Operating Cost per year _______%

Example 2:

If your company plans to secure 6 points or the maximum of 12 points, what are the corresponding percentages (%) as higher initial capital cost of the artificial lighting system and lower operating cost per year of energy consumption that are considered as acceptable for a typical residential development?

a) For 6 Green Mark points (i.e. 20% energy efficiency improvement):

   High Initial Capital Cost _______%
   Low Operating Cost per year _______%

b) For 12 Green Mark points (i.e. 40% energy efficiency improvement):

   Very High Initial Capital Cost _______%
   Very Low Operating Cost per year _______%

iii) Acquire knowledge from industry experts to develop the system. The 8 experts who had participated are mainly in senior management positions in well-established property development companies, as well as architectural, engineering and cost consulting firms. A total of 119 property development companies and 21 architectural, engineering and cost consulting firms had participated in the postal questionnaire survey.

iv) Establish fuzzy membership functions by combining the horizontal and graphical methods. The major steps consisted of normalising
fuzzy whole-life cost components, quantifying fuzzy whole-life cost components, deriving the $X$ values of the membership functions, deriving the $A$ values of the membership functions and formulating fuzzy membership functions. For a start, the fuzzy whole-life cost components had to be transformed from linguistic terms into mathematical formulae (see Table 4.1).

### Table 4.1. Normalisation of fuzzy whole-life cost components

<table>
<thead>
<tr>
<th>Area of Energy Efficiency Assessment</th>
<th>Mathematical Formula</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Building Envelopes</strong> - RETV:</td>
<td></td>
</tr>
<tr>
<td>Initial Capital Cost (%)</td>
<td>$= \frac{\text{Actual Cost} - \text{Normally Expected Cost}}{\text{Normally Expected Cost}} \times 100%$</td>
</tr>
<tr>
<td>Operating Cost per year (%)</td>
<td>$= \frac{\text{Actual Cost per year} - \text{Normally Expected Cost per year}}{\text{Normally Expected Cost per year}} \times 100%$</td>
</tr>
<tr>
<td>Where,</td>
<td></td>
</tr>
<tr>
<td>- Normally Expected Cost is the cost of the building envelope designed to meet the mandatory requirement of RETV of 25 W/m$^2$.</td>
<td></td>
</tr>
<tr>
<td>- Actual Cost is the cost of the building envelope designed to meet the pre-requisite requirement of RETV of 22 W/m$^2$ or 20 W/m$^2$.</td>
<td></td>
</tr>
<tr>
<td><strong>Artificial Lighting Systems:</strong></td>
<td></td>
</tr>
<tr>
<td>Initial Capital Cost (%)</td>
<td>$= \frac{\text{Actual Cost} - \text{Normally Expected Cost}}{\text{Normally Expected Cost}} \times 100%$</td>
</tr>
<tr>
<td>Operating Cost per year (%)</td>
<td>$= \frac{\text{Actual Cost per year} - \text{Normally Expected Cost per year}}{\text{Normally Expected Cost per year}} \times 100%$</td>
</tr>
<tr>
<td>Where,</td>
<td></td>
</tr>
<tr>
<td>- Normally Expected Cost is the cost of the artificial lighting system designed at the maximum lighting power budget that complies with SS 530.</td>
<td></td>
</tr>
<tr>
<td>- Actual Cost is the cost of the artificial lighting system designed to meet the energy efficiency improvement that is equivalent to 6 or 12 Green Mark points.</td>
<td></td>
</tr>
</tbody>
</table>
The fuzzy rules adopted a generic *if-then* structure. By applying the ILOG *JRules* software, it involved a set of pre-established vocabulary to define the rule’s conditions and actions, as well as present the rule in a readable language. A few examples of the generated decision rules for ‘building envelope’ and ‘artificial lighting system’ are presented as follows:

i) **Decision Rule for Building Envelope Design:**

IF building envelope design meets “RETV requirement which is set at 22W/m² or lower”,

THEN set initial capital cost to “high” and add the message “the initial capital cost is 5% to 17% higher than normal”,

AND set operating cost per year to “low” and add the message “the operating cost per year is 1% to 6% lower than normal”.

ii) **Decision Rule for Artificial Lighting System Design:**

IF artificial lighting system design meets “energy efficiency improvements that are equivalent to 6 Green Mark points”,

THEN set initial capital cost to “high” and add the message “the initial capital cost is 5% to 15% higher than normal”,

AND set operating cost per year to “low” and add the message “the operating cost per year is 2% to 24% lower than normal”.

5. SUMMARY OF FINDINGS

In Study 1, the concept of constructing a national-level ‘Whole-Life Cost Index’ for buildings is new. It can be defined as an index that measures the relative change in building ownership costs over time, relative to a base period. Singapore has yet to have a whole-life cost index for buildings and developing one is timely in view of the rapidly growing interests in sustainable design and performance of buildings. The concept and methodology proposed here is similar to the ones adopted by the BCA to construct the National Building Tender Price Index for Singapore’s Construction Industry which started in 1990. As the number of Green Mark certified buildings continues to grow, the Index would be able by 2030 to cover at least 80% of all buildings in Singapore.

In Study 2, the BIM-based decision support tool contains fuzzy rules related to the assessment of whole-life cost implications of designing and constructing environmentally-friendly buildings. The elective requirements of the assessment criteria, as specified in the BCA Green Mark Scheme, were assigned to their respective building elements. From the classification of the elective requirements by building element, each requirement was transformed into logical decision rules and assigned a linguistic term (i.e. High; Very
High; Low; Very Low) for each applicable whole-life cost component. Initial costs and operating costs were the two whole-life cost components applied.

In the process of developing the tool, it had demonstrated a systematic approach to appraise alternative building designs and technology that would meet the respective Green Mark ratings (i.e. Certified; Gold; Gold\textsuperscript{Plus}; Platinum). The aim was set out to improve the decision-making process of clients together with their consultants in the early stage of design and cost planning. The developed tool supports clients in decisions related to (whole-life) cost budgeting and designing of environmentally-friendly buildings.

Clients who are owners must realise that in order to attain best value for their building projects, there has to be a fair balance of consideration for both initial costs and future costs which are costs that would be incurred from operating the premises over their physical or economic life. More often, practice has shown that with an increase in capital expenditure on certain building elements, it can translate into longer run savings in terms of operating and maintenance costs. Some applicable elements include the building envelope, roof systems, air-conditioning and mechanical ventilation systems, lifts and electrical installations.

6. CONCLUSION

In February 2008, the Inter-Ministerial Committee on Sustainable Development was formed to formulate a clear national framework for sustainable growth of Singapore. Among the strategic directions set out to promote environmental sustainability in the context of building a sustainable city, one of them was to focus on introducing more green buildings and taking a lifecycle approach to green buildings. Since April 2008, all new buildings and those existing buildings which undergo major retrofitting works have to be environmentally-friendly under the new Building Control (Environmental Sustainability) Regulations. As such, the research initiatives presented in the paper are purposeful in helping Singapore’s construction industry progress with new directions for developing improved thinking, methods and practice that can translate into better knowledge, skills and technology in future.

The consideration of whole-life costs in the design, construction and operation of building developments is holistic and a key part of sustainable development. When more reliable cost information that applies throughout the life span of a building is made available, it should raise stakeholders’ confidence in adopting whole-life cost concepts for their existing or new projects. Such buildings with whole-life cost considerations will achieve better value-for-money to benefit owners in the long run. Specifically, the novelty of the two research initiatives lies in their common goal of reinforcing life-cycle cost thinking in the early project phases. The ideal outcome is to bring about a shift in practice from the traditional ‘designing to capital cost’ to current...
‘designing to whole-life costs’ when translating the client’s brief for developing green buildings. The ‘Whole-Life Cost Index’ enables prospective clients to appreciate the total cost of building ownership, while for the existing owners to monitor and predict cost efficiency levels of their buildings. In addition, the developed decision rules can interface with BIM technology to allow clients and their consultants to work collaboratively to arrive at a better integrated design with life-cycle costing of their green building projects.

7. ACKNOWLEDGEMENTS

The research has been wholly funded by the National University of Singapore under the research grants R296000111112 and R296000144646. Acknowledgement is also due to the public and private organisations which have provided useful cost data and industry experts who participated in the postal questionnaire survey for knowledge elicitation.

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BUILDING INFORMATION MODELLING (BIM): AN ASSESSMENT OF ITS VIABILITY IN COST MANAGEMENT IN THE ZAMBIAN CONSTRUCTION INDUSTRY

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ABSTRACT

Purpose of this paper

The construction industry has in the recent past experienced the emergence of Building Information Modelling (BIM) aimed at enhancing efficiency and effectiveness in cost management. Although at the moment the implementation of BIM is highly concentrated in the developed countries, the benefits of its implementation are likely to extend to developing countries too. This paper was therefore aimed at assessing the viability of utilising BIM in cost management in the Zambian Construction Industry (ZCI).

Design

The research utilised primary and secondary data. Secondary data was obtained through literature available on BIM and its application worldwide. Primary data was obtained through the use of a questionnaire survey to quantity surveyors, contractors and various design consultants in the ZCI.
Findings
The results indicated that there is limited knowledge regarding BIM and that it is not being utilised in the ZCI. Additionally, the respondents expressed the desire for implementation of BIM in a quest to have an efficient and accurate cost management system. The results further indicated that most consultants have the physical infrastructure required to implement BIM.

Research limitations/implications
Only contractors and consultants were approached as they are the main players in cost management.

Practical implications
The implementation of BIM will enhance efficiency and accuracy where cost management is concerned.

The value of the paper. This paper will highlight a new approach that can be used to manage construction cost in a much more efficient and effective way in the ZCI and elsewhere in construction.

Keywords: building information modelling, cost management, deployment challenges.

1. INTRODUCTION

The construction industry has made several attempts to eliminate wastages, cost overruns and dispute on projects (Olatunji et al., 2010). Where success has been recorded, such success has been short-lived. The industry has yet to mature to a level where it can guarantee continuous success in a number of projects if not all, when it comes to eliminating the above mentioned problems. The most probable impediment to the elimination of the aforementioned problems is the nature with regards to the kind of products and the role players within the industry. With particular reference to construction products such as hospitals, Sebastian (2011) noted that there are many role players with varied interests, duties and responsibilities who are actively involved in the project. The diverse nature of the role players and the fragmented nature of the industry possess a huge challenge to the elimination of, cost overruns, wastages and dispute on projects. In order to counter this challenge, measures have to be put in place to aid organisational efficiency, capacity and effectiveness in construction projects. One such measure is the utilisation of software technology and processes such as Building Information Modelling (BIM), have been introduced in the market. BIM is one of the latest ways of integrated thinking in relation to software systems in the built environment which utilises data models. Hence, the objective of this paper was to assess the viability of utilising BIM in the Zambian Construction Industry (ZCI) to enhance cost management.
2. CURRENT COST MANAGEMENT IN THE ZCI

The utilization of information systems (IS) in the construction industry is of great importance in order to enhance the effectiveness of construction projects throughout their life cycle and across different construction business functions (Jung and Joo 2011). Currently, cost management in the ZCI can be said to be poor as construction projects are characterised with cost overruns (Kaliba, Muya and Mumba 2009; Kaliba, et al. 2013). Insufficient analysis of initial costs, lack of coordination among team members and size of the projects were some of the reasons cited for poor project performance (Kaliba, et al. 2013). In addition, the ZCI, like any other construction industry, has been facing a paradigm shift to (i) increase: productivity, efficiency, infrastructure value, quality and sustainability, (ii) reduce: lifecycle costs, lead times and duplications, via effective collaboration and communication of stakeholders in construction projects (Arayici et al. 2011). This can be achieved by using certain software packages that (i) increase: productivity, efficiency, infrastructure value, quality and sustainability, and (ii) reduce: lifecycle costs, lead times and duplications. The ZCI is not an exception of the advancement in the technology and the known challenges that still surround it. It is for this reason that the key disciplines such as cost engineering, quantity surveying, construction economics and project management realise the benefits of BIM through their ability to utilise electronic models to provide estimates and cost plans in real time (Smith 2014). In addition, BIM enables the instant generation of cost budgets, simplifies the planning process, offers an opportunity to evaluate work flow, and reduces estimation time from weeks to minutes with improved accuracy of estimates (Kaneedan, 2010).

3. BUILDING INFORMATION MODELLING

BIM is a multi-dimensional model that acts as a communication and information resource over the life cycle of a construction project and consists of 3-dimensional (3D) design functions, namely: cost estimating, programming and scheduling functions (Gee, 2010). Further, Eastman et al. (cited in Lee et al. 2014 p.1) defines BIM as “a new approach to design, construction, and facilities management, in which a digital representation of the building process is used to facilitate the exchange and interoperability of information in digital format”. On the other hand, other scholars (Ding et al. 2014) have defined BIM as being a knowledge resource used by professional during the life cycle of the project, from conception to demolition. This enables BIM to improve efficiency at various stages in the construction...
process (Smith, 2010). Hence the focus of this paper is to realize how the ZCI can improve such a stage or process through BIM; cost management. Essentially BIM involves the exchange and interaction of process, technologies and policies in order to manage the information of a project during its life cycle (Bryde et al. 2014). The following are some of the core characteristics of BIM:

**Object-orientated Modelling:** BIM produces designs which have sides that can be viewed and appreciated even before their actual implementation. These designs are commonly referred to as three dimensional (3D) designs. This is derived from increased interest and research in building information integration and interoperability, and follows the expansion of 3D CAD modelling with various attributes in an attempt to improve the efficiency and effectiveness of design and construction processes (Lee et al., 2005). The model is basically constructed by the software itself through pre-programmed building objects creating a spatial experience, which enables the stakeholders of the project to make concrete decisions based on proper visualization of the drawings or building elements (Ding et al. 2014; Gee, 2010).

**Interoperability:** According to Venugpol et al. (2012) interoperability ‘is the ability of diverse systems and organizations to work together’. This interoperability in models is achieved by the use of Industry Foundation Classes (IFC). The IFCs was created by the International Alliance for Interoperability primarily to facilitate the exchange of information reliably and consistently between two dissimilar applications (Matipa, 2008). A software interoperability environment therefore enables computer programs to share and exchange data automatically regardless of the type of software or where the data may be residing. BIM is such a system or process that revolves around virtual models that make it possible to share information throughout the entire building industry (McNeill et al., 2010).

**Parametric Modelling:** Parametric modelling forms the basis for BIM processes. It is data based modelling which utilises large digital data-bases containing building information regarding structural components and their relationship with other building elements (Ding et al. 2014; Gee, 2010; Monteiro and Martins, 2013). The elements of the designs done with BIM are interconnected to an extent that any change made to the elements results in a proportionate alteration to the overall design. The benefit of which is the saving on time needed to undertake independent measurements of such changes in the long run.

**nD Modelling:** Unlike the traditional process which operates on 3D, BIM basically expands 3D into nD allowing dynamic and virtual analysis of project parameters such as scheduling, costing, maintaining, stability, safety,
sustainability and any other performance parameters/objectives (Bryde et al. 2013; Ding et al. 2014). This part of BIM helps in the planning process hereafter, making it possible for better construction planning and functioning of a facility.

Challenges Associated with BIM Implementation

As much as the use of BIM has been known to have positive effects on construction projects, there are challenges that can be associated to it. Barlish and Sullivan (2012) identified the following challenges; a) Benefits may be intangible; b) Costly organizational changes with introduction of new system c) Diverse stakeholders involved and may have conflicting opinions d) Fear of the new system and how it will affect their jobs and e) Practical difficulties such as interconnected systems.

Further, Olatunji (2011) also notes that there are also corporate costs such as software and technology acquisition, training, hardware and contingency services for its full function. However, realizing its overall benefits for the industry with respect to cost management and control, its application (BIM) in the ZCI is recommended. Some of the benefits include, cost and time savings, improved communication and effective control of other project parameters (Bryde et al. 2013).

4. AREAS OF APPLICATION OF BIM IN THE COST MANAGEMENT PROCESS

Building information Modelling is a tool that is used in cost management to improve the efficiency and accuracy of the cost management system (Cameron, 2012, Lee, Kim and Yu 2014; and Jung and Joo 2011). This is achieved because of its characteristics. The following are the cost management areas where BIM can be applied:

Production of Bills of Quantities: A Bill of Quantities is one of the main tools used in the cost management of construction projects because it offers a basis for cost analysis, which are subsequently used on future contracts, in cost planning (Seeley, 1988). The automatic production of bills of quantities is one of the functions that BIM technology has as the fifth dimension (Kaneedan 2010), provided the Standard method of measurement is configured in the system. This saves on time as a document that could take weeks to produce can only take minutes using BIM. It should also be noted that before the bill of quantities can be prepared taking off can be done within the BIM technology (Monteiro and Martins, 2013).

Rapid Updating of Costs: With an ever increasing demand for speed and accuracy in cost information service, automating the retrieval and analysis of
Cost information is crucial (Matipa, 2008a). Thus, when using BIM, in the preparation of material quantities, they are automatically extracted and changed whenever changes are made in the model (Azhar et al., 2010). This also aids in cost control and as a material management tool (Jung and Gibson, 1999). In addition BIM also supports the generation of cost budgets (Kaneedan 2010). The system also demonstrates the capability to handle data collection and storage of lifecycle costing, and the automatic calculation of lifecycle costs, that are capable of responding instantaneously to any changes effected by users (Smith, 2010). The application of this tool reduces the exhaustive manual work and consequently improves the effectiveness and efficiency of lifecycle costing (Fu et al., 2007).

Cost Estimate: According to Lee, Kim and Yu (2014) cost estimation is the process of predicting project costs and resource requirements. BIM technology can extract accurate quantities and spaces that can be used for cost estimating at any period of the design of a project (Gee, 2010). However the accuracy of the estimate will be dependent on the detail in the design (Lee, Kim and Yu 2014). The BIM model can easily make available design and variable information, such as the floor-to-ceiling height of each area, the perimeter/floor area ratio, the height of the building and many other measurements as required that need to be taken into account as it can have an impact on the cost per unit. With the visual aspect of the model it becomes easier to establish which elements have been estimated and those that require attention (Gee, 2010; Jung and Joo 2011). It also allows estimators to identify and communicate relationships between quantities, costs and locations, and distinguish how areas and components of the building are contributing to the total cost of the project (Kaneedan 2010).

Management of Variations: Variations are a common feature of most construction projects. Once design changes are made to the model, the cost estimate gets automatically updated with quantities extracted from the modified model, without the estimator needing to take-off quantities. This allows project managers to quickly optimise construction schedules with ever-changing material deliveries, seasonal cost and availability (McNeill et al., 2010). Incremental value management while the project is being developed allows realistic assessment throughout the design of the project, which can result in valuable cost savings and resource utilisation (Eastman, 2007). As variations are implemented into BIM and costs are updated automatically, all project participants are able to extract the cost of the changes they make, thus keeping them informed of the cost implications of the variations issued by them and consequently enhancing the communication process (Bryde et al. 2013). The quick calculation of variation orders facilitates prompt and simplified production of information for cost reporting of monthly valuations. Therefore initial costs of the building,
including modifications and upgrades can be evaluated for cost effectiveness (Gee, 2010).

**Progress Valuation:** Valuation is a process that is used in a contract to provide details of all works done and cost incurred (Cartlidge, 2009). BIM facilitates faster and accurate valuation process because of its ability to produce automated bills of quantities which are very important in this process. The bills of quantities produced using BIM are linked to databases where information regarding material, labour and other costs are stored (Gee, 2010; Kaneedan 2010). All this information is required in the valuation process because one has to check the materials used and labour costs of work done. Consequently, BIM accords an easier valuation process because expenses relating to changes in design can be generated in real time, without the need to measure and recalculate quantities. Communication and records of the project are important requirements of accurate valuation because consultants need to share information. Thus, BIM enhances communication and record keeping due to its ability to hold all information in a single repository ensuring consistency, accuracy and accessibility of data (Arayici, 2008 ; Takim, Harris and Nawawi 2013). Essentially, this information is more easily shared and can be improved upon and re-used in the process.

5. **RESEARCH METHODOLOGY**

Both quantitative and qualitative methodologies were used. The combination of the two methodologies was favoured on the merit that it took into consideration both the people’s perception and attitude towards adoption of BIM in the ZCI. Structured questionnaires were utilised in this research since highly structured questionnaires facilitate reduction in variations in the data collected (Saunders et al. 2009). The following sources of data were used;

Secondary data included both unpublished and published sources (Saunders et al., 2009). This source of data was used because it provides the main source of information needed to answer the research question(s) and to address the objectives. Primary Data included Interviews which were conducted with professionals and institutional bodies involved in cost management in the ZCI. This involved 21 contractors, 11 architects, 6 Quantity Surveyor, and 7 engineers, who were selected on the basis of simple random selection.

6. **RESEARCH FINDINGS AND DISCUSSION**
Systems Used in Cost Management in ZCI

A survey was undertaken to establish the most commonly used systems between software system and manual system.

The survey revealed that majority of the respondents (67%) indicated that the software system is widely used. Based on the responses, it suffices to say majority of the role players in the ZCI have the basic infrastructure (hard and soft) which enables them to work with software, such as computers. Therefore, this implies that certain costs associated with BIM implementation in the ZCI are already catered for.

Software and Communication Tools Currently in Use

Based on figure 1.1, the most used software package is AutoCAD followed by Microsoft excel and Microsoft project. WinQS and Microsoft Excel are the most widely used systems for the preparation of quantities, estimating and cost planning, cost monitoring, and final accounts management while AutoCAD is the most widely used system for designing. In addition to the above mentioned software packages, Revit, ArchiCAD and Microsoft Project are some of the software packages used in the ZCI which are directly connected to cost management.

![Figure 1.1: Software Packages Used in the Zambian Construction Industry](image)

Knowledge of BIM and the Available Supporting Software

This part of the survey focussed on the establishment of the awareness of BIM and its complementary software packages within the ZCI. The following were the main findings as per figure 1.2 below.
It was found out that despite the ZCI being up to date with the technological advancements; it has not translated into the awareness of the various software packages that support the use of BIM. The findings indicated that only 4% of participants had extensive knowledge of BIM. 52% had no prior knowledge of BIM, while 44% were not sure what BIM is. Further, respondents who new BIM stated that their knowledge of BIM was solely based on literature, hence, they did not know any software packages that support the use of BIM which can be utilised in the ZCI.

Perceptions on Challenges Regarding Adoption of New Technology (BIM) in the ZCI

The findings from the survey indicated that there was a strong perception that BIM as a new technology would be easily adopted. 52% were of the view that adoption of BIM would not be a major challenge. 22 % were not sure while the remaining 26 % were of the view that it would be a challenge. All respondents however, acknowledged the fact that use of BIM would come with cost implications and might compromise issues relating to confidentiality.

7. DISCUSSION OF RESULTS

The use of BIM could be viable in the ZCI cost management process and can help to solve the pitfalls that are in the current system. As a result;

i. The cost management process in the ZCI is prone to inefficiency in terms of time and accuracy. Although there is use of software systems in the industry, there are still some inconsistencies especially on the information exchange among consultants. This could be improved by the use of BIM since it has characteristics of interoperability which can help to enhance communication. The system being used currently is more suitable for small projects where resources can be easily accessed. If applied on larger...
projects, however, it increases the risk of inefficiency. This is so because larger projects call for execution of huge volumes of work within a short time and information exchange among consultant to be done effectively in order to avoid delays.

The current system requires many people and a lot of time especially in the information exchange, whereas, with the automated system, all the necessary information exchange is done at once using a single media hence improving the information accuracy. Hence the use of BIM would be more suitable and cost effective on larger projects compared to smaller ones.

ii. In the ZCI, there is already basic infrastructure of software system which just needs to be improved to suit the use of BIM. Like in other countries where BIM is being used, institutions had to be formed to make guidelines on how BIM would be implemented. Hence, for the model to be used effectively in the ZCI for cost management there is need to form a body that would make guidelines and regulations of how the system will be used.

iii. Importantly, it is prudent to be aware of the measures and challenges involved in the implementation of BIM one challenge being implementation costs. Its implementation is expensive due to the costs associated with procuring and installing the model, training of personnel and creation of a data base that would be suitable to the standards of the ZCI.

8. CONCLUSION

Cost management is an integral part of the successful execution of construction projects. The ZCI is currently faced with inefficiencies in managing costs. With the advancement of technology the industry can adopt BIM to cartel these inefficiencies such as inaccurate estimates. However, this will pose a challenge to the industry in terms of acquiring a BIM system such as the cost of buying and renewing software packages, training and copyrights. Despite the challenges that may be experienced in implementing BIM, the benefits will outweigh the cost. In light of this, the ZCI must consider implementing it.

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A Study on the various possible policy frameworks for the effective adoption of Building Information Modeling (BIM) in South African Architectural Engineering and Construction (AEC) sector

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ABSTRACT
Building Information Modelling is the current buzz word around the developing and developed countries. The BIM philosophies are well developed and documented through many researches and the implementation reports in the developed nations. However the adoptions of BIM in the developing economies are hurdled by many factors. Among these the socio economics factors and industry readiness to the BIM adoption play a major role in the BIM adoption. These socio economic factors and the industry readiness can be influenced through various policy frameworks by different stakeholders of the AEC sectors. This paper focuses on the readiness towards the BIM implementation and the possible policy framework in South Africa. The study used interviews and the questionnaire survey to collect the data. Outcome from the study can be considered as the starting point for the stakeholders such as the statutory councils and the government agencies to explore the
BIM adoption through staged adoption and new policy framework in South African AEC sector.

Key words: Building Information Modeling (BIM), Policy Framework, Technology Adoption, Government initiation.

1. INTRODUCTION

The modern Architectural Engineering and Construction (AEC) projects are multi-disciplinary, distributive, fast track and complex in nature. There exists millions and millions of project data which need to be coordinated and managed by various project participants. So far manual methods are used and to some extent simple information technology applications such as use of worksheets, common project database etc., are also been adopted. However, the increasing complexities of modern AEC projects together with the concurrent execution of project activities are posing huge challenges on managing the project information. This affects the productivity, efficiency and quality of the project delivery in terms of delay, rework, substandard outcome and cost overruns. In order to mitigate this, the AEC industry around the world is undergoing a paradigm shift towards the adoption of information technology and automation applications.

CAD based technologies such as 2D and 3D modelling have been developed over the past and was used as a medium to manage the project information. However, the interface management using these simple geometrical modelling especially during the design stage of the project becomes challenging. One of the recent developments towards managing the challenges is to utilize a parametric modelling technique called Building Information Modelling (BIM), it is an intelligent information management model, which can capture and manage the geometric and non-geometric objects and its relationships of all building elements throughout its life cycle of the project (Singh et al., 2011). BIM allows the sharing of information regarding a project amongst the stakeholders involved during the design, construction, and operation phases of a project. BIM has allowed the stakeholders to demand, mimic and estimate each of the building components as a life cycle entity with speed and accuracy. Improvements to the existing BIM models can constantly take place throughout the lifecycle of the project (Kasprzak and Dubler, 2012). With these capabilities, BIM has been proved as an efficient tool to manage the modern complex multi-disciplinary AEC projects as recorded in the past research studies (Mcauley et al., 2013; Barlish and Sullivan, 2012; Manderson et al., 2012; Udom, 2012; Cerovskek, 2011; Sebastian, 2011; Succar, 2009).
Despite the numerous benefits of using BIM, AEC sectors around the world are experiencing challenges towards the implementation of BIM. Many studies have been done to identify the barriers and challenges towards the BIM adoption. Typically the challenges and barriers can be classified into three categories such as Process, Technology and People related. Many strategies have been adopted around the world to control the above categorised factors; one among the important and widely tested strategies is the government/ regulatory involvement or push for the adoption in the public projects (Porwal and Hewage, 2013; Khosrowshahi and Arayici, 2012.). With the aid of government/regulatory support, BIM is now widely used in countries such as the USA, UK, Australia, Hong Kong, Canada etc. (Porwal and Hewage, 2013). However, the adoption also depends upon the industry readiness to adopt the technology. The developing nations such as South Africa, are still struggling to adopt BIM (Senthilkumar et al., 2013). Hence, investigating the industry readiness and exploring the possible policy related BIM adoption initiatives becomes of paramount important. Hence, the present study focuses on investigating the industry readiness and further explores the possible policy framework by the government/ regulatory authorities towards the effective adoption of BIM in South Africa. The paper has six sections; the next section discusses the literature on the industry readiness towards the BIM adoption followed by the various effective policy initiatives from various government/ statutory councils in some of the developed nations. The fourth section outlines the adopted research methodology and the fifth section explains the data analysis. The sixth section discusses the study results followed by the conclusions at the end.

2. Industry readiness on BIM adoption

BIM implementation is varying from country to country. Even within any given country, its adoption rate is inconsistent from project to projects (Giel and Issa, 2012). Typically the adoption is driven by three important factors such as the availability of the BIM technology, the readiness of the AEC stakeholders and the existence of government or the regulatory body’s guidelines and the mandate. The government and the regulatory bodies can exert a greater influence on the other two factors towards the wider BIM adoptions through the strategies and policy initiatives. Further, the BIM adoption is effective only when the industry is ready for the same. A study by Gu et al., (2010) categorised the adoption factors based on the following three readiness factors such as technology, process and people related. Much Research had been done in the past to understand and quantify the industry readiness towards the BIM adoption based on the above said three categories. The compilation of the same are as follows; the individual company’s motivation and readiness towards BIM adoption, readiness from the client through demand and initiatives, supply chain readiness, cultural
and social readiness towards the change, IT readiness, readiness towards financial and cost implications, readiness on BIM training, readiness on the appointment of BIM personnel, readiness to develop BIM strategy, readiness to identify the BIM adoption challenges, readiness towards measuring the performance, readiness on the competent human resource production, readiness towards the modification on the procurement strategies and the legal implications (NFB, 2013; Paine and Marasini, 2013; Giel and Issa 2012; Liu et al., 2010; Zhou et al, 2012). Exploring the readiness on the above said aspects may assist in strategically design the policies which may lead to the effective BIM adoption in South Africa.

The South African construction industry is still dominantly practicing the traditional ways of delivering the construction projects. This includes traditional 2D and 3D drawings which still have a major role in all the projects. Further, there exists a significant gap in terms of IT sophistication, competitiveness and scale of development between South Africa and Western developed countries, hence investigating the current status of the SA AEC industry’s readiness is important. However, some of the readiness may need to be nurtured through the adoption strategies and policies by the AEC stakeholders. Government / regulatory authority’s role through policy framework is one among the important strategy towards effective BIM adoption by the AEC stakeholders. The following section briefs some of the various BIM implementation strategies adopted by the government/ regulatory authorities around the world.

3. BIM policy related Implementation strategies around the world

BIM is been implemented through the government and the other regulating body’s policies, strategies and mandate in various countries. United States of America is the earliest adopter of BIM technology and has pushed the implementation through the government mandate as well as the other strategies such as the development of BIM implementation standards, creating BIM awareness etc. (Smart Market report, 2012). National BIM Standard-United States (NBIMS-US™) is one among their many governmental BIM implementation initiatives (National Institute of Building Sciences, 2014). Further, the General Services Agency (GSA) in USA played a major role in the early BIM implementation process (Wong, et.al., 2011). The Agency’s first BIM program was launched in 2007, which was mandated to establish a nationwide adoption policy, to support the current BIM adopters, to liaise with the industry stakeholders, to increase the BIM awareness, to exercise the pilot implementation and propagate the lessons learnt. Further many state government bodies in USA were also assisted in BIM implementation, Wisconsin state administration is the first state to introduce the mandatory requirement by the local government towards the
adoption of BIM practices for their state-funded construction projects from 2009 onwards (Broyless, 2014).

The Building SMART and Built Environment Innovation Council, Australia, have developed a National Building Information Modelling Initiative (NBI) report which outlines the strategies for the adoption of BIM. Their initiatives include the conduction of a series of BIM conferences in partnerships with the government, industry, academia and other built environmental stakeholders throughout the Australian states between 2011 and 2012. The outcome of these conferences sets a BIM implementation targets for the Australian government. Some of the key targets include the modification of the existing procurement practices towards BIM friendly collaborative contracts, the development of BIM implementation guidelines, Guidelines towards educating by introducing the multi-disciplinary approach, the development of the BIM libraries and the data exchange framework, the possible introduction of BIM implementation mandates to the government projects etc. (Building SMART Australasia, 2012).

The UK government together with the UK construction industry have introduced a four year BIM implementation programme. The government has encouraged firms to adopt BIM as a mandatory requirement for public sector centrally procured construction projects, such as the project documents to be delivered using level 2 BIM from 2016 (Department for Business, Innovation & Skills, 2012). The UK’s BIM implementation initiatives divided the strategies related in to three main components such as BIM governance; people and technology alignment and process sophistication (National BIM report, 2013). Further, the UK government is supportive in developing BIM guidelines and standards along with the various professional councils and the developers. The Nordic countries such as Finland, Norway and Denmark governments also took BIM implementation initiatives through the various policies and strategies (Jenson and Johanneson, 2013; Wong, 2010).

3. Brief Research Methodology

The research methodology adopted in this study follows the interpretivism philosophy. The study adopted a combination of interviews, literature and documentary review in the first phase to understand the existence and the importance of various BIM adoption policy frameworks in the developed nations. Further, the industry readiness and the possible South African government implementation initiatives the policy frameworks have been identified, analysed through the interviews and the questionnaire survey. The content validity of the interview and questionnaire contents was tested through 3 pilot interviews before the start of the data collection. The pilot interviews were conducted with the project managers who have vast experience in using BIM in South Africa and around the world. The necessary modifications were done in the questionnaire appropriately. The respondents
were chosen randomly. There were 72 Questionnaires circulated among the contractors, the consultants and the clients. Only 32 valid questionnaires were returned. Among the 32 responded, there are 9 participants from the clients side, 5 participants from the consulting firms and the remaining 18 are from the contracting companies. The collected data was analysed and the findings were triangulated. The following section explains the data analysis and the results.

Figure 1. BIM adoption readiness – Technology related

5. Data Analysis on the BIM adoption readiness of South African AEC industry

The collected data were analysed to find the BIM readiness and the possible BIM implementation policy initiatives by the government and the other regulating authorities. Figure 1, 2 and 3 depicts the BIM readiness in South Africa with respect to the 3 main categories explained in section 3 such as technology, people and processes related.
Based on Figure 1, it is evident that there exists a lack of the availability of the BIM tools, the affordability and the knowledge to adopt the BIM tools. However the supportive technologies such as the internet, the software and hardware environments were realized as adequate for the possible BIM adoption. Figure 2 depicts the insight related to the people related readiness. The readiness exists with the individual factors, however all the other factors as shown in Figure 2 are dominated on the inadequacy side of the spectrum. However, the awareness of the BIM and its benefits are relatively better than its counterparts on the inadequacy side. Figure 3 shows the process related readiness and it is obvious that all the process related readiness factors are not matured enough to receive the new BIM technology in the sector.
Figure 4. Perceived regulatory involvement towards BIM adoption in SA.

Figure 4 shows the perceived regulatory involvement towards the BIM adoption in South Africa. Most of the respondents felt that the CIDB and the Federal Government play a major role in introducing policy initiatives for the BIM adoption. Further the other two categories such as the professional councils (The Council for the Built Environment(CBE), The Engineering Council of South Africa (ECSA); The South African Council for Project and Construction Management Professions (SACPCMP); South African Council for the Quantity Surveying Profession (SACQSP); South African Council for the Landscape Architectural Profession (SACLAP) etc.) and Construction Education and Training Authority (CETA) also perceived to have a mandatory role to play in the policy initiatives towards effective BIM adoption in South Africa. Figure 5 shows the various policy initiatives which were introduced around the world, as the attributes on the ordinates of the radar plot. In addition, the policy initiatives which are perceived by the participants as the strategies to improve the BIM adoption are also plotted as the position points in Figure 5. From the plot, it is evident that the awareness through BIM conferences, the training, development of BIM implementation standards and the contractual mandates are suggested as the important strategies in which the government or regulatory agencies are expected to introduce the policies related to the BIM implementation. Push through the accreditation agencies for the BIM education and training, the BIM task group and the incentives for the BIM implementation were surprisingly been perceived as not an important...
initiatives by most of the respondents. There exists a mixed response for the other factors shown in Figure 5.

6. Discussions and Conclusions
The current study revealed two important aspects related to BIM implementation in South Africa. The first part of the study explores the South African AEC Industry’s readiness for the BIM adoption. From the study it is evident that there exists a decent amount of technological readiness, however the people and process related readiness are perceived as inadequate. The study also found that the National Government and the Construction Industry Development Board (CIDB) are expected to play a major role in introducing policies and strategies related to the BIM adoption in South Africa. BIM awareness through conferences, the development of BIM implementation standards, the contractual mandate, the BIM training were perceived as the effective strategies, in which the policy initiatives are expected to be made for the wider BIM adoption in South Africa. Further in-depth statistical analysis may reinforce the generalization of the study findings. The categorical analysis based on the respondent’s profile (such as client, contractor and consultant) may further assist the policy makers to design the strategies and policies accordingly.

7. Acknowledgement
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8. References


The effectiveness of contractor performance reports in the South African construction industry

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ABSTRACT

Purpose:
The aim of this study was to determine the effectiveness of contractor performance reports in the construction industry in South Africa.

Design/methodology/approach:
An assessment form was developed to assess the contractors’ performance on a project with respect to five project parameters (time, cost, quality, site conditions and health and safety) which was tested by means of a pilot project within a provincial public works department.

Research limitations/implications:
Only building projects consisting of new infrastructure, maintenance, refurbishment and restoration projects to the value of maximum R10 million was available for the study, further studies of the application of contractor performance reports for both building and civil engineering projects above R10 m would be required.

Findings:
Contractors’ performance on construction contracts with respect to the five project parameters can be consistently assessed by the clients.
Practical implications:
Public sector clients may assess the performance of contractors at practical completion of construction contracts and use the scores as a track record of contractors when procuring construction contracts.

Originality/value: The study demonstrates that contractor performance reports can be used to effectively measure the contractors’ performance on construction contracts and for selecting good performing contractors.

Keywords: Contractors, performance, assessment, registers, schemes, projects.

1. INTRODUCTION

This paper is based on a pilot study conducted by the Construction Industry Development Board (CIDB) with the Provincial Government Western Cape Department of Public Works from June 2010 to March 2012.

The purpose of the study was to:

- test the processes to complete the contractor performance reports;
- test the robustness and technical integrity of the prompts for judgment contained in the assessment forms of the CIDB contractor performance reports in order to establish whether the client could consistently assess the contractor’s performance on a construction contract;
- obtain input from the pilot study participants where improvement to the wording of the prompts for judgment was required; and
- establish whether the criteria for assessing the contractor’s performance on a construction contract was adequate.

The testing of the processes and criteria part of the study is not included in this report but is discussed elsewhere (Cassiem, 2012).

The authors would like to extend their appreciation and thanks to the CIDB and the Provincial Government Western Cape Department of Public Works for making available their resources and information for this study.

2. BACKGROUND

The CIDB was established by an Act of Parliament (CIDB Act 38 of 2000). Through the CIDB Act, the Board is required, amongst other duties to “determine and establish best practice that promotes improved industry stability; improved industry performance”.

To promote best practice, the Board:
"must establish and maintain a national register of contractors …, which provides for categories of contractors in a manner which facilitates public sector procurement.

must establish and maintain a best practice contractor recognition scheme …, which promotes contractor development and monitors contractor performance.

must establish and maintain the register of projects and the best practice project assessment scheme … for the promotion, assessment and evaluation of best practice on construction contracts" (SA Government, 2000)

2.1. CIDB Registers

The CIDB Register of Contractors captures and reflects the registration status of contractors in the respective categories in the construction industry. Public sector clients are only allowed to contract with CIDB registered contractors in their respective CIDB grades and class of works as required by the construction contract (SA Government, 2000, DPW, 2004).

The CIDB Register of Projects provides information on the nature, value and distribution of projects. It is a CIDB requirement that all public sector and private sector clients register their contracts above a certain threshold with the CIDB after a date from which the client or employer accepted the contractor’s offer in writing to carry out the construction works project which will be reflected on the CIDB Register of Projects (DPW, 2004).

2.2. CIDB Best Practice Schemes

The CIDB register of contractors and projects are well established in the construction industry. The Board is required by the CIDB Act to establish a best practice contractor recognition scheme and a best practice project assessment scheme within a reasonable period after the establishment of the CIDB registers.

The CIDB Best Practice Contractor Recognition Scheme is based on the Malcolm Baldrich Business Model of Excellence where the CIDB intends to recognize a contractor’s competence, construction management systems and contractor performance reports (Milford, 2012).

The CIDB Best Practice Project Assessment Scheme is intended to assess and evaluate the performance of public sector clients on construction contracts with regard to skills development, enterprise development, energy efficiency, contractor performance reports, health and safety, environment and quality management plans and other applicable CIDB standards.
2.3. CIDB Contractor Performance Reports

It is seen that the CIDB Contractor Performance Reports form an integral part of the CIDB Best Practice Contractor Recognition Scheme and the Best Practice Project Assessment Scheme.

Contractor performance reports must provide for the uniform and consistent method of assessment of the performance of a contractor with respect to the management of time, cost, quality, site conditions and health and safety on a construction works project.

It is envisaged that public sector clients complete contractor performance reports at practical completion of the construction contract and submit the report to the CIDB within 30 days of the practical completion date.

It is envisaged that summarised information contained in the CIDB contractor performance reports will be displayed on the CIDB Register of Contractors as a contractor’s track record to “facilitate public sector procurement” (SA Government, 2000).


The CIDB consulted with a construction industry focus group in June 2009 to discuss the content and further consulted with a broader stakeholder group in November 2009 who advised the CIDB to test the contractor performance reports within the construction industry.

3. THE PILOT STUDY

To enable the CIDB to test the performance reports within the construction industry, public sector clients responsible for infrastructure delivery were required to implement the pilot study.

3.1. Public Sector Clients

The CIDB engaged five clients responsible for infrastructure delivery to implement a pilot study to test the contractor performance reports. However, CIDB was only successful to implement the pilot study with the Provincial Government Western Cape Department of Public Works.

3.2. Pilot Study Workshops

To enable the pilot study participants to understand the requirements of the pilot study, the CIDB and the Department had a workshop in August 2010.
with the officials within the Department and a subsequent meeting in November 2010 with the professional service providers and contractors doing work for the Department.

The Provincial Government Western Cape Department of Public Works is referred to as the “Department” in this report.

These workshops were followed by a feedback session in 2011 where the CIDB and the Department shared the progress and learning experienced during the pilot study with the pilot study participants.

3.3. Pilot Study Participants

Contractor performance reports need to be completed by three parties involved in the construction contract — the reporting officer, contractor and the employer’s representative (CIDB, 2009).

The following persons participated in the pilot study:

- Eighty nine contractors registered in CIDB grades 2 to 6.
- Thirty nine inspectors, chief inspectors and project leaders who are permanently employed by the Department and ten professional service providers who are employed as quantity surveyors, project managers, engineers and architects by the Department who served as reporting officers.

A Reporting Officer is defined as “the employer’s representative or his/her delegated representative that is authorized to complete the contractor performance reports on behalf of the employer” (CIDB, 2009).

- Seventeen inspectors, chief inspectors, assistant managers and managers who are permanently employed by the Department who served as employer representatives.

An Employer Representative is defined as “the person authorized to represent the employer and named as such in the contract data” (CIDB, 2009).

3.4. Projects

One hundred and sixty one projects in the CIDB General Building (GB) class of work between R200 000 and R10 million were available for the pilot study. Of these 95% were categorised in the CIDB grade 2 to 4 tender value threshold (Cassiem, 2012).
The projects are new infrastructure, maintenance, refurbishment and restoration projects in hospitals, clinics, schools and general infrastructure.

3.5. Completed Contractor Performance Reports

The completed performance reports were sent to the Supply Chain Management unit within the Department who sent the reports to the CIDB Provincial Office who then sent the reports to the CIDB office in Pretoria for analysis.

4 ASSESSMENT OF CONTRACTORS

The assessment form (Table 4.1) contained in the Draft Requirements and Guidelines for CIDB Contractor Performance Reporting (cidb 2009) was used to assess the performance of contractors during the pilot study.

The assessment form provides for prompts for judgement for each of the project parameters to enable the Reporting Officer to score the performance of a contractor on a scale of -1 (poor) to 2 (excellent). The assessment of the contractor’s performance must only be based on those factors within the control of the contractor on the construction contract.

It is a requirement that the reporting officer be familiar with the contract, have direct liaison with the contractor and be competent in contract management (cidb, 2009, New South Wales Government, 1999) to enable him to make a factual assessment of the performance of a contractor.

The contractors were allowed to review the assessment results of the Reporting Officer and could either agree or disagree with the assessment results. The contractor performance reports were then sent to the Employer’s Representative for ratification.

Table 4.1 CIDB Contractor Performance Report Assessment form (CIDB, 2009 and Jackson-Robbins, 1998)

<table>
<thead>
<tr>
<th>Indicator</th>
<th>Prompt for judgement</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Poor (-1)</td>
</tr>
<tr>
<td></td>
<td>Adequate (0)</td>
</tr>
<tr>
<td></td>
<td>Good (1)</td>
</tr>
<tr>
<td></td>
<td>Excellent (2)</td>
</tr>
</tbody>
</table>

**TIME MANAGEMENT**

<table>
<thead>
<tr>
<th>Skill and commitment in managing time</th>
<th>Prompt for judgement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Significant delay attributable to contractor</td>
<td>On time, no delays attributable to contractor</td>
</tr>
<tr>
<td>Some delay attributable to contractor</td>
<td>Ahead of time, within extension granted</td>
</tr>
</tbody>
</table>

COST MANAGEMENT

<table>
<thead>
<tr>
<th>Skill and commitment in managing</th>
<th>Prompt for judgement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Significant cost over-run, disputed by</td>
<td>Completed for contract sum plus agreed</td>
</tr>
<tr>
<td>Some cost over-runs, with limited client dispute</td>
<td>Completed within contract sum including</td>
</tr>
<tr>
<td>Indicator</td>
<td>Prompt for judgement</td>
</tr>
<tr>
<td>-----------</td>
<td>----------------------</td>
</tr>
<tr>
<td><strong>Poor (-1)</strong></td>
<td><strong>Adequate (0)</strong></td>
</tr>
<tr>
<td>cost</td>
<td>client extras only absorbing additional costs</td>
</tr>
<tr>
<td><strong>QUALITY MANAGEMENT</strong></td>
<td></td>
</tr>
<tr>
<td>Skill and commitment in managing quality</td>
<td>• Need for close attention by inspectors • Significant re-working required • Handover subject to list of defects • Slow attention to defects after handover</td>
</tr>
<tr>
<td><strong>SITE CONDITIONS</strong></td>
<td></td>
</tr>
<tr>
<td>Skill and commitment in managing site conditions</td>
<td>• Untidy, dusty, noisy site • Soil and/or water contamination • Wastage of materials • Lack of respect for natural environment</td>
</tr>
<tr>
<td><strong>HEALTH AND SAFETY MANAGEMENT</strong></td>
<td></td>
</tr>
<tr>
<td>Skill and commitment in managing health and safety</td>
<td>• H&amp;S plans on current project • No evidence of consistent review of health/safety incidents</td>
</tr>
</tbody>
</table>
5. ANALYSES OF DATA

For this pilot study the robustness and technical integrity of the prompts for judgment for the different project parameters contained in the contractor performance reports were tested with the reporting officers, contractors and employer representatives to determine whether the performance of a contractor can be consistently and objectively assessed on a construction contract.

5.1 Selected assessment forms

Thirty four contractors completed more than one contractor performance report amounting to 106 out of the 161 completed contractor performance reports that were considered for the analysis.

The aim was to compare the assessment of a contractor's performance on different construction contracts by reporting officers in order to determine the degree of variance in the scores obtained for the project parameters for different construction contracts by the same contractor.

5.2 Determination of Variance

The statistical Variance was used to determine how spread out the scores obtained for the respective project parameters was for the 34 contractors that completed more than one construction contract.

\[
\text{Variance} = \frac{\sum (X - \overline{X})^2}{N - 1} \quad (5.1)
\]

\( X = \text{score obtained from contractor performance report} \)

\( \overline{X} = \text{the mean of the sample} \)

\( N = \text{number of scores} \)
The variance was calculated for the contractor’s skill to manage time, cost, quality, site conditions and health and safety. The variance for the contractor performance scores for all five project parameters (Figure 5.1) was consistent up to the 0.5 variance value after which the variance values above 0.5 became more dispersed for all the project parameters.

For this study, the variance value of 0.5 was used as a cut-off value to distinguish the contractors’ scores that indicated an acceptable amount of variance from a value larger than 0.5 that represented an unacceptable amount of variance.

5.3 Variance for contractor’s skill in managing cost

For the management of cost, 11.8% of the contractors had a variance above 0.5 (Figure 5.1). Cost management is a traditional project parameter and should be well engrained as part of a contractor’s skill in submitting a competitive tender and then controlling the cost during construction (Jackson-Robbins, 1998).

5.4 Variance for contractor’s skill in managing health and safety

For the management of health and safety, 23.5% of the contractors had a variance above 0.5 (Figure 5.1). Health and safety is a legislative requirement for both clients and contractors implementing construction contracts (SA Government, 1996; SA Government, 2003).
The Department employs independent health and safety agents to ensure that contractors provide and implement a health and safety plan on each construction contract, but the high variance shows that contractors do not implement the health and safety plan consistently on all their construction contracts.

5.5 Variance for contractor’s skill in managing time

For the management of time, 29.4% of the contractors had a variance above 0.5 (Figure 5.1). This is a high value considering that time management is a traditional project parameter and should be well engrained as part of a contractor’s competency which is necessary to carry out his business (Jackson-Robbins, 1998).

5.6 Variance for contractor’s skill in managing quality

For the management of quality, 32.4% of the contractors had a variance above 0.5 (Figure 5.1). This is a high value considering that quality is a traditional project parameter and should be well engrained as part of a contractor’s competency to carry out the construction contract.

Jackson-Robbins, 1998 states in the CIRIA document: Selecting Contractors by Value that “[T]he essential contractual obligation of a contractor is to deliver consistently the quality of construction specified by the client, without the need for close inspection by the client’s representatives.”

5.7 Variance for contractor’s skill in managing site conditions

For the management of site conditions, 35.3% of the contractors had a variance above 0.5 (Figure 5.1). This is a project parameter, although legislated (SA Government, 1989; SA Government, 1998) and has commercial benefit, for example minimising wastage on site (Jackson-Robbins, 1998) that is highly neglected by the construction industry.

Contractors can implement a number of measures that benefit the environment, by minimising wastage on site and complying with relevant legislation (Jackson-Robbins, 1998) and municipal by-laws.

5.8 Identification of causes for variance larger than 0.5

It is seen that there is a high percentage of contractors who have a variance larger than 0.5 for all the project parameters. Contractors were identified who had more than one incidence of a variance larger than 0.5 for the five project parameters and a sample was selected based on their
proximity to the Department’s head office for ease of logistics (Cassiem, 2012). These contractors were interviewed with the respective Reporting Officers and Employer representatives on 27 and 28 March 2012.

The reasons provided by contractors for the high variance larger than 0.5 were that:

- The contractor had difficulty in estimating the time required when given a variation order with the subsequent submission of low prices for the extra works causing cash flow problems on the project.
- The submission of uncompetitive prices at tender stage and the lack of controlling of cost during construction resulted in short payments.
- The contractor did not plan the work properly according to the requirements of the project and could not deliver the project on time.
- Contractors failed to take logistical issues into account, resulting in a huge amount of time lost in transporting staff to and from the place of work.
- Contractors failed to distinguish between capital projects and maintenance projects, resulting in costs, time and quality implications.
- Contractors had competent teams on some of their projects while not having the same quality teams on other.
- Some projects were more complex than others due the high technical requirements and challenges.
- Contractors did not take into account the availability of certain materials required for a particular project, thus the lack of appropriate planning.
- Some contractors had to be guided by the Reporting Officer to clean the workplace.

6. CONCLUSIONS

The study has shown that the prompts for judgment for the five project parameters — a contractor’s skill in managing time, cost, quality, site conditions and health and safety used in the contractor performance report are adequate to enable a reporting officer to consistently assess a contractor’s performance on a construction contract.

The CIDB contractor performance report is an effective instrument to assess the performance of a contractor which the CIDB intends to reflect as a contractor’s track record on the CIDB Register of Contractors to “facilitate public sector procurement” (CIDB, 2000).

The pilot study provided sufficient evidence that contractor performance reports can be applied to contractors in the CIDB Grade 2 to 4 General Building (GB) as 95% of the projects are between R 650 000 and R 4 million.
7. RECOMMENDATIONS

It is recommended that:

• more studies should be conducted to provide information on the application of contractor performance reports on construction contracts with a higher CIDB grade tender value and civil engineering class of work.

• contractor performance reports should be used on construction contracts for contractors registered in the CIDB Grades 2 to 4 in the General Building (GB) and Civil Engineering (CE) classes of work.

• the CIDB should consult broadly with stakeholders in the construction industry to obtain buy-in of the draft CIDB Standard for Contractor Performance Reports to recommend to the Board that the Standard for Contractor Performance Reports be gazetted as a CIDB Standard to be implemented by public sector clients.

8. REFERENCES


Assessing innovation in Public-Private Partnerships: A discussion paper

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ABSTRACT AND KEYWORDS

Purpose of this paper
This paper aims to provoke a discussion and interest in research into innovation within Public-Private Partnerships (PPPs). The need to define innovation in this setting and the resulting benefits have to be explored further in order to inform industry role-players on the true value of PPPs with regards to innovation.

Design/methodology/approach
As a discussion paper the text lays out possible aspects to consider for future studies. The potential of PPPs for innovation being the centre of the work, a comparison between different project forms is briefly introduced.

Findings
The claim that PPPs result in innovation may be misleading. Other project forms may be realizing the potential to improve and innovate too; however a tool needs to be developed to forecast innovation potential in order to inform decision makers on better procurement routes.

Value
Creating a discussion and interest in an applied field of research relevant to the construction industry and questioning some common believes.

Keywords
Research approach, Assessment tool, South Africa
1. INTRODUCTION

Public-Private Partnerships (PPP) are used around the world for the development of infrastructure. In South Africa the most common model followed for PPPs is that of funding, designing, building as well as operating infrastructure needed by the public party, i.e. government, by a private party. The private party typically consists of a consortium of companies, tailored to tackle the government need, with a financier (bank) financing the private enterprise on the promise that the public party will pay a unitary fee for the usage of the completed infrastructure. Advocates of PPPs often cite the potential of PPPs with regards to unleashing ‘innovation’ (e.g. Davey, Powell, Cooper, & Powell, 2004; Witters, Marom, & Steinert, 2012) related to projects. Innovation can here be broadly understood as finding a different, improved solution to a task or problem. The base of this claim of a PPP-Innovation link is the assumption that if a private entity is to find a solution for a typical government function, the private party is more likely to find such potential to improve compared to an in-house government approach. Here underlying is the profit-driven approach by the private party. Firstly, in order to win a contract the approach to providing a sought solution will be to be innovative in order to create ‘appetite’. This first opportunity is hence linked to the design and building project with a PPP concession. Secondly, the long-term nature of PPPs give long-term potential for sustained returns, this can be enhanced through improved solutions. This second opportunity may hence relate to the operating phase of a PPP concession. The type of innovation may hence vary from design approaches to building technology to operating procedures. Measuring innovation compared to a baseline is to be difficult.

The difficulty in proving the PPP-Innovation claim is the lack of comparability, the lack of baseline. The uniqueness of construction projects is generally accepted (Ballard & Howell, 1998). It is hence difficult to measure the level of innovation see in any project since it is only executed once. This is particularly true for measuring innovation when comparing two different forms of procurement, i.e. traditional government led projects vs. PPP projects. This discussion paper hence seeks to provoke a discussion on how innovation can be measured in government infrastructure projects. It tries to sketch an alternative way of conducting PPP projects, a way which may enable the judgement on innovation found to be more measurable. The paper aims to sketch a possible field of applied research enabling the measurement of innovation in future.

2. DEFINING INNOVATION

In order to have a discussion on the potential of PPPs with regards to innovation, innovation itself needs to be better defined. Lu and Sexton (2006)
deducted from a literature review that the common smallest denominator of describing innovation was the concepts of a ‘new idea’. Some factors on time-span, setting are however described too; and innovation appears to have to take this into account too. Train and Egbu (2006) establish that the novel value creation for an organization or society is being a key point of innovation. Quinn (1985) in his seminal work on how firms create innovation falls short of defining innovation. Arguably the method of his investigation gives a clue on the used conceptualization of innovation too: something new. Also Hartmann (2006) does not define innovation explicitly, his work however describes potential of innovations regarding differing aspects in construction projects. It hence looks at not yet realized benefits from conducting business in another way. With innovation being an abstract concept until such innovation is realized a clear cut definition is yet to be found; albeit a common understanding of the term seems to exist.

As an initial work-in-progress definition of innovation the following can be adopted: an idea, product or service newly introduced into a market, which can be an economic sector and/or country, creating value. In a PPP setting a differentiation in innovation may be:

- Once off benefit during design and construction, with subsequent savings in capital cost
- Benefit in improved operations of a facility

Such definition will allow the development of some measure to judge projects on their embedded innovation; and it will allow a first depiction of scenarios expected in a PPP-Innovation line of questioning.

3. PPP PROJECTS AND INNOVATION

The focus here shall be on the private sector innovation within infrastructure PPPs. With capital PPP project undergoing distinct phases, these being design, building, and operating it is worth to look at the different phases and scenarios as to where ‘innovation’ may occur. Each phase may have different actors and hence bring knowledge and opportunities to learning (Davey et al., 2004) and innovation to the fore.

The design phase of a PPP project starts with the public sectors call for solutions to an identified need, typically based on a solid feasibility study. In capital projects teams of designers will embark on a project and various consortia will eventually submit their bids for a project. This bid will include not only sample designs of facilities, but will already try to depict on how a facility will operate. This gives the client the confidence if a proposal will in deed satisfy the identified public sector need. During the design phase of PPP project traditional professional service providers, i.e. engineering firms, architectural firms, join forces with contractors and facility
managers/operators to jointly develop proposals. Using the Activity theory (Engeström, 1999), looking at this multi-disciplinary setting and opportunities to change thinking, combined with the economic need of companies involved to succeed (Train & Egbu, 2006) this phase certainly can be identified as having the potential for the creation of innovative ideas.

While at the design and bid phase the final product is typically not yet fully defined and designed, the next phase may be interesting to look at innovation potential too. Following the adjudication of a bid a PPP consortium, now typically led by a construction firm, will embark on the production design and construction project. During the phase the above mentioned actors would still be involved, however the facility manager/operator may well take a step back from the process, having defined clear requirements in the earlier stage. It can further be expected that the professional team may start working more as a sub-consultant to the contractor, with the contractor taking centre stage in the production and construction of a facility. The potential to innovate may hence shift too. At this stage the eyes would be on the contractor and innovative solution to construction problems.

The construction culminating in the commissioning of a facility will be the start of the third phase: operations. The shift in the lead of a consortium will be from contractor to operator. The operator would typically deliver the Hard Facility Management services to the client for the duration of a PPP concession. While many large international contractors have established themselves as total service providers, and a project dependent constellation of the consortium has to be considered, it is unlikely that the same staff is to continue the project pass the commissioning stage. During the operations of a facility the long-term benefits of a potential initial idea have to be realized. Benefits here may have to strains and beneficiaries. Firstly, the private consortium itself may realize savings or benefits in having implemented a novel idea or practising a new way of operations. Secondly, the public partner as the user of the facility may benefit from a novel idea, e.g. reduced walking distances for staff due to design innovation. The seed for any such innovation would however likely have been sown during the design phase of a project. Innovative operations are however possible, and the continued emphasis in optimizing operations, and hence creating value, may be a driver for further innovation led by the operator – typically to the benefit of the private consortium.

4. TRADITIONAL PROJECTS AND INNOVATION

With the claim that PPPs may unleash innovation it may be prudent to briefly consider the alternative, the traditional procurement route which is on the other spectrum of the possibilities to develop a facility: Design by employer.
In this type of contract the public client may firstly conduct a feasibility study to establish the need too.

The funding for a project will be sourced from public funds as capital expenditure. The client will then engage a set of professional service providers tasked to design a facility. Subsequent to the design the client will procure the services of a contractor to construct a facility. Following the commissioning the client may, or may not, opt to engage a facility management service to maintain a facility.

The combination of role players in this procurement route differs. The main difference being that a finalized idea is typically developed by professional service providers, without the input of contractors. Further the operator of the facility will only be contracted at the start of the operations. Hence any inputs ahead of the operations possibly informing design may not be possible.

The task in a traditional project is hence to foster innovation at the design phase. Currently used contracting strategies by public entities to engage professional service providers however have little incentives build in for these to become innovative. Percentage fee scale based appointments are the norm, and the incentive may rather be to maximize cost of a project in order to maximize fees. The benefit accompanying innovation may hence only be realized by service providers.

Similar the construction phase has little incentive for innovation to benefit society or the client. Adverse relationships and conflict (Gardiner & Simmons, 1998) are the norm in construction projects with (innovative) claims by contractors not being the exception.

Partnering approaches to construction projects may however overcome some of these shortcomings, and address adverse relationships as well as free up potential to jointly innovate to the benefit of all parties involved. However also here incentives need to be set, ensuring that true partnering is achieved.

5. INNOVATION AND OTHER TYPES OF CONTRACTS

Using the idea of incentivising other forms of project procurement in order to foster innovation, the claim of PPP-Innovation may be less true. If different form of contracting, such as design-build or develop-construct are to become the norm of contracting in the public sector many innovative ideas may come forth too. Even with changes to the appointment of professional service providers in terms of determination of fees, but also their composition, more innovation may be realized. The use of operators / facility managers to inform the designers of facilities during design stage in a traditional project may leverage some potential to innovate.
Other types of contracts as used by public entities, may in future hence show the relativity of the PPP-Innovation claim even more. Arguably other forms of contracts may not be the preferred route of procurement due to risk transfer, types of project etc. Innovative approaches to contracting and procuring itself may be the key to unlock innovation within the actual projects. However the risks and costs of differing procurement routes need to be considered too. Innovation may not be the only determinant and driving force within projects. It may only be a welcoming side effect in traditionally procured projects. Enhancing the entrepreneurial spirit of professionals, aiming to gain market shares through innovative ideas and cutting-edge approaches, may be the key in levelling the field among different forms of projects.

6. CONCLUSION

The measurement of innovation within a project procured using a PPP approach is difficult. The uniqueness and singularity of projects prevents the opportunity to truly compare traditionally procured vs. PPP procured projects. Concepts to establish a comparison are yet to be developed. Other types of contracts have potential too to foster innovation within projects. Partnering, differing combination of professional skills and services, and incentivizing contractual parties to innovate are possible ways to achieve innovation. All these may make the claim of PPPs being sources of innovation even less.

However, to assess innovation, tools to measure this need to be developed. If PPPs are truly sources of innovation, these tools need to be developed in order to substantiate the claims of PPPs foster innovation. Unbiased applied research, possibly based at universities but linked to projects may be ways to tackle this task. However the underlying question possibly really is: Would these innovation not have appeared in any other form of project procurement with the same knowledge based deployed upon finding solutions to identified challenges?

7. REFERENCES


The impact of FDI in Infrastructure Delivery on International Competition in Africa

Babatunde, Oluwayomi Kayode¹ and Low, Sui Pheng²

ABSTRACT

Purpose of this paper
Developing economies in Africa are increasingly undertaking infrastructure delivery through foreign direct investments (FDI). This study investigates the impact of FDI in infrastructure delivery on international competition with the domestic firms in the African countries.

Design/methodology/approach
The research design involves the critical review of the relevant literatures. Sequentially, from the African country population of 55, 44 African countries were systematically sampled for analysis. Following, stratified sampling of 10 African countries with good FDI strategy was undertaken for analysis in depth. Lastly, purposive sampling of 4 major African countries drawn from the north, east, west, and south of Africa was undertaken for validation.

Findings
This study found: (1) a strong positive correlation between competitiveness and infrastructure delivery in all the 44 African countries; (2) a strong positive correlation between the number of competitive domestic and international firms in the 10 African countries with good FDI strategy; and (3) significant difference among the 10 African countries with good FDI strategy and supported by the 4 major African countries sampled.

Research Limitations/implications
This study is limited to the 44 African economies sampled as well as to correlation as being a measure of association as against causation. Being at its exploratory stage, it has sourced and analyzed secondary data for further investigation in a future study.

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Practical implications
This study underscores boosting the international competitiveness of the African economies through sustained infrastructure delivery. FDI in infrastructure delivery attracts international competition that the domestic firms can maximize to develop their competitive strategies. Consequently, this study makes recommendations for policy-makers, domestic and international firms, and future research in the African economies.

KEYWORDS: Africa; Competitive strategy; Foreign direct investments; Infrastructure delivery; International competition

1. INTRODUCTION

FDI determinants are multifaceted and can, as a result, be analyzed through a variety of theoretical models (Faeth, 2009). In Africa, large local markets, natural resource endowments, good infrastructure, low inflation, efficient legal systems, and good investment frameworks promote inward FDI (Asiedu, 2006). In addition, FDI in infrastructure responds positively to effective domestic regulatory frameworks (Kirkpatrick et al., 2006) as well as subscribing to international trade agreements (Büthe and Milner, 2008). Conversely, FDI in infrastructure breeds competition between the foreign and the domestic players, which the latter view as being monopolistic. On the one hand, monopolistic competition contributes to import varieties, enhanced efficiency, and reduced markups (Feenstra, 2010), with aftermarket monopolization consolidating these benefits (Carlton and Waldman, 2009). On the other hand, the perception of competition and its benefits are relative both at the levels of the individual (Russell and Fiske, 2008) and the firm (Baum et al., 2011). Sustainable FDI is premised on some strategic positioning for both the foreign and the domestic players (Kwok, 2011; Zhang et al., 2010). Notably, Sivak et al. (2011) have investigated the strategic positioning from the perspective of governance and its impact on innovation. Consequently, Ajakaiye and Ncube (2010) have also underscored the need for FDI in infrastructure delivery in Africa. This is because the prevalent stunted infrastructure development in the majority of the African countries impact on their economic growth (see Jerome, 2011). As such, African countries alike, in their varying entrepreneurial capacities as being catalytic, community-owned, competitive, mission-driven, results-oriented, customer-driven, decentralized, or market-oriented (Osborne, 1993), are grappling with FDI strategies (see Darley, 2012). Strategically, some African countries have morphed into the status of “FDI African Countries of the Future” according to the fDi Intelligence (www.fdiintelligence.com), which assesses the 55 African countries in six categories including FDI strategy. The top ten best overall countries for 2013 in descending order include South Africa, Morocco, Mauritius, Egypt, Kenya, Ghana, Nigeria, Botswana, Tunisia, and
Namibia. Conversely, a study on the variance of the impacts of regulatory framework and international trade agreement (ITA) on FDI infrastructure in these different countries is non-existent. The foregoing can, possibly, be assessed under the broad concept of governance. Consequently, this study aims to investigate regulatory framework and ITA response to international competition on FDI infrastructure in the African countries. The objectives include investigating: (1) international competition in the African countries, (2) the impacts of regulatory framework and ITA on infrastructure delivery in the African countries, and (3) the viability of regulatory framework and ITA as competitive strategies to sustain infrastructure delivery in the African countries.

2. CONCEPTUAL FRAMEWORK

Globalization has undermined countries’ exclusive rights to their domestic markets. This is because the opening up of any economy unlocks and/or maximizes the potentials lurking in such an economy. China's resurgence of interest in global trading since the 1970s and its now ascension into the status of the most competitive construction industry with particular expertise in infrastructure delivery best typifies this. The construction industry facilitates international trade through its backward and forward linkages so much so that it has been contributing significantly to economic development for decades (Dang and Low, 2011). Respective country’s provision of the necessary soft and hard infrastructures, according to Portugal-Perez and Wilson (2012), sustains this trade. Consequently, private participation has become a strategic route to providing the infrastructures even among the emerging economies (Kateja, 2012). Similarly, infrastructure delivery’s huge investment is an opportunity cost to many of the African countries due to their teeming and rapidly urbanizing population. Hence, the African countries alike are now increasingly adopting public–private sector collaboration to improve the performance and the sustainability of their infrastructures (Koppenjan and Enserink, 2009; Luiz, 2010). This eliminates, or more aptly, minimizes monopolistic competition (Zhelobodko et al., 2012) as supported by Zhang and Chen’s (2013) framework for infrastructure delivery. In addition, FDI has been found having initial negative impacts on the domestic players in Africa (Adams, 2009) as well as in a developed country like Singapore (Low and Kho, 2008). International construction presents diverse challenges to the extent that foreign players’ performance and success is also largely contingent on their domestic competitiveness (Jin et al., 2013, Ofori, 2003). Similarly, domestic players facing international competition at home must expand to thin out the foreign players' advantages (Chang and Hyuk-Rhee, 2011; Guler and Guillén, 2010). This will ensure that they are well positioned for the strategic benefits of infrastructure FDI spillover effects (see Ardelean and Lugovskyy, 2010, Feenstra, 2010, Marcin 2008). The
positioning can be achieved through governance (Sivak et al., 2011); more specifically, through domestic regulatory framework and ITA as discussed in the preceding section. And regulatory framework and ITA consolidate the “foundational competitiveness” of a country. Delgado et al. (2012: 8) have advanced “foundational competitiveness” as the expected level of output per working-age individual given the overall quality of a country as a place to do business. Figure 2.1 presents the conceptual framework of sustainable infrastructure delivery as being dependent on regulatory framework and ITA. The foregoing two variables can boost the competitiveness of the African countries as they continue to attract FDI to meet their infrastructure needs. This study has assumed governance as a proxy to measuring regulatory framework and ITA.

![Figure 2.1 Conceptual framework: Variables for sustainable infrastructure delivery](image)

3. HYPOTHESES

From the conceptual framework, this study posits that the perceptions of monopolistic competition will thin out for sustainable competition on infrastructure delivery as supported by Baltkyté and Tvronavičienė (2010). It is also being construed that with good governance, plausibly, creating equal opportunities, the foundational competitiveness of the African countries will lead to the domestic firms being as competitive as the international firms working thereof. Thus, the following seven hypotheses have been formulated in this study:

- Hypothesis 1: There is a significant association between the number of competitive domestic firms and competitive foreign firms in the African countries as a whole.
Hypothesis 2: There is a significant association between the number of competitive domestic firms and competitive foreign firms in the African countries with good FDI strategy.

Hypothesis 3: There is a significant association between the competitiveness and the infrastructure delivery of the African countries as a whole.

Hypothesis 4: There is a significant association between the competitiveness and the infrastructure delivery the African countries with good FDI strategy.

Hypothesis 5: The Domestic firms in the African countries with good FDI strategy are equally competitive as the foreign players operating in their countries.

Hypothesis 6: There is no significant difference among the African countries with good FDI strategy on competition, competitiveness, infrastructure delivery, and governance.

Hypothesis 7: Regulatory framework and ITA, construed as governance, are competitive strategies sustaining infrastructure delivery in the African countries with good FDI strategies.

4. METHODOLOGY

While ontological and epistemological stances intuitively influence the choice of methodology, general guidelines, nonetheless, exist to select the most appropriate methodology to achieve the research aim and objectives (Panas and Pantouvakis, 2010). On the other hand, the inherent flaws in the qualitative and quantitative methods have seen to the increasing adoption of mixed methods in order to be able to triangulate results (Abowitz and Toole, 2010). Consequently, the crux is ensuring validity by seeing to it that each phase of the methodology adopted rigorously adheres to the highest standards of quality (Lucko and Rojas, 2010). As such, considering the exploratory nature of this study, the methodology adopted has been delineated into the three sequential phases as explained subsequently.

4.1 Critical and systematic literature reviews

Phase 1 involved the critical review of the relevant literatures culminating into the conceptual framework presented in Figure 2.1. Phase 1 is analogous of narrative literature review, which provides a comprehensive
background on the existing knowledge to determine the research questions or (as applicable in this study) hypotheses (Cronin et al., 2008) as presented in Section 3 discussed earlier. Phase 2 involved the systematic review of the literatures, which is geared towards proving the different hypotheses. Cronin et al. (2008: 39) suggested that a systematic review should detail the time frame within which the literature was selected, as well as the method used to evaluate and synthesize the findings. Following, adopting the five keywords developed in this study, quantitative secondary data for the years 2010 to 2013 were sourced from relevant authoritative sources through desktop research in April 2014. The sources of the data include the: fDi Intelligence, African Studies Center at the University of Pennsylvania (www.africa.upenn.edu/Home_Page/Country.html), Africa Report (www.theafricareport.com), Engineering News-Record (ENR) (http://enr.construction.com), World Economic Forum (WEF) (www.weforum.org), and World Bank as discussed next.

FDi Intelligence is the global FDI center of excellence that also assesses the African countries in the six categories of economic potential, labor environment, cost-effectiveness, infrastructure and business friendliness, and FDI strategy. The African Studies Center maintains a list of the African countries while the Africa Report maintains a list of the top 500 companies in Africa’s key business sectors. ENR, on the other hand, maintains a list of the top 250 international contractors operating around the world including in the African countries. WEF assesses the global competitiveness of 148 countries (as of date) through its global competitiveness index rankings derived from its twelve pillars. These pillars include institutions, infrastructure, macroeconomic environment, health and primary education, higher education and training, goods market efficiency, labor market efficiency, financial market development, technological readiness, market size, business sophistication, and innovation. Lastly, the World Bank maintains a list of the rankings of different countries in the six governance indicators including voice and accountability, political stability, government effectiveness, regulatory quality, rule of law, and control of corruption.

During the Phase 2, from the African country population of 55 as supported by the fDi Intelligence and the African Studies Center, a sampling frame of 44 African countries was drawn. This was achieved through a systematic sampling of the African countries having at least a domestic company featuring in the Top 500 Companies in Africa and/or at least one of the ENR Top 250 International Contractors operating in the country between the years 2010 and 2013. Following, as presented in Table 4.1, a further stratified sampling of the 10 African countries with good FDI strategy (in the shaded cells), and then purposive sampling of the 4 African countries representing the four geographical zones in Africa (in the shaded cells with bold texts) were adopted. The choice of the different sampling techniques was to ensure validity that can be achieved by triangulating the results from the respective analysis. As also indicated in
Table 4.1, averages were adopted in order to minimize chance occurrence, which could result if data for a single year were considered. Similarly, where data were only available for one or two years as against the three-year span prescribed, the denominator changed to one or two as applicable to prevent outlaying observations.

Table 4.1 Competition and competitiveness of the African countries

<table>
<thead>
<tr>
<th>No</th>
<th>Country</th>
<th>No of domestic firms in the top 500 in Africa</th>
<th>No of top 250 international firms operating in the country</th>
<th>Average competitiveness ranking</th>
<th>Average infrastructure pillar ranking</th>
<th>Average governance ranking</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Algeria</td>
<td>23</td>
<td>81</td>
<td>94</td>
<td>93</td>
<td>137</td>
</tr>
<tr>
<td>2</td>
<td>Angola</td>
<td>4</td>
<td>43</td>
<td>136</td>
<td>138</td>
<td>93</td>
</tr>
<tr>
<td>3</td>
<td>Benin</td>
<td>0</td>
<td>9</td>
<td>109</td>
<td>118</td>
<td>241</td>
</tr>
<tr>
<td>4</td>
<td>Botswana</td>
<td>2</td>
<td>14</td>
<td>78</td>
<td>88</td>
<td>432</td>
</tr>
<tr>
<td>5</td>
<td>Burk. Faso</td>
<td>5</td>
<td>4</td>
<td>134</td>
<td>136</td>
<td>238</td>
</tr>
<tr>
<td>6</td>
<td>Burundi</td>
<td>0</td>
<td>6</td>
<td>140</td>
<td>136</td>
<td>77</td>
</tr>
<tr>
<td>7</td>
<td>Cameroon</td>
<td>9</td>
<td>22</td>
<td>113</td>
<td>127</td>
<td>114</td>
</tr>
<tr>
<td>8</td>
<td>Cape Verde</td>
<td>0</td>
<td>3</td>
<td>119</td>
<td>111</td>
<td>400</td>
</tr>
<tr>
<td>9</td>
<td>Congo</td>
<td>1</td>
<td>20</td>
<td>0</td>
<td>140</td>
<td>91</td>
</tr>
<tr>
<td>10</td>
<td>Cote d’ivoire</td>
<td>22</td>
<td>10</td>
<td>130</td>
<td>103</td>
<td>86</td>
</tr>
<tr>
<td>11</td>
<td>D.R.Congo</td>
<td>4</td>
<td>9</td>
<td>0</td>
<td>0</td>
<td>21</td>
</tr>
<tr>
<td>12</td>
<td>Egypt</td>
<td>49</td>
<td>38</td>
<td>94</td>
<td>74</td>
<td>182</td>
</tr>
<tr>
<td>13</td>
<td>Ethiopia</td>
<td>1</td>
<td>26</td>
<td>115</td>
<td>118</td>
<td>135</td>
</tr>
<tr>
<td>14</td>
<td>Gabon</td>
<td>11</td>
<td>15</td>
<td>99</td>
<td>117</td>
<td>208</td>
</tr>
<tr>
<td>15</td>
<td>Gambia</td>
<td>0</td>
<td>3</td>
<td>96</td>
<td>77</td>
<td>207</td>
</tr>
<tr>
<td>16</td>
<td>Ghana</td>
<td>10</td>
<td>21</td>
<td>110</td>
<td>109</td>
<td>333</td>
</tr>
<tr>
<td>17</td>
<td>Guinea</td>
<td>1</td>
<td>26</td>
<td>141</td>
<td>142</td>
<td>67</td>
</tr>
<tr>
<td>18</td>
<td>Kenya</td>
<td>9</td>
<td>20</td>
<td>105</td>
<td>103</td>
<td>168</td>
</tr>
<tr>
<td>19</td>
<td>Lesotho</td>
<td>0</td>
<td>5</td>
<td>133</td>
<td>123</td>
<td>291</td>
</tr>
<tr>
<td>20</td>
<td>Liberia</td>
<td>0</td>
<td>8</td>
<td>111</td>
<td>115</td>
<td>144</td>
</tr>
<tr>
<td>21</td>
<td>Libya</td>
<td>0</td>
<td>54</td>
<td>113</td>
<td>92</td>
<td>65</td>
</tr>
<tr>
<td>22</td>
<td>Malawi</td>
<td>1</td>
<td>8</td>
<td>124</td>
<td>132</td>
<td>245</td>
</tr>
<tr>
<td>23</td>
<td>Mali</td>
<td>5</td>
<td>0</td>
<td>129</td>
<td>114</td>
<td>192</td>
</tr>
<tr>
<td>24</td>
<td>Mauritania</td>
<td>3</td>
<td>0</td>
<td>135</td>
<td>120</td>
<td>133</td>
</tr>
<tr>
<td>25</td>
<td>Mauritius</td>
<td>13</td>
<td>0</td>
<td>54</td>
<td>55</td>
<td>448</td>
</tr>
</tbody>
</table>

3 Sourced from the Africa Report (www.theafricansreport.com)
4 Sourced from the Engineering News-Record (http://enr.construction.com)
5 Sourced from the World Economic Forum (www.weforum.org)
6 Sourced from the World Economic Forum (www.weforum.org)
7 Sourced from the World Bank (www.govindicators.org)
4.2 Meta-analysis

Phase 3 adopted a meta-analysis technique, which Cronin et al. (2008) noted as being the process of conducting statistical analysis on a large body of quantitative findings in order to integrate the findings and enhance understanding. Prior to the statistical analysis, it is worth noting, as parts of the ethical considerations, that all the data sourced were publicly available with neither subscription nor registration. To support the foregoing position, according to Arndt and Oman (2006: 28), the World Bank’s six governance indicators are the most comprehensive publicly available governance indicators. In addition, due acknowledgement have been given to the different sources of data as discussed in the preceding section. The yearly update of the data also served to guarantee that the data were current as of the time of this research. The disclosure of the respective authoritative sources was necessary in order to gauge the authenticity of the data. The Association of Internet Researchers (AOIR) (2012) has rightly asserted that ethical decision-making is best approached through the application of practical judgment that is responsive to the specific context. And since meta-analysis largely employs statistical techniques to draw conclusions and detect patterns and relationships between findings (Cronin et al., 2008), the statistical tests performed following the collation of the quantitative data in Table 4.1 are subsequently explained.
5. DATA ANALYSIS

For hypotheses 1 to 4, Spearman rank correlation tests were performed. For hypothesis 1, Spearman rank correlation test performed at a degree of freedom \( n-2 \), where \( n = 44 \), revealed a weak positive correlation between the number of competitive domestic firms and international firms in the African countries as a whole (\( r_s (42) = 0.314, P = 0.377 \)). The result is significant at \( p > 0.05 \); thus, \( H_0 \) for hypothesis 1 was not rejected. This suggests that there is a tendency for an increase in the number of competitive domestic firms as the number of competitive international firms increase in the African countries as a whole; however, this will be irregular. Conversely, for hypothesis 2, Spearman rank correlation test performed at a degree of freedom \( n-2 \), where \( n = 10 \), revealed a strong positive correlation between the number of competitive domestic firms and international firms in the African countries with good FDI strategy (\( r_s (8) = 0.734, P = 0.231 \)). The result is also significant at \( p > 0.05 \); thus, \( H_0 \) for hypothesis 2 was not rejected. The result suggests that in the African countries with good FDI strategy, the number of competitive domestic firms increases as the number of competitive international firms increases (and vice versa). For hypothesis 3, Spearman rank correlation test performed at a degree of freedom \( n-2 \), where \( n = 44 \), revealed a strong positive correlation between competitiveness and infrastructure of the African countries as a whole (\( r_s (42) = 0.789, P = 0.215 \)). The result is significant at \( p > 0.05 \); thus, \( H_0 \) for hypothesis 3 was not rejected. The result suggests that increase in infrastructure delivery leads to increase in competitiveness (and vice versa) of the African countries. Similarly, for hypothesis 4, Spearman rank correlation test performed at a degree of freedom \( n-2 \), where \( n = 10 \), revealed a stronger positive correlation between competitiveness and infrastructure of the African countries with good FDI strategy (\( r_s (10) = 0.879, P = 0.190 \)). The result is also significant at \( p > 0.05 \); thus, \( H_0 \) for hypothesis 4 was not rejected. The result likewise suggests that increase in infrastructure delivery leads to increase in competitiveness (and vice versa) of the African countries with good FDI strategy.

For hypothesis 5, Mann-Whitney test was performed on the competitive domestic firms and international firms in the African countries with good FDI strategy. The test revealed a \( z \) score of 0.0378 , \( P = 0.968 \), which is significant at \( p > 0.05 \); thus, \( H_0 \) for hypothesis 5 was not rejected. This confirms that the domestic firms in the African countries with good FDI strategy are as competitive as the international firms in their countries. For hypothesis 6, Friedman test was performed on the ranks of the African countries with good FDI strategy. The Friedman test revealed that there is a significant difference among the countries difference (\( X^2 (4) = 425, P = 0.00001 \)), which is significant at \( p < 0.05 \). Thus, \( H_0 \) for hypothesis 6 was rejected. And lastly for hypothesis 7, Spearman rank correlation test was
performed on the infrastructure ranking and the governance indicators. The Spearman rank correlation test performed at a degree of freedom $n-2$, where $n = 44$, revealed a moderate negative correlation between infrastructure delivery and governance in the African countries with good FDI strategy ($r_s (8) = -0.539$, $P = 0.295$). The result is significant at $p > 0.05$; thus, $H_0$ for hypothesis 7 was not rejected. The result means that, to a certain extent, there is a tendency for the FDI strategy to be improved with governance in the African countries with good FDI strategy. Premised on the statistical test result for hypothesis 6, it can be appreciated that the ten African countries with good FDI strategy still has individual competitive strategies as supported by the statistical result. To corroborate the foregoing position, an overview of the rankings for Egypt, Kenya, Nigeria, and South Africa in the six assessment criteria adopted by the fDi Intelligence reflects notable differences among these four African countries. And the differences agree with the findings from other similar studies on investment strategic decisions in the four countries, notably, the World Bank's Ease of Doing Business.

To ensure reliability and validity in construction research, Abowitz and Toole (2010) have suggested the following five considerations: (1) careful research planning and design, (2) explicitly defining theoretical concepts, (3) operationally defining theoretical concepts, (4) explicitly stating causal relationships hypothesized, and (5) adopting appropriate statistical analysis. These have all been considered in this study as can be gathered in the preceding sections. Unique in this study, the comprehensive online tool for statistical tests (www.socscistatistics.com) designed by the Social Science Statistics has been adopted. Abowitz and Toole (2010: 108) expounds on construction as being a social process.

6. DISCUSSIONS AND CONCLUSION

As set out in its aim, this study has investigated regulatory framework and ITA response to international competition on FDI infrastructure in the African countries. This was achieved by gauging the impact of governance as a broader notion that encapsulates regulatory framework and ITA as presented in the conceptual framework developed in this study (please refer to Figure 2.1). Premised on the framework, this study achieved its first objective by investigating and finding a strong positive correlation in the number of competitive domestic and international firms in the African countries with good FDI strategy (please refer to the statistical test results for hypotheses 1 and 2). This validates Kirkpatrick et al.’s (2006) conclusion that FDI in infrastructure responds positively to effective domestic regulatory frameworks. Similarly, it validates Portugal-Perez and Wilson’s (2012) conclusion that each country’s provision of the necessary soft and hard infrastructures sustains international trade and the eventual associated forward and backward linkages. This study also achieved its
second objective by investigating and finding strong correlation between
the African countries’ competitiveness and their infrastructure delivery
(please refer to the statistical test results for hypotheses 3 and 4). This
corroborates Cervero’s (2009) study that argued in favor of infrastructure
being a catalyst for economic growth and expansion; thus, leading to global
competitiveness. The finding also underscores the position by similar past
studies (Ardelean and Lugovskyy, 2010; Feenstra, 2010; Marcin 2008)
about countries’ positioning for the benefits of the spillovers from FDI in
infrastructure. Similarly, this study achieved its last objective by
investigating and finding a moderate negative correlation between
governance and infrastructure delivery, especially in the African countries
with good FDI strategy (please refer to statistical test result for hypothesis
7). The negative correlation can be further supported by the findings that
there is a significant difference among the African countries with good FDI
strategy on competition, competitiveness, infrastructure delivery, and
governance (please refer to statistical test result for hypothesis 6). Still,
governance plays an important role in infrastructure delivery as supported
by Globerman and Shapiro’s (2002) position of a country’s institutions and
policies as being its governance infrastructure. From the afore-mentioned
results, it is imperative for domestic firms to be able to develop their
competitive advantages unhindered through regulatory framework and ITA.
Good governance manifests through foundational competitiveness, which
dispels perceived monopolistic competition among the domestic firms.
African countries have historically been partnering with the foreign players
to bridge their developmental gap especially in view of the linkage of the
construction industry to the other sectors. FDI in infrastructure delivery will
continue and competitive domestic firms must be strategically positioned in
order to boost domestic small and medium enterprises. In conclusion, a
recommendation is being made to policy makers in Africa to consolidate
effort towards improving the competitiveness of their domestic firms with
regard to FDI in infrastructure delivery. The FDI strategy including
regulatory framework and ITA being adopted should boost and sustain their
foundational competitiveness through infrastructure delivery. It is also
critical that both the domestic and international firms operating in Africa
develop sustainable domestic competitive strategies since they both
experience the initial negative impacts of FDI. Consequently, domestic
firms should be well positioned to compete internationally at home since
international construction (see Ofori, 2003) pervades infrastructure delivery
in Africa. Rapidly changing international competition dates back (Porter,
1986) leading to a framework that enhances the understanding of
international competitiveness of firms (Smit, 2010). However, the tailing
infrastructure delivery in Africa and the performance thereof contrasts the
absorptive capability and competitiveness of the domestic firms (Marcin,
2008) with their perceived barriers to internationalization (Baum et al.,
2011). International competitiveness can equally be developed at home to
attract FDI in infrastructure delivery. To this end, a future study should
investigate the preference among firms to be internationally competitive at home or in overseas. Lastly, this study has responded to the impact of FDI and international competition on infrastructure delivery in Africa. Being in its exploratory stage, its findings are limited to the African countries sampled and to correlation as not being a measure of causation.

REFERENCES


An Assessment of the Impact of Public Sector Contractor Development Programmes (CDPs) in South Africa

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ABSTRACT

Purpose:
The aim of the study is to evaluate the impact of public sector Contractor Development Programmes (CDPs) in South Africa on the growth of contractors. The aim is also to help understand the opportunities and challenges that black contractors face within the CDPs, and the linkages between CDPs and infrastructure delivery.

Design/methodology/approach:
This study is based on quarterly monitoring reports obtained from the CDPs, supported by contractor information obtained from the cidb Register of Contractors, supported by the cidb Status-Quo report on Contractor Development Programmes and other industry related literature.

Research limitations/implications:
The study focuses only on the public sector CDPs, linked to public sector infrastructure delivery.

Practical implications:
The study is used in highlighting areas of improvement needed, in terms of implementing CDPs using the National Contractor Development
Programme (NCDP) Framework and CDP Guidelines for contractor development.

**Originality/value:**
The study demonstrates the state of industry development in terms of CDPs and how these CDPs impact on the development of the black contractors.

**Keywords:** Contractor Development Programmes (CDPs), cidb Register of Contractors, National Construction Development Programme (NCDP), black contractors
1. Background

An important instrument in supporting transformation initiatives within the construction sector is the National Contractor Development Programme (NCDP), which is a public sector led programme comprising of a partnership between the cidb, National and Provincial Public Works and other willing stakeholders and partners\(^1\). The objective of the NCDP is to increase the capacity, equity ownership, sustainability, quality and performance of cidb registered contractors – effectively raising the contribution of the construction industry to South Africa’s accelerated and shared growth initiative.

To achieve these objectives, participants within the NCDP should commit, amongst others, to:

- improve the grading status of contractors in targeted categories and grades;
- increase the number of black women, disabled, and youth-owned companies in targeted categories; and
- create sustainable contracting enterprises by enabling continuous work through a competitive process.

Key to achieving the objectives of the NCDP is that Government will use its procurement and delivery of infrastructure in order to achieve contractor development. This in turn will also increase the industry’s capacity to roll out the government’s infrastructure programme.

The Construction Industry Transformation Summit which was held on 23 November 2012 that was initiated by the Minister of Public Works endorsed that the pace and depth of transformation in the construction industry is lagging, and is not representative of what government, society or the industry desires.

Arising from the Transformation Summit, several Focus Groups were established, of which a Focus Group on Contractor Development was tasked to develop a Discussion Paper providing an assessment of the roll-out of contractor development being achieved through the National Contractor Development Programme (NCDP), including:

- contractor development programmes (CDPs); and
- the cidb Standard for Indirect Targeting for Enterprise Development.

---

2. **Context**

2.1 **Contractor Registrations**

As context, the distribution in the number of General Building (GB) and Civil Engineering (CE) contractor registrations in Grades 1 to 9 is given below:

<table>
<thead>
<tr>
<th>Grade</th>
<th>GB</th>
<th>CE</th>
</tr>
</thead>
<tbody>
<tr>
<td>9</td>
<td>38</td>
<td>51</td>
</tr>
<tr>
<td>7 &amp; 8</td>
<td>358</td>
<td>402</td>
</tr>
<tr>
<td>5 &amp; 6</td>
<td>1440</td>
<td>1543</td>
</tr>
<tr>
<td>2 to 4</td>
<td>4443</td>
<td>3672</td>
</tr>
<tr>
<td>sub-Total</td>
<td>6279</td>
<td>5668</td>
</tr>
<tr>
<td>1</td>
<td>51342</td>
<td>24642</td>
</tr>
</tbody>
</table>

The percentage of black-owned contractor registrations in Grades 2 to 8 is given below, from which it can be seen that black-ownership in GB and CE Grades 2 to 4 exceeds 90%, but that ownership drops off rapidly with increasing grade of contractor registration:

<table>
<thead>
<tr>
<th>Grade</th>
<th>GB</th>
<th>CE</th>
</tr>
</thead>
<tbody>
<tr>
<td>7 &amp; 8</td>
<td>68%</td>
<td>59%</td>
</tr>
<tr>
<td>5 &amp; 6</td>
<td>84%</td>
<td>80%</td>
</tr>
<tr>
<td>2 to 4</td>
<td>94%</td>
<td>93%</td>
</tr>
<tr>
<td>Total</td>
<td>91%</td>
<td>91%</td>
</tr>
</tbody>
</table>

It is clear from the above (as highlighted at the Transformation Summit) that a need exists to focus on, amongst others, transformation at contractor Grades 7 to 9.

2.2 **Access to Work Opportunities**

An estimate of the access to work opportunities by black-owned contractors is given below, in which an estimate based on limited data of public sector infrastructure contracts awarded to black-owned contractors in grades 2 to 8 is given:

<table>
<thead>
<tr>
<th>Grade</th>
<th>GB</th>
<th>CE</th>
</tr>
</thead>
<tbody>
<tr>
<td>7 &amp; 8</td>
<td>72%</td>
<td>41%</td>
</tr>
<tr>
<td>5 &amp; 6</td>
<td>86%</td>
<td>75%</td>
</tr>
<tr>
<td>2 to 4</td>
<td>96%</td>
<td>80%</td>
</tr>
<tr>
<td>Total</td>
<td>77%</td>
<td>50%</td>
</tr>
</tbody>
</table>
A lack of access to work opportunities by larger black-owned contractors is noted from the above. (Note that Grade 9 contractors have been excluded due to the dominance of public listed companies in this category.)

A further indicator of access to work opportunities by black-owned contractors is given below, in which the annual turnover of black-owned contractors in Grades 2 to 8 as measured from the income statements of contractors is given as a percentage of the total turnover of contractors:

<table>
<thead>
<tr>
<th>Grade</th>
<th>GB or CE</th>
</tr>
</thead>
<tbody>
<tr>
<td>7 &amp; 8</td>
<td>44%</td>
</tr>
<tr>
<td>5 &amp; 6</td>
<td>64%</td>
</tr>
<tr>
<td>2 to 4</td>
<td>75%</td>
</tr>
<tr>
<td>Total</td>
<td>55%</td>
</tr>
</tbody>
</table>

Again, the lack of access to work opportunities by larger black-owned contractors is noted.

### 2.3 Contractor Upgrades

As of Quarter 3 of 2013, the percentage of contractors that have upgraded one or more grade during the previous 12 months is given below, based on the contractor grade prior to the upgrade (i.e. the grade from which the contractor has upgraded from):

<table>
<thead>
<tr>
<th>From Grade</th>
<th>GB</th>
<th>CE</th>
</tr>
</thead>
<tbody>
<tr>
<td>7 &amp; 8</td>
<td>3%</td>
<td>5%</td>
</tr>
<tr>
<td>5 &amp; 6</td>
<td>10%</td>
<td>12%</td>
</tr>
<tr>
<td>2 to 4</td>
<td>10%</td>
<td>12%</td>
</tr>
<tr>
<td>1</td>
<td>2%</td>
<td>3%</td>
</tr>
</tbody>
</table>

An alternative assessment is given below, in which the annual percentage of contractors that have upgraded one or more grade is given based on the current contractor grade (i.e. the grade to which the contractor has upgraded to):

<table>
<thead>
<tr>
<th>To Grade</th>
<th>GB</th>
<th>CE</th>
</tr>
</thead>
<tbody>
<tr>
<td>9</td>
<td>11%</td>
<td>10%</td>
</tr>
<tr>
<td>7 &amp; 8</td>
<td>16%</td>
<td>24%</td>
</tr>
</tbody>
</table>
Note that although around 25% of the current Grade 2 to 6 contractors have upgraded one or more grade per year – relatively few contractors in fact achieve more than one upgrade over several years. For example, as illustrated in the table below, only around 74 contractors (or 4% in total) that are currently in Grade 5 or above have upgraded 3 or more grades over the past 5 years:

<table>
<thead>
<tr>
<th>To Grade</th>
<th>GB</th>
<th>CE</th>
</tr>
</thead>
<tbody>
<tr>
<td>9</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>7 &amp; 8</td>
<td>32</td>
<td>47</td>
</tr>
<tr>
<td>5 &amp; 6</td>
<td>39</td>
<td>25</td>
</tr>
<tr>
<td>Total</td>
<td>73</td>
<td>74</td>
</tr>
</tbody>
</table>

(A further discussion on contractor development is provided in the cidb publication *The Construction Industry as a Vehicle for Contractor Development and Transformation*).

### 3. Assessment of Contractor Development Programmes

A CDP is defined within the NCDP as:

> an entity that is established for the purpose of providing developmental support to contractors. Contractors who participate within CDPs receive structured developmental support which is targeted to achieve predetermined developmental objectives.

Work opportunities are typically provided through direct contracts with the developing contractors within the CDP. Structured developmental support could be provided by the government institution that is providing the work opportunities, or could be outsourced to a developmental institution.

---

In support of CDP’s the NCDP has developed guidelines for implementing CDPs\textsuperscript{3} which includes:

- targeting of budgets, projects and contractors;
- evaluation of contractors when entering a programme;
- training and mentoring;
- sharing the cost of contractor development;
- risk and cost sharing in contracts;
- payment dispute resolution;
- exiting from the programme; and
- monitoring and evaluating the programme.

Note that, in support of allocating work opportunities to CDPs, the cidb has also produced Practice Note 29, Allocating Sustainable Work Opportunities to Contractor Development Programmes\textsuperscript{4} to assist clients, together with a brochure on Client Tips and Advice; Demystifying Set Asides and Ringfencing. The outcome has been clients such as DPW and several municipalities now aligning their policies to the CDP guidelines and proposing new rollout plans. In these guidelines, it is recommended that client departments allocate around 5\% to 10\% of their infrastructure budgets in tender grades 2 to 4 to CDPs.

As detailed in the following table, 21 CDPs are presently being monitored as part of the NCDP:

\begin{tabular}{|c|}
\hline
\end{tabular}


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Table 7. CDPs Monitored

Province
Eastern Cape

Free State

Gauteng
KwaZulu-Natal
Limpopo

M pumalanga
Northern Cape
North West
Western Cape























CDP
Buffalo City M unicipality (Learnership)
COEGA (REDP)
Chris Hani DM (Vuk’uphile)
Department of Roads and Public Works
IDT (Khutaza)
SEDA (SCI)
Dept. of Roads and Transport
IDT
M angaung M etro M unicipality (Vuk’uphile)
Public Works
eKurhuleni (Vuk’uphile)
SEDA (Incubator)
Dept . of Transport (Vukuzakhe)
IDT
Lepelle-Nkumpi (Vuk’ uphile)
Polokwane M unicipality (Vuk’ uphile)
IDT (Sakabakhi)
Prov. Roads and Transport (Clinic project)
Prov. Roads and Transport (Upington Hospital)
Dept. Public Works, Roads and Transport
Department of Transport & Public Works (Senyuka)

An assessment of the number of contractors in terms of initial and current
registrations within these CDPs is given in the Tables below, together with
the number of registration upgrades over a three year period. A three year
period has been used as a reference period as the date of entry of the
contractors into the CDPs is largely not available or reliable. Also included
in the tables below is the average annual percentage of registration
upgrades over the three year period, together with the national average (or
benchmark – see Tables 5a and 5b):
Table 8a. Assessment of Contractor Development (Upgrades From Grade)
CDPs
Benchm ark
From Grade
Initial Total
Num ber
%
% pa
Registrations Upgrades 3 yr average
GB
5&6
30
8
9%
10%
2 to 4
185
83
15%
10%
1
376
81
7%
2%
CE
5&6
24
9
13%
12%
2 to 4
362
157
14%
12%
1
237
91
13%
3%

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ISBN 978-0-620-60356-0


It is seen that in terms of the ‘forward looking’ approach in Table 8a, the average percentage of registration upgrades (around 14% in Grades 2 to 4 and 11% in Grades 5 & 6) is comparable to or slightly higher than the national average. However, in terms of both the ‘backward looking’ approach in Table 8b, the average percentage of registration upgrades (around 17% in Grades 2 to 4 and 22% in Grades 5 & 6 is comparable to or slightly lower than the national average. It should be noted however that these CDPs do not comply with most of the CDP Guidelines (which have been introduced post the implementation of the CDP’s reviewed) – and it would be anticipated that significant improvements in would be achieved by CDPs complying with the NCDP Guidelines.

In summary, it appears that at best, it can be concluded that the rate of upgrades within the CDPs currently being monitored is comparable to the national average (i.e. which largely exclude developmental support). This could be attributable to:

- the unreliability of the data (including a lack of details regarding the dates of entry into a CDP); and/or
- the sub-optimal performance and lack of alignment of CDPs to date.

The contributing factors above need to be investigated further.

It should however further be noted that, to date, the available data suggests that:

- no contractors have yet exited from CDPs; and
- no contractors have yet graduated in terms of meeting competence requirements identified the cidb Guidelines for Implementing Contractor Development Programmes.

Notwithstanding the limitation of only using upgrades and competence as a measure of development, there is somewhat disappointing evidence regarding the contractor development being achieved through these CDPs to date. However, there is little doubt that significant potential exists for
CDPs to contribute substantially to contractor development – and specifically if the CDPs were appropriately aligned to the NCDP Guidelines.

Specifically, it is estimated (as an indicative target that could be proposed to client departments) that allocating 10% of public sector construction expenditure allocated through CDPs for construction works contracts could potentially amount to:

- around R3.3bn of work opportunities and developmental opportunities per year for contractors in Grades 2 to 6;
- around 2,000 Grade 2 to 4 contractors and around 200 Grade 5 & 6 contractors receiving developmental support per year (or around 30% of the total black-owned Grade 2 to 6 contracting capacity per year).

Clearly, the above contractor development opportunities are substantial. However, it should be noted that achieving a target of 10% of public sector construction expenditure allocated through CDPs will require a significant growth in the number of CDPs (aligned to the NCDP Guidelines), and will need to extend across SoEs, national, provincial and local government.

Going forward, it must be recognized that currently the cidb is in year 1 of a planned 3 year process in terms of capacitating client infrastructure department officials and having the CDP’s aligned to the NCDP and to the NCDP Guidelines. Furthermore, municipal Corporate Government and Traditional Affairs (CoGTA) and South African Local Government Agency (SALGA) approval at the Ministers and MECs (MinMEC) was obtained in September 2013 and capacitation and monitoring in 2014/15 should see a step change in the uptake of CDP’s. In 2014/15, the cidb will pilot a level of CDP alignment assessment and provide monitoring reports to political and administrative heads of departments and MEC’s.

4. Summary and Concluding Comments

The objective of this discussion paper has been to provide an assessment of the roll-out of contractor development being achieved through the NCDP – and specifically through contractor development programmes (CDPs) and through the cidb Standard for Indirect Targeting for Enterprise Development.

In this regard it should be noted that:
• the NCDP Summary Framework was only endorsed by NDPW MinMEC at the end of September 2012 and launched in December 2012, but only endorsed by SALGA and then by COGTA MinMEC in September 2013, and the extent of implementation of CDPs and the alignment of CDPs to the NCDP Guidelines is to date therefore limited; and

• the cidb Standard for Indirect Targeting for Enterprise Development is only likely to be regulated in 2014, and thereafter rolled-out incrementally.

It is unlikely therefore that significant results could have been achieved to date, but the following progress must be noted:

• Guidelines for Implementing Contractor Development Programmes were launched in December 2012 and adopted by SALGA and COGTA MinMEC in September 2013 for 2014/5 rollout;
• a limited number of CDPs (which are largely ‘non-compliant’) are presently being monitored are as part of the NCDP; and
• the cidb best practice Standard for Indirect Targeting for Enterprise Development was published in February 2013, and the intent is to regulate this Standard in 2014.

Based on the limited data and using upgrades as a measure, it is however concluded that the rate of upgrades within CDPs is at least comparable to the national average – and this serves as a benchmark for going forward. It is however also noted that the available data suggests the compliance of CDPs with the NCDP Guidelines is low and it is likely that with increased alignment to the NCDP Guidelines this scenario will improve significantly.

Notwithstanding the limited performance to date, there is little doubt that significant potential exists for CDPs and the expected potential impact has been quantified in this paper.

Going forward, the cidb is focusing on the following objectives:

• enhancing compliance of CDPs with the cidb Guidelines for Implementing Contractor Development Programmes (with an objective of 90% alignment to the CDP Guidelines by 2 client departments per province in 2014/5);
• broadening the roll-out of CDPs at provincial and local/municipal level (with an objective of 60% of municipalities being capacitated on the NCDP in 2014/5);
• regulating the cidb Standard for Indirect Targeting for Enterprise Development in 2014/5, and rolling the Standard out from national
departments and SoEs to low-capacity municipalities incrementally over 5 years;

• exploring introducing further mandatory requirements for contractor development; and

• ongoing monitoring of the roll-out of contractor development being achieved through CDPs and the cidb Standard for Indirect Targeting for Enterprise Development.

In conclusion, as noted previously, the objective of the NCDP is to increase the capacity, equity ownership, sustainability, quality and performance of cidb registered contractors. The current focus of these objectives on various contractor Grades is summarized below:

<table>
<thead>
<tr>
<th>Grade</th>
<th>Increased Capacity</th>
<th>Increased Equity Ownership</th>
<th>Increased Sustainability</th>
<th>Increased Quality and Performance</th>
</tr>
</thead>
<tbody>
<tr>
<td>9</td>
<td>✗</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>7 &amp; 8</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>5 to 6</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>2 to 4</td>
<td>✓</td>
<td>✗</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>1</td>
<td>✓</td>
<td>✗</td>
<td>✓</td>
<td>✓</td>
</tr>
</tbody>
</table>

Note that the objective of increasing the contracting capacity in Grades 5 to 9 is still being investigated – and at present there is no indication that any capacity constraint exists in these grades (other than capacity constraints in black-owned contractors).

Key to achieving the objectives of the NCDP is to provide access to work opportunities and to developmental opportunities to black-owned contractors.
6. References


Enhancing construction infrastructure delivery through restructuring of the Vuk’uphile Learnership Programme

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ABSTRACT AND KEYWORDS

Purpose of this paper
To provide an overview on review and restructuring of a construction contractor learnership programme and the quality management under the infrastructure sector of the government’s Expanded Public Works Programme (EPWP). The programme is called the EPWP Vuk’uphile Learnership Programme (VLP).

Design/methodology/approach
The research is supported by a literature survey. An evaluation of role player’s participation in the existing learnership programme was undertaken. Experiential data was obtained from practice. Quality management procedures were developed for future utilisation. The results have been reduced to descriptive research outcomes contained in a practice manual.
Findings
The restructured and streamlined Vuk'uphile Learnership Programme should optimise utilisation of labour on infrastructure construction projects and increase labour intensity, whilst simplifying managerial requirements on the programme.

Research limitations/implications
The research is focussed on the EPWP VLP of the National Department of Public Works (NDPW). The restructured VLP, supported by a computerised total quality management system, will improve the efficiency and outcomes of the programme. This research is ongoing.

Practical implications
As a result of this research a streamlined VLP Practice Manual is created, stripped of impediments that may have existed in prior programmes. The manual will be a useful guide for all role players, indicating the inter-relationships and required contributions by all stakeholders.

What is original/value of paper
The completed manual will be a definitive practice guide, supported by a computerised total quality management system (TQM) that was previously not available. The manual thus provides an easily accessible practice guide and a measurable TQM-based system. The managerial requirements regarding the programme are thus simplified.

Keywords: Construction contractor, learnership, labour intensity, practice manual, programme management, total quality management, Vuk'uphile Learnership Programme.

1. INTRODUCTION

The research, which is still ongoing, was based on two main premises: Firstly, consideration of the historic premise regarding the organisation and development of learnership opportunities, the promotion of sustainability in the emerging construction sector, optimisation of utilisation of labour-intensive methods, enhancement of labour intensity, the creation of work opportunities and Broad Based Black Economic Empowerment (BBBEE). Labour intensity is that portion of the construction fees that are spent on labour expressed as a percentage of the total construction fee.
Secondly, the development of the Vuk'uphile Learnership Programme (VLP) of the Expanded Public Works Programme (EPWP) was tracked over its development period so that lessons can be learned from previous VLP programmes in order to implement the necessary improvements.

This research utilised the above two premises to prepare a restructured VLP, incorporating the lessons learned/experiential data. The restructured programme incorporates a Total Quality Management (TQM) system. The TQM approach entails that the programme design is fully
integrative regarding activities of all the role players in the programme, easy to implement in a computerised format, providing measurable and qualitative outcomes that culminates in a substantive close-out report for each participating client body (local, provincial, national implementing body or state owned entity).

2. METHODOLOGY

The research methodology adopted was as follows:

- A literature survey regarding emerging contractor development was undertaken. Literature review entailed the evaluation of previous work undertaken by the CSIR in the area of emerging contractor development, particularly the South African Construction Excellence Model (SACEM) and the Integrated Emerging Contractor Development Model (IECDM), which are skills development tools for construction firms. The literature review also entailed evaluation of policies, legislative framework and structural interventions underpinning the EPWP VLP such as the:
  - Construction Industry Development Board Act (No 38 of 2000);
  - Broad-Based Black Economic Empowerment Act (No 53 of 2003);
  - Labour Relations Act (No 66 of 1995);
  - EPWP Management Manual;
  - EPWP Disciplinary procedures; and
  - The Skills Development Act (No 97 of 1998)

- An evaluation of all aspects regarding the existing NDPW’s VLP under the EPWP. The sources of experiential data provided by the NDPW, such as the EPWP Vuk’uphile Management Plan and its addenda, resulted in development of the following:
  - Objectives of the programme;
  - Implementation guidelines by all the stakeholders in the VLP, including clarity on their roles and responsibilities;
  - Reporting structures; and
  - Mentorship and training models and guidelines.

- TQM principles were analysed and adapted to enhance the VLP. TQM is an established management philosophy which found relevance in the structuring of programme planning, evaluation, control and reporting. The TQM approach was also useful in ensuring that the needs of NDPW were proper interpreted and communicated by the CSIR during the course of the project.

- Aspects requiring critical intervention to streamline managerial processes and learning outcomes were synthesised out of all sources/data.
3. STRUCTURAL INTERVENTIONS UNDERPINNING THE VLP

The following structural interventions have been made by government, and other organs of state, in order to create an “enabling environment” for the rapid development of, inter alia, construction contractors. These interventions were all considered in the review of the VLP.

3.1 Construction Industry Development Board

The CIDB mandate is, inter alia, encapsulated in the following specific relevant abstract in the Construction Industry Development Board: Annual Report (2004/2005:12): “Promote sustainable growth of the construction industry and the sustainable participation of the emerging sector”. In fulfilment of this mandate the CIDB has developed a National Contractor Development Programme (NCDP) to guide contractor development in the country.

3.2 Broad Based Black Economic Empowerment

Government initiatives are supported by the Broad Based Black Economic Empowerment Act (No 53 of 2003) (BBBEE, 2003:2) that is in the implementation phase.

3.3 Expanded Public Works Programme

The Expanded Public Works Programme (2005:2), inter alia, states: “The emphasis of the EPWP is to expand the use of labour-intensive methods in government-funded service delivery projects to create more work opportunities and stimulate entrepreneurial activity”. The South African Constitution’s Section 217 allows for allocation of work for developmental purposes, thus providing a necessary legislative framework to support contractor development.

3.4 South African Construction Excellence Model

The Council for Scientific and Industrial Research (CSIR) has been involved in research work to develop the South African Construction Excellence Model (SACEM). Dlungwana and Rwelamila (2005:2-3) reported as follows: “The South African Construction Excellence Model (SACEM) is a business performance assessment tool developed to evaluate the overall performance of contractors in addressing many of the challenges addressed above”.

3.5 Construction Education and Training Authority

The Skills Development Act (Act 97 of 1998) provides for the creation of a Sectoral Education and Training Authority (SETA) for each of the various economic sectors. SETAs are established to work out and implement sector skills plans, promote learnerships and hand out funds for development of individuals in their sectors. In this regard the Construction Education and Training Authority (CETA) is responsible for the construction industry.

4. PROGRAMME OBJECTIVES, OUTCOMES AND PROCESS MANAGEMENT

From the analysis of the EPWP VLP and consideration of structural interventions (see Section 3 above) it became possible to establish two directives on which to base a comprehensive re-structured operational model/manual of the VLP, underpinned by a TQM-based monitoring, evaluation and reporting system. The latter is elaborated in Section 5 of this paper, whilst the following two directives constitute the development platform:

Firstly, the broad, long term objectives and outcomes which have been set for this programme outlined in Table 11.1.

Table 11.1 Long term objectives and outcomes

<table>
<thead>
<tr>
<th>Nr</th>
<th>LONG TERM OBJECTIVES</th>
<th>OUTCOMES</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Alleviate and reduce unemployment</td>
<td>Work opportunities created through the Vuk’uphile Learnership Programme under the EPWP</td>
</tr>
<tr>
<td>2</td>
<td>Introduce Labour Intensive Construction (LIC) projects in the public sector at all levels</td>
<td>Labour intensive technologies and design criteria to facilitate the usage of LIC in the public sector. Contract documents incorporating LIC designs and contractual conditions</td>
</tr>
<tr>
<td>3</td>
<td>Improve labour intensity on construction projects</td>
<td>Projects with enhanced labour intensity (LI), ie LI &gt; 5%</td>
</tr>
<tr>
<td>4</td>
<td>Develop skills of emerging contractors</td>
<td>Learner Contractors and Learner Supervisors competent in LIC, administration, contracting and general entrepreneurial skills</td>
</tr>
<tr>
<td>5</td>
<td>Develop sustainable construction contracting companies</td>
<td>Construction companies able to sustain their businesses in the open market</td>
</tr>
</tbody>
</table>
Secondly, a management process chart that shows the interaction and inter-relationships between role-players involved with the VLP has been developed. See Figure 11.1.
5. VLP OPERATIONAL PROCEDURES

From the research, which followed synthesised long term objectives and outcomes, as well as the management process chart (see Section 4), it was possible to develop a practice “manual” which reflects all aspects of the re-designed VLP, also taking into account the historical background and practices to date. New perspectives that were developed during the research process have also been built into the VLP Manual.

The VLP Manual is structured to specifically address the role of each stakeholder shown in the management process chart, Figure 11.1.

The VLP has thus been developed to create job opportunities among the targeted population groups and to build capacity amongst emerging contractors to execute an increasing amount of labour intensive work. The Vuk’uphile Learnership Programme is intended to train two (2) individuals, one being a Learner Contractor (LC) and the other being a Learner Supervisor (LS), through an existing (or newly established) learner contracting company.

This training programme is registered with the Construction Education and Training Authority (CETA), with emphasis placed on Labour Intensive Construction (LIC) technology. Existing Contractors (learner contracting companies) cannot enter the programme unless they are registered with the Construction Industry Development Board (CIDB).

All the research done thus culminates in a manual that constitutes the entire re-developed VLP, containing six distinct Sections A – F, as described below:

5.1 Section A – VLP objectives and outcomes

This section of the “manual” has been compiled to “set the stage” by providing long-term objectives, outcomes, definitions and terminology regarding the programme as a whole. The entire Vuk’uphile Learnership Programme (VLP) is “unfolded” in sections B, C, D, E and F. These sections have been compiled in a way that allows each section to be autonomous, addressing a specific aspect of the VLP. The following aspects are covered in the VLP Manual.

5.2 Section B – VLP management structure

This section provides an overview of the VLP management structure. A VLP management process chart is provided (see Figure 11.1), which indicates the (inter)linking of all the role players in the programme. Abbreviated Tasks regarding each role player (bodies and persons) and the Activities flows from the above-mentioned process chart.

The main objective of Section B is thus to provide a summarised overview of the entire VLP, thus establishing a managerial constituting structure.
5.3 Section C – Participant and stakeholder execution guidelines

This section is the operational heart of the VLP. It provides managerial Execution Guidelines for Role Players and Stakeholders regarding their participation in the programme.

This is the most fluid of all the sections. It reflects lessons learned and operational changes to the programme, thus a living document that will be updated continuously to reflect best practices regarding the role of each participant in the programme.

The main objective of Section C is thus to provide a living practice execution guide that describes the deliverables required of each role player in the VLP.

5.4 Section D – Progress evaluation and reporting: Total Quality Management

This section contains the Total Quality Management (TQM) tools for the VLP. All the key areas influencing effective management of VLP (8 in total), are covered by TQM evaluation forms. The relevant role players complete these forms and data captured effectively provides ‘dashboard’ indicators for evaluating VLP progress and effectiveness. This provides both quantitative and qualitative data. The format is such that the quantitative data can be computed easily into multi-dimensional reports, while the qualitative data can be reflected in a comprehensive narrative report.

The main objective of Section D is thus to implement TQM procedures that measure programme progress and outcomes, facilitating an overall focussed management approach.

5.5 Section E – Standard procedural documentation

This section contains the Standard Procedural Documentation needed in the VLP in order to streamline the implementation and management of the programme. Documentation in the following categories has been developed, and is included in this section:

- Evaluation and/or reporting documentation required by the NDPW to provide leadership to the programme.
- Non-TQM evaluations and/or reporting documentation required by other VLP stakeholder.
- Standardised legal documentation/contracts for the implementation and management of the VLP nationally.
5.6 Section F – Close out reports

This section contains standardised templates, which all implementing bodies or other role players can use to prepare Close-Out Reports regarding groups of learners or phases of a completed VLP. It is closely linked to Section D, where information can be sourced from the TQM process and pulled into the close out report.

6. CONCLUSION

The following conclusions are drawn from the research:

- It was possible to identify short comings in present processes and develop a substantive VLP Practice Manual that also incorporates existing best practices.
- Managerial challenges regarding the practical implementation of the VLP should be reduced as a result of incorporating various dispersed documents into a single substantive practice manual that guides all role players in the programme.
- The introduction of a TQM process that provides quantified and qualitative data, emanating from critical management evaluation points, will enhance overall management of the VLP.
- Simplified procedural documentation will ease managerial pressure and improve programme effectiveness.
- Close-out reporting per client/programme and per stage of the programme will be a standard feature when the VLP is applied by a client body (implementing body).

7. REFERENCES


Department of Public Works, EPWP Vuk’uphile Learnership Programme, 2010, Learner Guide, January 2010, Rev 6 (NDPW Internal document)
The Feasibility of Integrated Risk Management in reducing Risks on Infrastructure Projects in the Zambian Construction Industry (ZCI)

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ABSTRACT AND KEYWORDS

Purpose of this paper
Risks are inherent in every construction project. The challenge is usually borne in the selection of the risk management approach to utilise. The study thus focuses on the feasibility of utilising the integrated risk management approach in reducing risks.

Design/methodology/approach
The research utilised primary and secondary data. Secondary data were obtained from literature available on integrated risk management and comparability to the traditional method. Primary data were obtained through the use of a questionnaire survey to consultants and contractors in ZCI.

Findings
The management of risks in the ZCI on infrastructure projects is hugely hampered by the over-reliance of project executors on the traditional method of procurement in which teams are segregated with adversarial relations. Such an approach may not be as effective to ensure successful completion of projects. It is for this reason that more innovative approaches like the IRM are required to enhance management of risk in ZCI. Integrated risk management encourages team work, from inception of a project to completion. This in turn enhances communication, and builds relationships that aid collaboration resulting in reduced overall project risks. Based on these findings, it can therefore be argued that Integrated Risk Management is
a feasible tool that can be used to reduce selected risks on infrastructure projects in the ZCI.

**Research limitations**
The study focused on the use of the integrated risk management approach on the traditional procurement method only and did not explore its application on other procurement routes.

**Practical implications**
The reduction of risks in infrastructure projects cannot be effectively achieved traditionally due to fragmentation of the parties involved. There is needed to change the traditional procurement paths that do not encourage integration of project parties in order to reduce poor performance of infrastructure projects.

**What is original/value of paper.**
Realizing that millions are spent by the government in providing infrastructure, the research endeavoured to assess the feasibility of reducing risks on infrastructure projects through Integrated Risk Management and contributed to the knowledge of risk management in the ZCI.

**Keywords**: Risk, Integration, Infrastructure, Management, Zambia.

1. **INTRODUCTION**
Risks are more widespread in the construction industry than any other industry (Akintoye and MacLeod, 1997; Smith, 2003). The same can be said about the Zambian Construction Industry (ZCI) where contracting parties have repeatedly suffered the consequences of failure to manage risk such as design failure, cost overruns and delayed completion. This makes the management of risks in infrastructure development a very important factor to consider. This is important given that the construction processes involve diverse parties whose aim in a project may not be the same. Unfortunately, in mitigating risks in Zambia, clients usually transfer risks through the traditional risk management process (design, bid and build), particularly in the public sector. Thus, all contracting parties should be concerned with risk management because risks have far reaching consequences beyond the party that fails to mitigate them (Rahman, 2003). Consequences usually include poor project performance characterised by time and cost overruns, poor quality, and tensions (Sillars and Alsalmam, 2013).

1.1 **The Concept and Definition of Risk**
According to PMI (2008), risk is defined as "an uncertain event or condition that, if it occurs, has a positive or negative effect on one of project objectives". On the other hand, Ward and Chapman (2003) argue that the
term “risk” is often associated with adversity and focuses more on threats, not opportunities. In this research, risk is defined as a probability of occurrence of an event and the magnitude of its consequence (Kaplan and Garrick, 1981). In view of this, risk can be measured using equation 1.1 below:

\[ R = P \times I \] (1.1)

Where: \( R \) = the degree of risk, \( P \) = probability/extent of occurrence of a risk factor; \( I \) = the consequence or perceived impact on a project.

1.2 Effects of Risks on Infrastructure Development Projects

Risks have an impact on one or more of the project objectives. While several scholars (for example see Akintoye and McLeod, 1997; Smith et al. 1999) only give cost, time and quality, Mills (2001) adds productivity and performance to the list of objectives. Accordingly, mitigating the occurrence of the risks reduces the negative impact of the risks and enhances where the risks have a positive effect.

1.3 Traditional Risk Management

Realising the drastic effects risks have on infrastructural projects, construction professionals and practitioners apply the following procedure in managing risks:

- **Risk identification**: Risk identification is the basic step of risk management which determines the potential risks by looking at all the project activities and considers possible risks associated with project activities. Correct risk identification ensures effective risk management (Tcankova, 2002).

- **Risk analysis**: Risk analysis is concerned with assessing the potential impact of a risk. It basically determines the probability and consequences, and combines them to estimate the level of a negative or positive impact (Australia /New Zealand Standards, 2004).

- **Risk evaluation**: This step focuses on determining whether a risk is acceptable or needs treatment by considering the probability of occurrence and its tolerance, to provide adequate information for decision making (Vrijling, Hengel and Houben, 1995).

- **Risk treatment**: This involves selecting and implementing one or more options for treating risks such as avoidance, changing the likelihood of occurrence, changing the consequences, sharing risk and retaining risk (Australia /New Zealand Standards, 2004). In general, like in any other industry, the following options are used:
- **Avoidance**: The team changes the project plan to eliminate the risk or to protect the project objectives from its impact. The team might achieve this by changing scope, or adding resources.
- **Transference**: The team transfers the financial impact of risk by contracting out some aspect of the work. Transference reduces the risk only if the a party is is capable of handling the risk.
- **Mitigation**: The team seeks to reduce the probability or consequences of a risk event to an acceptable threshold.
- **Acceptance**: The team may decide to accept certain risks. They do not change the project plan to deal with a risk but agree to address the risk if it occurs (Tenah, 1985; Fisk, 1997).

- **Monitoring and review**: Risks need to be monitored to ensure that the changing environment does not alter risk priorities and that the risk management process is effective. If not, other effective measures must be put in place (Ehan et al. 2010).

2. CONSTRUCTION PROCESS AND KEY PARTICIPANTS IN THE ZCI

The briefing stage is often the early stage in the construction process during which the client’s requirements are written down in a formal document (Ashworth, 2008). This gives a fixed reference point for the subsequent design of the building. At the design and procurement stage the architect will produce the architectural design, and the engineers will produce the engineering design according to the client’s requirements from the briefing stage (Flanagan, 1993). Based on the traditional procurement approach the key participants in a building project are the client/financier, contractors, and designers consisting of architect(s), engineers (structural, civil and service engineers) and quantity surveyor(s). These form a temporary organization to undertake the project.

2.1 Types of Risks in the ZCI

Early identification of risks is important for risks to be mitigated successfully (Flanagan and Norman, 1993). There are different types of risks at various stages of a construction project and can be classified broadly into the following groups;

- **Construction Risks in Project Undertakings**: These happen during the construction phase in a project life cycle (Enshassi et al. 2007). Examples include delayed site possession, equipment breakdown, design failure, poor inventory management, poor quality and lack of labour (Baker, 1999).
• **Environmental Risks in Construction Project:** Most of these types of risks fall under uncontrollable risks called *force majeure* (acts of God) such as inclement weather, floods and landslides (Flanagan, 1993). Others may include ecological damage and topographic limitations (Berkeley, 1991; Chapman, 2001).

• **Legal – Contractual Risks in Construction Project:** These include liability to others, local law and codes, suppliers, conditions of contract and government regulations (Chapman 2001; Ward 2003).

• **Financial and Political Risks:** Financial risks include unavailability of funds, inflation, exchange rate fluctuation, under-pricing and changes in interest rates (Berkeley, 1991; Chapman, 2001), while political risks range from changes in law, revolution, civil disorder, availability of labour, customs and export restrictions and procedures (Baker, 1999).

2.2 Shortfalls Of The Traditional Risk Management In The ZCI

Traditional risk management in the ZCI is organized into “camps” with diverse interests that sometimes converge and other times do conflict; owner, consultants and contractor. As a result, traditional projects have organizations that resemble silos or chimneys, with each camp organized vertically and separated from each other by contractual walls (Beckett, 2005). Evidently, the traditional approach does little in effectively managing risk due to fragmentation of the parties. Hence the industry needs a more innovative integrated approach.

3. **INTEGRATED RISK MANAGEMENT (IRM) PROCESS AND BENEFITS**

The IRM is a risk management approach which encourages all key parties involved in a project to focus on the best outcome of the project at the best final cost (Chapman 2001). At the beginning of every project, a team is established by the selection of different partners, and these are based primarily on the needs of the project (Lovins 1999). The team is comprised of the client, consultants, contractors and suppliers. This team then works in a group to accomplish the best project possible for the client (Meubroek, 2002).

The owner benefits most of all, with new assurance that the project will be built on time and within budget. This is by bringing parties together from the early stages of the project, allowing them to develop a much higher level of common understanding of the project. This breaks down traditional silos and
connects each team member to the entire building process (Beckett, 2005). Importantly, the consultants and contractors develop a closer, more productive relationship as they work, solving problems together and gaining insight on the other's works (Ward, 2003). Each member of the integrated team is chosen based on many factors such as experience, commitment and technical competence. This reduces on the effects of avoiding, transferring and mitigating risks (Smyth, 2008).

**IRM and Traditional Management Processes Contrasted**

Knowledge of the differences between IRM and other systems is imperative in understanding the preparedness of an industry for its integration. Table 1.1 presents a comparison between an integrated delivery process and a traditional method which also has a bearing on how risks are mitigated.

<table>
<thead>
<tr>
<th>Traditional Delivery</th>
<th>Project</th>
<th>Integrated System</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fragmented,</td>
<td>Teams</td>
<td>Integrated team, assembled early, collaborative</td>
</tr>
<tr>
<td>Linear, segregated;</td>
<td>Process</td>
<td>Concurrent, early contributions of knowledge and expertise, open</td>
</tr>
<tr>
<td>Individually managed, transferred</td>
<td>Risk</td>
<td>Collectively managed, appropriately shared</td>
</tr>
<tr>
<td>Individually pursued: first-cost based</td>
<td>Reward</td>
<td>Team Success tied to project success; value-based</td>
</tr>
<tr>
<td>Blame, exploiting loopholes,</td>
<td>Culture</td>
<td>Learning, continual improvement,</td>
</tr>
<tr>
<td>Separated from work</td>
<td>Decisions</td>
<td>Integrated with work; based on data</td>
</tr>
<tr>
<td>Budget output, activity,</td>
<td>Measures</td>
<td>Focuses on capability and variation</td>
</tr>
<tr>
<td>Functional silos fragmented, based,</td>
<td>Organization design</td>
<td>Based on demand, value and flow: open, integrated team</td>
</tr>
<tr>
<td>Hoarded in silos</td>
<td>Knowledge</td>
<td>Shared openly &amp; early</td>
</tr>
</tbody>
</table>

Source: Adapted from American Institute of Architects, 2009

**4. OBJECTIVES OF INTEGRATED RISK MANAGEMENT**

The effectiveness of IRM is hinged on the following objectives;

**Goal Driven:** Lovins (1999) states that the primary goal of an integrated risk management is a successful project, but with explicit subsidiary goals, objectives and targets set as a means to get there.

**Structure:** According to Zimmerman (2005) IRM is structured in a way that it incorporates everyone on the team and each participant gets to have the full involvement of the project. It forms a working culture where everyone has a
chance to inquire and advise where necessary to reduce on certain risks and encourages participants to look at the interest of the project rather than their own (Beckett, 2005).

**Clear decision-making:** Meetings are held from the start of the project and are called for time and again when matters arise to have a full involvement of participants. This helps to prevent conflicts and disputes during the construction stage in terms of how something ought to have been handled (Chapman, 2006).

**Inclusive:** The IRM includes everyone who has a role to play on a project from the client right through to the architect and the sub-contractors. This motivates participants as they will realize their value on the project (Lovins, 1999).

**Non Traditional expertise and Sharing of risks:** Other non-buildings-related expertise may be helpful. Their knowledge and experience in certain areas are crucial for the success of the project (Zimmerman 2005). Further, risks are evenly distributed amongst team members in accordance with best placed party to handle a particular risk. This reduces on having too many contingencies on the budget as knowledge on mitigating that risk would have been shared (Zimmerman, 2005).

**Holistic and systematic thinking:** The goal is to optimize the performance of buildings by considering all the building components and subsystems together and their interactions (Zimmerman, 2005). When this is done right, the end product is greater than the sum of the parts, and it may even be cheaper (Meubroek, 2002).

**Iterative:** The traditional phases of the building design process do not disappear in Integrated Risk management Process. Lovins (1999) describes the intermediate workflows as being “iterative loops”. The team continuously reviews and refines ideas to resolve problems at whatever scale is appropriate, at each phase of design.

5. **RESEARCH METHODOLOGY**

The research adopted both qualitative and quantitative methods in collecting data. This involved the desk survey (literature review) which is an essential aspect of the research since it sets the pace for the development of knowledge on the area of interest (Fellows and Liu, 2003). Therefore, literature in form of books, journals and professional magazines were used for secondary information collection. Primary data was collected through a
questionnaire survey were questionnaires were administered to clients, consultants and contractors.

**Sample Design:** The professionals involved in the survey included Architects (23), consulting Quantity Surveyors (22) Building Contractors (71) and Civil Engineers (20). A non probabilistic sampling method (convenience sampling) was used to select the professionals for the survey since the technique allowed targeting of individuals with the required expertise (Fellows and Liu, 2003). Lusaka and the Copperbelt Provinces were selected due to the availability in the two provinces of a higher number of construction projects and construction professionals compared to the other provinces.

6. RESEARCH FINDINGS

6.1 Types of Projects Undertaken

From the survey, 44% of the respondents were involved in general building and housing projects, 22% in general civil engineering projects, 24% were involved in road and earth works and 10% were involved in electrical and telecommunications projects. The survey thus showed that vital infrastructure projects are being undertaken in the ZCI which by their nature are susceptible to risks. This highlights the need for risk mitigation in the ZCI.

6.2 Causes of Risks and their Impacts

All the professionals interviewed indicated cost variation as a major impact on infrastructure development. Considering the scarcity of resources for financing infrastructure, the need for managing risks through integration cannot be overemphasized. This is vital since the professionals indicated that poor project team relationship and communication amongst participants, unforeseen mistakes and discrepancies in design document are also encountered.

**Type of procurement methods common in the ZCI**

The survey revealed that 38% of the respondents used the traditional procurement, 33% used the design and build method of procurement, 19% used management contracting, 3% used project management and 7% used construction management. This confirms that traditional system is still the most used procurement system in the country despite its limitation in risk management.
Success in Mitigating Risks of the Traditional Procurement Method

The traditional system which is mostly used in the Zambian Construction Industry indicated a success rate of 11% in managing risks whilst design and build and management approaches indicated 44% and 45% of success, respectively. The traditional method was thought to be ineffective due to its adversarial relationships and self-aimed goals amongst project team members. Research also revealed that risks are usually allocated to one party and when they fail no one else from the project team takes them up consequently projects are abandoned or delayed.

Contractor Involvement in the Construction Process

From the contractors’ responses, only 11% of the respondents indicated that they have in the past been engaged at inception while 18% have been involved at feasibility stage. It therefore suffices to say that there is low contractor engagement at the identified stages. This can be attributed to the contractual arrangement of the traditional system which does not allow full participation of all team members at all stages. It can be argued that this contributes to the poor management of risks in the ZCI.

6.3 Mitigation of Risks among Construction Team Members

Sharing of risks in the ZCI is rarely done, yet it has been acknowledged by the respondents as being the best way of mitigating risks. This can be seen from the survey which revealed that 35% of the respondents preferred risks to be transferred, while 41% of respondents preferred sharing risks which shows that respondents see the need of integrating participants on a project to help contribute knowledge, experience and build trust and strong relationships to effectively deliver projects. Another 17% of participants suggested avoiding the risks which occur as not being effective because the client will be left unsatisfied. Only 7% were willing to accept the risk.

6.4 Risk Distribution among Construction Team Members

The survey indicated that 75% of risks are allocated to contractors whilst the design team had 25%. Contractors stated that any delay or departure from the signed construction contract will lead to breach of contract and hence failure to execute the desired needs of the client. On the other hand, Architects stated that they are exposed to risk as they mainly deal with design related risks. Once the design is complete it is up to the contractor to manage all the works and constructability.
6.5 Factors for Implementing a Successful Risk Management

The survey showed the following key success factors; open communication 38%, knowledge sharing 20% collaboration 13%, risk sharing 9%, mutual trust 8% and understanding each others' objectives and equitable and clear allocation of risks 7% and 5% respectively. This confirms that the involvement and the use of all stakeholders throughout the project lifecycle can result in a successful project.

6.6 Feasibility of Integrated Risk Management in ZCI

The majority (73%) of the respondents stated that IRM is feasible in the ZCI with 27% indicating that it is not feasible. Organizations such as the National Housing Authority have a similar arrangement of integrating project team members and this has helped them in reducing risks on their projects. This offers a stable base for the implementation of IRM in mitigating risks.

6.7 Risks That Can Be Mitigated Using Integrated Risk Management

The respondents acknowledged that risks can be effectively managed through IRM. However, it was noted that only a selected number of risks can be fully mitigated through IRM. Some of these risks are shown in Table 1.2 below.

<table>
<thead>
<tr>
<th>Item</th>
<th>Risks</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Conflicts amongst construction team members</td>
</tr>
<tr>
<td>2</td>
<td>Communication and coordination amongst construction team members</td>
</tr>
<tr>
<td>3</td>
<td>Contractor disregards quality of material in the way to get profit</td>
</tr>
<tr>
<td>4</td>
<td>Variation of works by client</td>
</tr>
<tr>
<td>5</td>
<td>Mistakes and discrepancies in design documents</td>
</tr>
<tr>
<td>6</td>
<td>Delay in completion of construction project</td>
</tr>
<tr>
<td>7</td>
<td>Lack of consistency between bill of quantities, drawings and specifications</td>
</tr>
<tr>
<td>8</td>
<td>Insufficient information in the contract specification, drawing and design</td>
</tr>
<tr>
<td>9</td>
<td>Delay in payments by consultants</td>
</tr>
</tbody>
</table>

6.8 Challenges in Adapting Integrated Risk Management in the ZCI
From the survey, 74% of the respondents indicated that they could adopt Integrated Risk management except that they were not very certain on its outcome, added costs, possibility of bringing all team members at once. Willingness to collaborate was also advanced. The traditional method of procurement was noted as a major challenge.

7. CONCLUSION

Like any other construction industry, the ZCI is faced with numerous risks in delivering its infrastructure projects. However, there has been a lack of knowledge on the various risk mitigation methods to minimize cost overruns, poor quality, late completion, and tensions which may lead to abandonment of projects. This is due to the fact that relationships amongst team members are adversarial due to the contractual arrangement. Further, in terms of relative comparison, the design and build system seems to be more effective largely owing to the fact that it is based on teamwork which is the basic underlying principle of IRM. This shows that IRM which encourages teamwork will enhance successful delivery of infrastructural projects in the ZCI when effectively applied. It is therefore important that design and construction should be integrated so that contractors can be involved to offer their knowledge at an early stage. This will also strengthen team relationships and avoid the blame game when risks materialize and encourage parties to combine their efforts in ensuring that the whole team wins. It is therefore recommended that the industry adopts Integrated Risk Management and its principles such as mutual trust and respect, sharing of risks, early involvement of key participants, and sharing of experiences and knowledge in risk management.

8. REFERENCES


South African E-toll Consultation Saga: Lessons for Public Consultation in Mega-Projects

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ABSTRACT
Purpose: To investigate the cause of resistance and legal challenges to the legitimacy of Gauteng e-tolling road financing model.

Design: A survey was conducted among Johannesburg motorists through the use of questionnaires and open-ended interviews with leading protagonists against e-tolling.

Research Limitations: The respondents were from Johannesburg and Pretoria was not covered. South African National Roads Agency Limited (SANRAL) was very reluctant to assist as the research was conducted during the legal proceedings. Surveys were conducted at shopping malls as permission to work on these establishments depended on the shopping centre management sentiments.

Research Findings: There is general discontent with the public consultation process before the project was implemented. The stakeholder analysis was inadequate as it left the important players who are now spearheading the resistance from all possible fronts.

Practical implications: The experiences garnered in this project are instructive, on how best-practice public consultation processes should be adapted to the South African context to avoid stifling infrastructure implementation in the future.

Value of Paper: The paper will assist the government to implement and manage well-structured, elaborate, measurable and monitorable public consultation protocol for mega projects.
1. INTRODUCTION

The growth of Gauteng, the economic hub of South Africa with a contribution of about 38% to the country’s economic activities, has resulted in a freeway network which is over capacity (SANRAL, 2012). The introduction of Gauteng Freeway Improvement Project (GFIP) was widely welcomed and supported by all. The South African road network, managed by the South African National Roads Agency Ltd (SANRAL) forms the arteries of the nation that connect major cities, towns and developing villages in rural areas of the country. The major benefits of the national road network are economic growth, tourism, social development and the creation of economic opportunities (SANRAL, 2012). According to the Government Gazzette (South African Government Notices, 2013), the SANRAL and National Roads Act, 1998 (South Africa, Act no. 7 1998) (South African Government, 1998) as declared by the Government Notice No. 30912 of 28 March 2008 (South African Government Notices, 2008) allows SANRAL to levy tolls on specific roads in Johannesburg. The roads are N1 sections 20 and 21, N3 section 12, N4 section 1 and N12 sections 18 and 19. Government notice No.31273 of 28 July 2008 (South African Government Notices, 2008) added R21 sections 1 and 2. SANRAL is entitled to determine the tolls to be levied and the rebates thereon and reductions thereof in the schedules that it will produce.

When fully operation the road network that criss-crosses Johannesburg, Ekurhuleni and Tshwane metropolitan boundaries will widen the freeways to at least four lanes in both directions and in some sections up to six lanes (SANRAL, 2009). The first phase of the project was to result in the upgrading of 185kms of the existing road network, the next phase was to see the further 376 kms of upgraded and newly constructed freeways. Apart from the road widening, the GFIP will also ensure that bottlenecks at major interchanges are resolved (ibid.). For the first phase 34 interchanges were upgraded including the Allandale, Rivonia, William Nicol, Gillooly’s and Elands Interchanges. When fully functional median lighting and an Intelligent Transport System (ITS) consisting of cameras, electronic notice boards and other traffic management features will be provided (ibid.). This will enhance traffic flow and the avoidance of congestion as motorists will be notified of accidents and alternative routes available to avoid unnecessary time wastage.

The implementation of this project has had its fair share of troubles. Apart from religious groups, other civic organizations and political parties, the two organizations that have rallied behind the drive to annul the tolling of Johannesburg roads is the Opposition to Urban Tolling Alliance (OUTA) and Confederation of South African Trade Unions (COSATU). OUTA is chiefly an alliance of truck owners and car hire operators in Johannesburg. OUTA constitution regards the tolling of the GFIP, as improper because there was no proper and/or lawful consultation with the private sector and
the public in advance thereof, whose consequences include an adverse economic impact upon the private sector in Gauteng and its citizens already overburdened by high local taxation and fuel costs; the consequences upon the local economy of the additional costs of the administration of such tolling scheme; an absence of clarity in respect of matters related to the computation of the excessively high costs to be levied upon road users; the absence of transparency with regard to the proposed use, and application and distribution by SANRAL of public funds raised through tolling; concerns with regard to the enforcement of tolling with specific reference to cloned plates, also the direct access by tolling agencies to private information and the bank accounts of companies and individuals; concern in regard to the lawfulness of the disposal of provincial assets by the Provincial Government to SANRAL; and environmental concerns related to potential traffic congestion arising pursuant to a shortage of or non availability of adequate alternatives to the tolled routes (OUTA, 2012). This paper seeks to unpack the public awareness of the consultation strategies adopted by SANRAL and the public’s perception about the project. The experiences of other tolling projects elsewhere will be instructive in assisting in the implementation of future projects in this country.

2. LITERATURE REVIEW

2.1 Defining Tolling

Road tolling refers to a fee related to the use of a roadway facility. In general, tolling involves the imposition of a per-use fee on motorists for a given highway facility. Historically these fees have generally been just flat tolls that may vary by number of axles and distance driven, but not by the time of day. The primary purpose has always been to generate revenue. The revenue can be invested in capacity expansion or used to pay for the operations of the facility and the maintenance thereof (U.S. Department of Transportation, 2012). In Norway where there are 48 operational urban tolling projects, the funds from these projects form the bulk of the financial source for road and public transport infrastructure programmes. On average 25-30% of the total state budget for road construction comes from toll revenue (Leromanachou, Potter, & Warren, 2006). Experiences in Norway, France and other countries show that implementation should follow an extensive public consultation.

A variation to the traditional tolling, is called Road Pricing which entails fees that vary by level of vehicle demand on the facility. This type of road pricing is variously called congestion pricing, value pricing, peak-period pricing, or market-based pricing. The strategy very closely mimics what has been applied in other industries to account for and manage demand. The common everyday examples are airline tickets, cell phone rates and electricity rates. In addition to serving as a revenue source for
transportation, road pricing in the form of congestion pricing can act as a tool for demand management. The variability of pricing depending on traffic conditions and policies capitalizes on market forces to manage the utility of finite roadway capacity. Although this strategy’s main aim is to raise revenue it can be applied to achieve other goals like to reduce congestion, environmental impacts through emissions associated with traffic congestion, reduce wasted time and other costs occasioned by road users (U.S. Department of Transportation, 2012).

2.2 Urban Tolling in Other Countries

1) There are four congestion pricing approaches that use tolling. The first is **Priced Managed Lanes**, which is sometimes referred to as “partial facility” where rather than pricing an entire road, individual lanes (one or two both ways) are priced and operate parallel to the free general purpose lanes. This helps in providing a new and reliable travel alternative in congested roadway corridors for transit riders, High Occupation Vehicle (HOV) motorists and paying non-HOV drivers.

2) **Priced Highways**: Full facility pricing of all lanes that varies by the time of day or congestion level such that peak period is more expensive than off-peak travel, encouraging motorists to move some trips to off-peak periods or other travel modes, such as passenger rail. Motorists in Lee County in Florida for example are offered 50% discount on their toll if they travel between 6:30 to 7 am, 9 to 11 am, 2 to 4 pm and 6:30 to 7 pm. The main purpose of this cost structuring is to encourage off-peak travelling to ease congestion (U.S. Department of Transportation, 2012).

3) **Priced Zones (Area or cordon pricing)**: This helps in easing congestion in city centres where during peak hours motorists are charged as they pass a set boundary (cordon) or travel within a specified zone (area). A wide range of charging options are available for these facilities, including varying charges by time-of-day, by vehicle type, and entry point. These charges can be also be levied once (per 24-hour period) or each time the cordon is passed or the zone is entered. Stockholm Congestion tax (cordon pricing) was deployed in January to July 2006 on a trial basis and the public acceptance led to its full activation. The residents of Stockholm voted for its continuation in a referendum on September 17, 2006, it was reinstated permanently in August 2007. Central London Congestion Charging (London Area Pricing) was implemented in February 17, 2003 when a standard per day charge is levied for motorists travelling within a zone bounded by an inner ring road. A number of exemptions from the charging plan are
4) **Priced Road Networks**: Here all or some of the lanes in a network in an area or region are priced. Singapore has been operating peak-period pricing in the mornings since 1975. This system was fully automated in 1988, to deploy electronic charging system. The system which was the first of its kind in the world has generated about US$70 million in revenue annually, and operating costs amount to about 7% of annual revenue. In addition to this there is also area pricing fee for vehicles entering the CBD during weekdays (U.S. Department of Transportation, 2012).

The SANRAL documents are not clear on whether all these different alternatives were compared and whether it might not have been wise to consult the public or at least the relevant major stakeholders on what could be the best approach given the peculiar Johannesburg local conditions. The next Section will deal with the issue of Public Consultation.

### 2.3 Public Consultation

According to the International Association for Public Participation (IAPP), ‘Public Participation’ means to involve those who are affected by a decision in the decision-making process. It promotes sustainable decisions by providing participants with the information they need to be involved in a meaningful way, and it communicates to participants how their input affects the decision (IAP2, 2013). The practice of public participation might involve public meetings, surveys, open houses, workshops, polling, citizen’s advisory committees and other forms of direct involvement with the public (ibid.).

Consultation should be regarded as a two-way process of dialogue between the project company and its stakeholders. This should be regarded as initiating and sustaining constructive external relationships and starting the process early and taking a long-term, strategic view which is in essence getting a “social license to operate” from the community (IFC, 2011). Smith (2003) argues that “public participation” encompasses a group of procedures designed to consult, involve and inform the public to allow those affected by a decision to have an input into that decision. Rowe and Frewer (2000) reiterate that “input” is the key phrase, differentiating participation methods from other communication strategies. Consultation should be grounded in a neo-institutionalist perspective that focuses on the
underlying organizational rules and arrangements pertaining to urban governance and public consultation that guide and shape political interactions (Barnes, Newman, & Sullivan, 2007). The emergence of public participation techniques like citizens juries and deliberation panels are important discursive political spaces through which competing claims to public resources are channelled and articulated in the neoliberal entrepreneurial context (Scherer & Sam, 2008).

The IFC (2011) advocates for a good plan before embarking on a consultation process, because it is vital to identify who needs to be consulted, over what topics and for what purpose. For projects with multiple stakeholder groups and issues, a preparation of a more formal Stakeholder Engagement Plan is imperative. The core values of public participation should be that the public should have a say in decisions about actions that could affect their lives. And there has to be a firm promise that the public’s contribution will influence the decision (ibid.). The strategy should be well articulated. It will appear from many complaints from the members of the public that perhaps the simplest principles of public consultation for a project of this magnitude were not properly followed.

2. RESEARCH METHODOLOGY

This research is mixed method qualitative in that it sought to engage with people and solicited their sentiments about their awareness and amenability to the tolling necessitated by GIFP. But since a questionnaire was extensively used it is also quantitative and therefore a mixed method approach. According to Maxwell (2012) to design a qualitative study, one cannot just develop (or borrow) a logical strategy in advance and then implement it faithfully. Qualitative research design, to a much greater extent than quantitative research is a “do-it-yourself” rather than an “off-the-shelf” process, one that involves “tracking” back and forth between the different components of the design, assessing their implications for one another. It does not begin from a predetermined starting point or proceed through a fixed sequence of steps, but involves interconnection and interaction among the different design components (Maxwell, 2012). Most pertinently the design must fit not only its use but also its environment. The methods deployed below were the ones we felt would be the most appropriate for this type of research. The method of analysis for this research was thematic content analysis proposed by Burnard (1991) which is an adaptation of Glaser and Strauss (1967) Grounded theory and other works on content analysis by among others Berg (1989). Validity was ensured by asking colleagues not involved in the study to read the interview transcripts and come up with their categories and comparisons were made with the original list (Burnard, 1991).

Before engaging with the respondents a clearance was obtained from the University of the Witwatersrand Ethics Committee. Interviews were
then conducted with key stakeholders who were at the forefront of opposing the e-tolling. These are OUTA and COSATU who are representing the working class in South Africa. This research is interested in the depth of the data and in appreciating its breath, to attain a proper understanding of the data the researcher has to play an active role in the data collection (Wimmer & Dominick, 1997). It was therefore decided that interviewing the people who have studied the project and have challenged the legitimacy of its consultative processes in the courts, through mass demonstration and in the media could yield much in appreciating why there is so much public resistance to this project. Describing what an interview is Frey and Oishi (1995) defined it as a “purposeful conversation in which one person asks prepared questions (interviewer) and another answers them (respondent)” this is done to gain an in-depth information on a particular area to be researched. Open-ended interviews were opted for and they are defined by Nichols (1991) as “an informal interview, not structured by a standard list of questions. Fieldworkers are free to deal with the topics of interest in any order and to phrase their questions as they think best.” Open-ended questions allow the interviewer, if they wish, to probe deeper into the initial response of the respondent to gain a more detailed answer to the question (Wimmer & Dominick, 1997). The richness of the data can thus be enhanced by this approach.

A questionnaire was used and more than 1800 respondents accepted to participate, at three shopping malls in Gauteng. The malls were chosen strategically depending on their catchment area and motorists were approached as they alighted their vehicles by trained student research assistants from the University of the Witwatersrand. A questionnaire is defined as a formalized set of questions for obtaining information from respondents. The overriding objective is to translate the researcher’s information needs into a set of specific questions that respondents are willing and able to answer. A questionnaire is the main means of collecting quantitative primary data (Malhotra, 2011). A questionnaire enables quantitative data to be collected in a standardized way so that the data are internally consistent and coherent for analysis. In all cases the role of the questionnaire is to provide a standardized interview across all subjects. This is so that when the questions are asked or presented, it is always in exactly the same way (Brace, 2013). To avoid a plethora of different responses that could be saying the same thing put in hundred different ways, questionnaires were thought to be the best tool to provide standard responses that could easily be analysed. The questions dealt with the citizens’ early awareness of the project and their attitude towards the e-tolling. The Surveymonkey software was used and the analysis was done automatically depending on the results we were looking for as different types of correlations could instantaneously be created.

The approach in this study is similar to the one taken by Leromanachou et al (2006) with regards to the Norway’s urban tolling where reports, articles, grey literature and a series of semi-structured
interviews with the members of the Norwegian Public Road Administration and local authorities were used.

3. RESULTS AND DISCUSSION

Below are some of the excerpts from the interviews with the leading protagonists against e-tolling.

**Respondent One:** Before you embark on a project of this magnitude you have to ensure buy-in. The critical point for GFIP is that at the initiation stages there needed to have been a more detailed consultation with the public and all the major stakeholders. The consultation was to have been two-fold, the first stage was to have demonstrated the importance of improving Gauteng roads. The second was to take the public into confidence in terms of the finance model. So in my view there has not been a proper process to inform the public of the available alternatives. During the world cup most of the projects were done with the view of improving infrastructure for the world cup and it was not identified as a stand-alone project. So much attention was not given by the public as they are doing now.

According to the respondent the project was piggybacked on the world cup and the members of the public were not told that this is a separate project that will have to be financially supported by the public through tolling. In this regard there was no honest consultation to take the members of the public into confidence on what was happening. The available alternatives that were articulated in the previous sections were apparently not made known to the members of the public to leverage informed decision-making on the best and suitable alternative.

The issue of costing was not clear during the world cup although it might have been muted by SANRAL. The issue of costing does not develop along the way it has always been known by SANRAL and it should have been made clear to all and sundry from the get-go.

The costing models and the available alternatives were not clearly articulated early enough in the process.

*In all roads that are being tolled you will find that there is always an existing alternative route. With regards to GFIP the alternatives are already congested roads, so they are not viable alternatives. So using a tolled road should be an alternative not a must, in this case they are a must.*

According to the respondent it appears as if the public was not given viable alternative routes if they do not want to utilize the tolled roads. This creates an impression of being forced by the state to use these routes.

*In another issue of the state role in infrastructure provision: What is the role of the state in infrastructure provision. We understand there are limited funds but we are also aware that currently there is not optimal use of the available resources.*

The respondent was very knowledgeable with regards to the issue of utilization of state resources. There was an implication that there is so
much resource wastage in the system, the rectification of which will nullify tolling the public.

**Respondent Number Two:** When governments are planning massive projects such as GFIP which involve tolling which is another form of taxation, you have to ensure that you have the society's acceptance and buy-in. It is one of those taxes that is very hard to administer and when you don't have the buy-in, it's not like a normal boom gate where you can say I will not open till you pay because people will drive through even without paying. E-tolling is not an easy method to administer, so it makes life difficult when the authorities ride roughshod over the administrative processes. Laws are as good as they are administrable. So laws that cannot be administered properly become useless. So I am afraid that is what is happening with e-tolls. We are trying to put up the biggest e-tolling system in the world, in a society that has a lack of trust in the government and a society that is battling to survive. Law-abiding citizens will be frustrated because there will be a lot of people flouting the law and it will look like amenable members of the society are basically subsidizing those who are not prepared to pay.

The respondent echoes the sentiments of the previous sentiment that consultation should have been the first step in implementing this project.

Now the question to SANRAL is; is this just taxation? That is why we hope that there should be robust laws that compel the likes of SANRAL to embark on robust consultative processes. Failure to do that is tantamount to inviting a revolt against the system.

There are currently organizations and individuals who are regularly in the media vowing that they will not pay for the Johannesburg roads, and daring the authorities to arrest them. There is at least a legal firm which has vowed to defend anyone who is accused of failing to pay the e-tolling. All this posturing has not been tested in court by the time of writing this paper.

SANRAL wanted to do the same thing in the Western Cape along the wine route in the early 2000s, but there was a consultation process which was wide ranging. Farming communities, businesses and everybody was involved. People were very clear this is not what we need; this is not what we want it's not going to work. And they did not implement it for that reason.

It appears that SANRAL had adopted a proper approach elsewhere and it is not clear why this was not carried in Gauteng.

Now here they did exactly the opposite, they did as little a consultation as possible. They placed one advert in six newspapers in October 2007. One advert telling everyone that this is what they wanted to do. They didn't explain exactly how it was going to work, they never gave the rates, they never gave enough information for people to able to say I understand what is going to happen and I can now go and lodge an objection. The result was that they got 28 responses from the public among 2.5 million motorists, one of which was a petition with 34 signatures to SANRAL, and SANRAL turned around and said we have 85 responses. I
don't care if there were 185 responses... we are talking about 2.5 million motorists. They failed, and they don't see that, and this is where everything has gone wrong. Now with those few responses SANRAL is saying we are safe we did what we had to do. The box is ticked let's move on.

There appears to have been a very limited publicity in informing the public on the imminent implementation of e-tolls and it appears as if the public was not afforded adequate time to mull over this development.

The law says you have to reach out as much as you can to the public and you have to give them minimum of 30 days to respond. The law says minimum of 30, it does not say you can go to 60 or 90 days. The project of this nature the biggest e-tolling project in the world at the African economic hub, on Gauteng's freeways which were previously free, that consultation was shockingly poor. What they should have done at that stage is to say stop the bus... we have failed. I don't think we have had enough input; we have not touched base with important stakeholders here. Have we gone to Car rental companies, have we gone to the AA, Road freight society, the Paraplegic society, all these organizations. Have we sought their opinion?

The stakeholder analysis and identification might not have been carried out properly; leading to a very stern resistance from the likes of OUTA who felt aggrieved by the implementation of this project at it was going to directly affect their businesses.

Below are the responses to some of the questions pertinent to public consultations that were contained in a questionnaire distributed to Gauteng residents.

![Figure ID4.1: Public responses from the survey](image)

-Although about 13% knew about the gantries when they were pitched on the Gauteng Highways the majority of residents did not know what was happening.
About 20% of the population believe the consultation was acceptable whereas 64% believe it was actually very bad.

Figure ID4.2: Public responses from the survey

-When the research was conducted there were consultation meetings held in Johannesburg and around Johannesburg. 78% of the respondents did not know about these.

-Even among those who knew about the meetings, those who chose not to attend did not think it was worth the trouble.

4. FINDINGS

The main resistors to e-toll implementation in South Africa appear know the different alternatives available in implementing urban tolling. The lack of extensive public consultation is a major glaring deficiency with the implementation of the GFIP. The world cup euphoria and the associated legacy projects misled the majority of the people in believing that GFIP was part of the world cup. It appears that lack of an independent publicity and outreach programme about GFIP caught most people by surprise hence the general alarm about the ‘suddenness’ of the tolling requirement in the eyes of the general public. The lack of openness about the project, poor publicity about the forums that were available to engage the public has led to a total lack of ‘psychological contract’ with the people of Gauteng.

5. CONCLUSIONS

The Improvement of Gauteng freeways is a very noble endeavour and it was long overdue. It appears as if SANRAL in its implementation of GFIP
did not abide by the basic principles of soliciting a “psychological contract” with the residents of Gauteng. The following have been identified as the concerns and sentiments of the major stakeholders and residents.

1. The public consultation process was very superficial and appears to have been intended for compliance and not imbued with genuine desire to solicit public input that was going to be used to shape the final decision in this project.
2. The costing models and the approach taken by SANRAL are still not clear to the majority of stakeholders.
3. The current resistance to pay e-tolls could be regarded as tantamount to a revolt because of lack of transparency on the implementation of this project.
4. The publicity about this project was eclipsed by the world cup but even after this global event, the residents of Gauteng appear not to have been informed about its final status, especially with regards to how it would be financed.
5. The consultation meetings that were being held periodically, before the project was operationalized, were not well advertised and it appears they were inconveniently located for most people.
6. The unprecedented and protracted court battles are indicative of a lack of dialogue between SANRAL and the main stakeholders, necessitating judicial intervention.
7. The legal process has been costly to both the Stakeholders and SANRAL necessitating a relook into how projects of this nature are implemented in the future in South Africa.

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Factors that affect budgeted cost through Building Production Process in South Africa Construction Industry

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ABSTRACT

Purpose of this paper: Construction industry operational systems are confronted with cost constraint to deliver product at time specified and at quality expected. Thus, this cost restraint predicament generates the need to investigate the factors that affect budgeted cost through building production process.

Design: The study explored quantitative questionnaire survey method to collect data from stakeholders in the construction industry in South Africa. SPSS software version 22 was used for quantitative data analysis.

Findings: Findings are increase income of workers, increase in output during production, application of effective techniques during building production process are among the principal factors that have significant effect on budgeted cost. In addition, influence of workers behaviour on site during production process and management of techniques during building production process affect budgeted cost substantially.

Research limitation: Few of the respondents that accepted completing the questionnaire, later returned the uncompleted questionnaires and complained of too busy.

Original/value of paper:
Careful consideration of the identified factors proposed in this study will not only lead to effective management of construction cost and production processes, but will also enhance stakeholders’ satisfaction.

**Keywords:** Budgeted cost, Cost constraint, Production process, Stakeholders satisfaction, Delivery time.

1.0 INTRODUCTION

The daily cost increase of construction resources makes the requirement for effective techniques cost management of construction production: to enhance the delivery of the project at cost which will not exceed the budgeted cost and stakeholders’ satisfaction. This study thus evaluates and ascertains the factors that affect budgeted cost through building production process in South Africa construction industry.

Construction industry operational systems are confronted with cost constraint to deliver project at time specified and at quality expected. Thus, this cost restraint predicament generates the need to investigate the factors that affect budgeted cost through building production process. Likewise, Al-Najjar and Enshassi (2008) argued that production processes are challenged with cost constraint to deliver project at budget specified and at time expected. Likewise, Fallahnejad (2013) confirmed that time overrun caused by mismanagement led to late delivery of building product during production processes. Similarly, Ramanathan, Narayanan and Idrus (2012) argued that several buildings during production, usually experience delay and cost overrun. Thus, Roger (2012) ascertained that in every construction project, completion within timeframe and at budgeted cost are significant factors to be considered during building production process. Hence, envisaging late delivery of project causes an anxiety for the construction team.

It is noteworthy that scope, time, cost and quality are inter-related and adjustment on any of cost, time, quality and scope will affect the other. Thus stakeholders and workers involve in production process must be aware of the significant of these triple constraints and potential consequent of adjusting any one of the constraints. This relationship is affirmed many several authors including Sambasivan and Soon (2007). Thus, there is a need for proper co-ordination and co-operation amongst the construction team and site worker to boost effective productivity in construction industry. Fryer (1990) asserted that building production processes is confined within constraints such as budget, quality and time, which requires effective management. Therefore a project is successful and efficiently managed when the project meets client and stakeholders objectives, (quality, time and cost) and satisfies client interest, (Lavenger 1996).
Survey conducted by Azhar et al. (2008) affirmed that cost efficient sites are product of efficient management. Hence, if attention is focused at the right time, scope changes are avoidable and additional work which causes cost overrun can be reduced. Evidence from the literature review and exploratory study conducted signify the need for determine the factors that affect budgeted cost through building production process in South Africa construction industry.

2.0 BUILDING PRODUCTION PROCESS APPROACH

Building production process is the supervision and management of budgeted cost, plan, equipment, materials and labour involved in the production process. Also, there is a need to comply with government rules and regulation established for production. The production process in construction industry should be design to run efficiently to keep time and cost low, and to allow returns on the investment to be realized as early as possible. Hence, construction production process involves the use of technique such as planning, organising, tendering, contracting, inspecting, and controlling. Similarly, Bertelson and Koskela (2002) confirm that the activity in construction industry is the process that involves production, planning and managing the work flow within the construction process.

Lavender (1996) discovered that production process in construction industry is unease over adding value to create wealth which the society needs. The major factors in construction industry that influences production are technological and social factors. Egan in Rethinking construction report (2002) supported the argument that production processes can be referred to as production of building, structure and infrastructures upon which most economic activities of a nation depend on. The effective construction therefore has a bearing on long-term economic growth of any nation; also individual effectiveness is on economic growth of a nation. This signify the need to considered five factors during production process in construction industry for enhancement of production reduction in capital cost, moderate construction time, better expectedness, prevent defects, increase productivities, increase income and profit and proper monitoring of health and safety compliance. Lavender (1996) define production as a conversion process which received input of resources such as labour, material, machinery, and capital and transforms them into a product.

Client is often an originator of ideas and concepts; thus, technique and tools to be implemented during construction project production process significantly depend on the information supplied by the client. Nina (2003) affirmed that client requirements represent the main sources of information for construction project, and the information, hence is of essential to the
successful operation the project. Nina (2003) asserted that the process in which the client’s needs are analysed, clarified and conveyed is called the briefing process. Bertelson and Koskela (2002) emphasised that, it is quite difficult for construction firm to plan, control, develop or choose a construction technique during production processes which would suit the firm modest with an inadequate briefing from the client. Koskela (1992) described production process as transformation of activities that add value to the final building product.

A building production life cycle can be referred to, as a collection of building production phases. Building production processes phases vary by the type of building or industries that are involved, but some general accepted phases include: concept, development, implementation and close-out/completion. The first two phase’s emphasis on planning and are often referred to as building product achievable. Likewise, the last two phase’s emphasis on deliverables and are often referred to as building product achievement (Lavender 1996)

3.0 METHODOLOGY

This study evaluates the factors that affect budgeted cost through building production process in South Africa construction industry. Literatures related to this study were reviewed to generate questionnaires’ questions for exploratory study. The exploratory study was conducted within Cape Town, South Africa to know existence of the problem, using non-probability and purposive sampling techniques. The information’s were obtained from professionals: architects, clients, site engineers, project managers, contract managers, quantity surveyors and contractors. In addition, observation as participant was explored to obtain additional information and data for the study. 30 closed-ended questionnaires were administered by hand delivery to stakeholders. 12 out of the questionnaires were retrieved after many phone calls, and visitation to the construction sites and consultant offices. The finding from the exploratory study indicated that the problem exists, and the results obtained were used to design questions for the main study after taken into consideration all suggestions obtained during the exploratory study.

For the main study close-ended quantitative questionnaire were employed for the data collection. The section ‘A’ of the questionnaire requested information about respondents’ bio-data. Section ‘B’ was structured to obtained information about the project types, cost of construction and delivery time. Section ‘C’ obtained information from the stakeholders on how the administrative management of their company is
been carry out, while Section ‘D’ sampled the respondents opinion on information concerning factors that affect budgeted cost through production process. The respondents were solicited to rank the itemised factors on Likert scale ranges from: 1 = strongly disagree, 2 = disagree, 3 = agree, and 4 = strongly agree.

Table: 1 Objective and Achievement

<table>
<thead>
<tr>
<th>Objective</th>
<th>Purpose</th>
<th>Achievement</th>
</tr>
</thead>
<tbody>
<tr>
<td>To identify the factors that affect budgeted cost through production process in South Africa construction industry</td>
<td>Delivery of project within budgeted cost and time specified</td>
<td>The objective was achieved through review of related literature, Participant observation survey, qualitative interview survey (semi structure interview) and quantitative questionnaire survey methods</td>
</tr>
</tbody>
</table>

SPSS statistic software version 22 was used to analyse quantitative close ended questionnaire, and the study reliability were ascertained by using Cronbach’s co-efficient alpha ranges in value from 0 to 1: the higher the coefficient the more reliable the data. The data Cronbach’s alpha coefficient of the 12 factors considered is 0.9: this signifies that the data collected are reliable.

4.0 DATA ANALYSIS AND DISCUSSION OF FINDINGS

4.1 DATA ANALYSIS

4.2 Response rate and respondents details

Data were collected through quantitative survey method, 319 questionnaires were administered to construction stakeholders: the architects, clients, project managers, contract managers, site managers, quantity surveyors and contractors. 54 were duly completed, returned and analyzed.
Table: 4.2 shown the details of respondents that participated in the study:

- 77.8% of the respondents are in construction firm, which is the highest among the partakers of the study.
- The respondents within 1-10years of experience in construction firm have the highest number, followed by 11-20years of experience rank; third age group is within 21-30 years of experience, while the last group is within 31-35years.
- Finding obtained signify that respondents that have age ranges between 21-30years are the majority of workforce working at the project sites studied.

The bio-data of the respondents shows that the participants are knowledgeable with several years of experienced and hold reputable status within their respective organisations. Thus, based on this bio-data, it is believed that the respondent could provide reliable and valid responses.

4.4 Factor that affect budgeted cost through building production process

This section presents the rank order of 12 factors that affect budgeted cost through building production process. The analysed result, 85% of the respondents indicated that ‘increase in income of workers’ is the paramount factor that influences budgeted cost during production process, followed by ‘increase in outputs during production’ and ‘application of effective techniques on site during production processes.’

Table: 4.2 shown respondent details

<table>
<thead>
<tr>
<th>Respondents’ Description</th>
<th>Questionnaires analysed</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Professional firms</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Architectural firms</td>
<td>2</td>
<td>3.7</td>
</tr>
<tr>
<td>Construction firms</td>
<td>42</td>
<td>77.8</td>
</tr>
<tr>
<td>Quantity surveying firms</td>
<td>4</td>
<td>7.4</td>
</tr>
<tr>
<td>Project consultant firms</td>
<td>3</td>
<td>5.6</td>
</tr>
<tr>
<td>Structural design firms</td>
<td>3</td>
<td>5.6</td>
</tr>
<tr>
<td><strong>Position of the respondents</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Architects</td>
<td>2</td>
<td>3.7</td>
</tr>
<tr>
<td>Project managers</td>
<td>9</td>
<td>16.7</td>
</tr>
<tr>
<td>Quantity surveyors</td>
<td>22</td>
<td>40.7</td>
</tr>
<tr>
<td>Site engineers</td>
<td>16</td>
<td>29.6</td>
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</tbody>
</table>
Factors that affect budgeted cost through building production process

<table>
<thead>
<tr>
<th>Factors</th>
<th>Mean</th>
<th>%</th>
<th>Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>Increase in income of workers</td>
<td>3.44</td>
<td>85</td>
<td>1</td>
</tr>
<tr>
<td>Increase in outputs during production</td>
<td>3.35</td>
<td>83</td>
<td>2</td>
</tr>
<tr>
<td>Application of effective techniques on site during production process</td>
<td>3.33</td>
<td>83</td>
<td>2</td>
</tr>
<tr>
<td>Site control structure during production process</td>
<td>3.29</td>
<td>82</td>
<td>4</td>
</tr>
<tr>
<td>Reduced construction time during production</td>
<td>3.25</td>
<td>81</td>
<td>5</td>
</tr>
<tr>
<td>Site planning processes for production</td>
<td>3.25</td>
<td>81</td>
<td>5</td>
</tr>
<tr>
<td>Reduced accident rate during production process</td>
<td>3.24</td>
<td>81</td>
<td>5</td>
</tr>
<tr>
<td>Site development during production process</td>
<td>3.18</td>
<td>79</td>
<td>8</td>
</tr>
<tr>
<td>Predictability for effective production</td>
<td>3.16</td>
<td>79</td>
<td>8</td>
</tr>
<tr>
<td>Defects planning during production process</td>
<td>3.14</td>
<td>78</td>
<td>10</td>
</tr>
<tr>
<td>Influence of workers behaviour on site during production</td>
<td>3.11</td>
<td>77</td>
<td>11</td>
</tr>
<tr>
<td>Reduced capital cost during production process</td>
<td>3.11</td>
<td>77</td>
<td>11</td>
</tr>
</tbody>
</table>

4.6 Discussion of findings

All the factors considered in the study are ranked above 70%. Thus, the result indicates that, all the factors affect budgeted cost significantly, during production process. However, towards delivery of project within budgeted cost, the importance of the factors varies.

The most paramount factors that affect budgeted cost through building production processes are: increase in income of workers, increase in outputs during production and application of effective techniques on site during
production process, and subsequently, the site control structure during production process, reduced construction time during production process.

‘Increase in income of workers’ signifies that the construction industry should increase income of workers in order to achieve efficient building production processes to deliver the project within the budgeted cost specify. As indicated in ‘Rethinking construction report’ by Egan (2002), there is a need for efficient building production processes, since most economic activities of a nation depend on the building structure and infrastructures. The quality and efficient of construction output therefore has a bearing on long-term economic growth of any nation, while individual effectiveness depends on economic growth of a nation.

Another major factor that affect budgeted cost through building production process is ‘increase in output during production process’, this infer that construction industry need to efficiently manage production output which could be achieved through making efficient use of construction resources during production process: to deliver project at budgeted cost earmark for a project. Lavender (1996) asserted the need for efficient use of factors of production in the construction industry: the adequate implementation of resources (labour, material, machinery, and capital) and the integration of the resources effectively during the production processes.

Additionally, findings also indicate that ‘application of effective techniques during production process’ affect budgeted cost, this imply that methods of managing production process affect budgeted cost, and has direct effect on workforce productivities. The ineffective methods make workforce to spend more time on a particular job, and demand for more overtime payment.

The unprofitable methods affect production, delivery of project at above budgeted cost specified. The production process in construction industry should be design to run efficiently to keep time and cost low, and to allow returns on the investment to be realized as early as possible. To Bertelson (2002) to achieve the best during production processes, the activity in construction industry required efficient production planning and effective management of the work flow within the construction process.

5.0 Conclusions and Recommendations

Findings indicated that the unprofitable methods of management make workforce to spend more time on a particular job, also demand for overtime payment, this affect delivery of project at construction cost above the budgeted cost specified. Careful consideration of the identified factors proposed in this study will not only lead to effective management of construction cost and production processes, but will also enhance stakeholders’ satisfaction.
5.1 Research limitations
Few of the respondents that accepted completing the questionnaire, later returned the uncompleted questionnaires and complained of too busy. This makes the response rate to be low. Though, based on the respondents’ biodata (Table 4.2), it is believed that the respondent could provide reliable and valid responses.

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THE SECONDARY IMPACT OF VARIATION ORDERS ON CONSTRUCTION PROJECTS: A QUALITATIVE ANALYSIS

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ABSTRACT AND KEYWORDS

Purpose
The research aims to qualitatively analyse the secondary impact of variation orders (V.Os) on construction projects, with the goal to assist contractors with its management.

Design
A qualitative analysis is done whereby the findings of previous research on the effects of V.Os are analysed. These are then validated for the South African contractor through means of an electronic questionnaire survey. Based on this information regarding the secondary impact, recommendations are given that would assist contractors with the management of the secondary impact of V.Os.

Findings
Based on the literature review and information gathered from the questionnaire survey the secondary impact can be explained as follows. It is the unforeseen loss of productivity on the unchanged work due to the synergistic effect of disruption caused by a multitude of V.Os. It is an impact on human factors and the cause of difficult working conditions. Secondary impact is a disruption that prevents project activities and events from starting and ending as planned. It prevents contractors from executing activities as planned.
Value
The research assists contractors with better understanding the secondary impact that V.Os has on their projects and thereby, makes it possible for contractors to better manage it.

Research limitations
The research focuses on projects that are delivered by the design bid and build project delivery strategy with specific interest on the construction phase of the project. It does not focus on a specific type of construction works but works in general. Furthermore, it considers the contractors point of view.

Keywords: Variation orders; Delay and disruption, Productivity, Project Management

1. INTRODUCTION

Variations made to the scope of work are part of construction projects. At the time of tender, both contractor and client are aware of the fact that the works which are tendered for, may and will be varied when construction commences. However, as stated by the great Anglican theologian Richard Hooker: “change is not made without inconvenience, even from worse to better” (Quotations from Richard Hooker, 1755).

It is well known that a project’s contract value and duration would increase where variations are present, simply because most variations have a cost and time value to it. In addition, most clients honour their contractual responsibilities and compensate contractors for it. How then is it that conflict still occurs and that cost and time overruns take place?

Although there is no real empirical evidence to support the following conclusion made by previous researchers, they conclude that the conflict, cost and time overruns on construction projects are due to clients not compensating contractors for the cost associated with the secondary impact of variations (Williams, 2002). The disruption caused by a variation made to one task may impact other activities not directly changed, through the ripple effect (Hanna et al., 2004). This paper refers to it as the secondary impact of variations. If the secondary impact of V.Os are not accounted for by means of compensation or mitigated by good management, variations made to a project are being underestimated (Williams, 2002).

The principal aim of the research is to understand the secondary impact of V.Os by qualitatively analysing it. Based on this understanding, it then aims to give guidelines and recommendations to assist contractors to manage the secondary impact of V.Os.
Different terminology is used for changes made in construction. Depending on the language used by the specific contract, changes can be termed as variation orders (V.Os) (General Conditions of Contract Works, 2010), contract instructions (C.Is) (Joint Building Contracts Committee, 2007) or change orders (C.Os) (Hanna et al., 2004). This research uses the term V.Os.

2. DEFINING THE SECONDARY IMPACT OF V.Os

In the USA, the secondary impact of V.Os is referred to as the cumulative impact (Jones, 2001) of change. After a critical evaluation of what is meant by the cumulative impact of change, no fundamental differences were found other than a difference in terminology. Hence, although it appears as if the advances made by the South African construction industry is slow in defining the secondary impact of V.Os, in the USA courts and boards of contract appeals have made significant advancements in developing a workable definition for what they refer to as the cumulative impact of change.

2.1 The Definition

The cumulative impact of change (secondary impact of V.Os) is the unforeseen loss of productivity on the unchanged work due to the synergistic effect of the disruption caused by a multitude of V.Os (Hanna et al., 2004, Ibbs, 2005, Jones, 2001). The cost due to the secondary impact, also referred to as the impact cost, is a combination of the cost for loss of productivity on unchanged work and also the increased cost of completing unchanged work (Jones, 2001).

2.2 Characteristics of the Secondary Impact

There are distinct characteristics concerning the secondary impact that must be highlighted. Firstly, the V.Os do not directly cause productivity loss on the unchanged work but indirectly (Jones, 2001). It creates causes of loss of productivity also known as delay and disruption events. The delay and disruption events interact and cause disruption on the project, which results in a loss of productivity on the work not included in the V.Os (unchanged work).

Secondly, the secondary impact considers the impact of all V.Os issued on a project. The loss of productivity experienced on the unchanged work is not due to the delay and disruption events caused by an individual V.O. It is due to the synergy of delay and disruption events caused by all V.Os issued. Hence, the impact cost cannot be ascribed to one specific V.O.
Thirdly, the secondary impact is unforeseen by the contractor. More specifically, the loss of productivity on the unchanged work is not foreseeable by the contractor at the time V.Os are issued. As explained by Ibbs and McElinery (2008), “a contractor cannot reasonably be expected to foresee a synergistic effect when it cannot foresee the number or size of changes [yet] to come.” This, together with the fact that the secondary impact is the impact of all V.Os issued on a project, cause some researchers, such as Williams (2002), to conclude that the magnitude of the secondary impact can only be known for sure, once the project is completed and all the V.Os have been issued.

Lastly, the use of the word synergistic is important in the definition and it is meaningful in its own right. In basic terms, it suggests that the combined effect of things is greater than the sum of its parts, “2+2=5 effect” (Williams, 2002). Individually, the impact of individual delay and disruption events on labour productivity may appear insignificant but the combined impact of all delay and disruption events together, is detrimental to a project’s productivity.

3. UNDERSTANDING DELAYS AND DISRUPTION

Part of the implication of the secondary impact of V.Os is delays and disruptions. Hence, it is necessary to understand delays and disruption in the construction context.

When any event or activity in the project is prevented from starting or ending at the planned time, a delay has happened (Caletka, 2009). A project has experienced disruption if the contractor is prevented from performing an activity as originally planned and as a result, the activity’s productivity is impacted (Cushman et al., 2001). Hence, when a project is impacted by the secondary impact of V.Os, what one would find are activities that start later than originally planned and activities not executed as originally planned, and therefore suffer a loss of productivity.

The Society of Construction Law Delays and Disruption Protocol (2002) refers to event that cause delays as delay events. In a similar fashion events that cause disruption can be termed disruption events. However, disruptions are not necessarily delays but delays are disruptions (Eden et al., 2000 and Williams et al., 2003). Hence, when referring to disruption in construction projects, it includes delays. Therefore, disruption is not just caused by disruption events but by delay events as well. This aids to the understanding of the part of the definition of the secondary impact that says, V.Os trigger delay and disruption events which cause a bigger disruption (Williams, 2002).

4. UNDERSTANDING LOSS OF LABOUR PRODUCTIVITY
In terms of the secondary impact of V.Os the loss of productivity is not the loss in productivity experienced on a particular unchanged activity but the sum of productivity loss of all work not directly changed by V.Os.

Consider the scenario where a multitude of V.Os is issued on a project. According to the theory of the secondary impact, the V.Os will trigger delay and disruption events that interact causing a loss of productivity on unchanged activities. Additional labour hours required to execute the variations are allowed for. If one is to disregard the approved V.O hours, and then compare the actual labour hours expended to complete the project, with the original estimated hours indicated in the bid, theoretically it is expected that they should be the same (Hanna et al., 2004). However, if the secondary impact is at play, a difference will exist between the estimated hours and the actual hours, see Figure 1.1. This difference in labour hours is the hours for which labourers were inefficient, due to the delay and disruption events triggered by V.Os.

Figure 1.1: Loss labour productivity on the whole project (Hanna et al., 2004).

5. SUMMARISING THE SECONDARY IMPACT OF V.Os

A literature search was conducted to find information on secondary impacts. From careful consideration of the literature it is derived that:

The secondary impact of V.Os occurs in two phases. Phase 1 includes everything that happens before the V.Os are implemented and largely revolves around information and approval delays associated with the change...
processes. It also includes the difficulties associated with the process and administration of V.Os. Phase 2 includes everything that happens after the V.Os have been issued and implemented on a project. The delay and disruption events associated with Phase 2 can be categorised in three stages namely, control actions, portfolio effects and acceleration methods. Each stage has delay and disruption events which impact labour productivity.

Phase 1:
In short, contractors discover errors and omissions (E&O) in designs and drawings, and then contractors request the engineer for information and clarification (Jerling, 2009). This activity is time consuming, and in addition, engineers often respond late or in vague terms which create conflict between the contractor and client and affect the flow of information between the two parties (Eden et al., 2000). V.Os are then finally issued but are issued late (Ibbs, 2005). The revised drawings are issued late and may again contain E&O (Neff, 2014). The contractor again requests the engineer for information and clarification. This leads to late issuance of V.Os, dilution in supervision, poor quality and rework and demolition which directly impact labour productivity (Schwartzkopf, 2004).

Phase 2:
Due to the delay and disruption events of Phase 1, progress on unchanged work is affected and the changed work is disrupted. Management intervenes by implementing control actions which include stop-and-go operations, out-of-sequence work and do nothing (Leonard, 1988). This leads to issues such as interruptions, initiate contributory and preparation work, labourers working in a rush manner, invalid initial assumptions, change in working conditions, perform work in illogical and uneconomical manner (Leonard, 1988). This further leads to demoralising, conflict, impact learning curve, impact job rhythm (Schwartzkopf, 2004). All of the mentioned delay and disruption events interact, causing portfolio effects such as deterioration of schedule, expensive activities executed at the same time, weather sensitive work executed in bad weather, and contract work falling behind schedule (Neff, 2014). E.O.T is denied and the contractor implements constructive acceleration (Neff, 2014). Method statements are re-sequenced, additional labourers are added, and labourers are working overtime and night shift. Labourers are fatigued, absent, not motivated and the learning curve is impacted, stacking of trades and overcrowding are experienced. The end result is a loss of productivity on the unchanged work.

6. QUESTIONNAIRE
It was necessary to confirm whether the events discussed in Section 5 still hold true today and if it applies to South African (SA) contractors.
Therefore an electronic questionnaire survey was conducted. The questions were designed to obtain respondent comments on the main events identified in Section 5. These are:

- The information and approval delays concomitant to the change process
- The implication of processing and administrating V.Os
- The impact on changed work
- The control actions
- The portfolio effects
- The acceleration methods

The rationale is, if these events occur on projects due to V.Os, then the delay and disruption events discussed in Section 5 are possible risks that realise or could realise on South African projects.

6.1 Methodology

The methodology used to gather information was an electronic questionnaire survey. Since the main aim of the investigation was to test whether S.A contractors experience the same events discussed in Section 5, it was of cardinal importance to question a large number of respondents. Due to this requirement interviews were disregarded and questionnaires were considered to be the best research instrument for the purpose.

6.2 Requirements of Respondents

In order for the data collected to be of value, the respondents had to comply with the following set of requirements:

- Must be employed by a S.A construction firm that are graded 9CE or 9GB by the construction industry development board (CIDB)
- Must be or have been directly involved with the management of V.O’s on construction projects
- Must have more than 5 years of experience, the type of civil engineering projects is irrelevant

6.3 Access to Potential Respondents

Contact details of potential respondents were gathered by use of three strategies. Firstly, the contact details were obtained of the individuals who attended the construction engineering management programme (CMP) held at the University of Stellenbosch in years 2008, 2009 and 2011, since all comply with the above requirements.
Secondly, different S.A construction firms were randomly selected and contacted via email to inform them about the survey. They were requested to make available the contact details of employees who complied with the above set requirements.

Lastly, some of the respondents provided contact details of their colleagues whom they thought would want to participate in the survey and who has knowledge concerning the topic of enquiry.

6.4 Questionnaire Distribution

After the contract details were obtained of the potential respondents, an email was send to the potential respondents informing them about the survey and inviting them to participate. The link to the survey was attached to the email allowing potential respondents easy access to the questionnaire.

6.5 Questionnaire Design

The questionnaire was designed to consist largely out of close ended questions and a minimum of two open-ended questions. Examples of the type of questions asked are:

- Do contractors experience difficulties regarding delay events accompany V.Os?
- Do contractors find the processing and administration of V.Os difficult?
- Do contractors apply control actions and are there other control actions?
- Do contractors experience portfolio effects as identified in literature?
- Do contractors apply acceleration methods instead of E.O.T when V.Os cause a critical delay?
- Do contractors acknowledge the learning curve when preparing a bid?
- Do contractors consider human factors when managing a project?

6.6 Data Analysis

Descriptive statistics were used to analyse data. This involved the use of frequencies, percentages and graphs such as pie charts, bar charts and tables. Microsoft Excel was the main software used to analyse data.
6.7 Results and Discussions

6.7.1 Survey Response

Out of 116 questionnaires that had been distributed via email, 44 were returned. This represents a response rate of 38%. The results of this survey may not be a representation of the entire South African construction industry, but it at least represents the views of the 44 experienced South African employees, thereby giving good insight into the customs experienced in the industry.

The respondents held senior management positions at their companies. Site agents and contracts managers/directors constituted respectively 27% and 24% of the respondent population. The years of experience of respondents in the industry range from 5 years to more than 31 years. Overall, 86% of respondents have experience of 11 years and more.

6.7.2 Delay events associated with V.Os

Respondents were asked whether they encountered information and approval delays accompanied by V.Os on past projects. They were also asked to indicate how problematic the approval and information delays had been for the respondent. All respondents (100%) indicated that delays such as approval delays and information delays accompany V.Os more frequently than seldom. 98% of respondents indicated that the impact of the delays on projects is more severe than minimal. Hence, on the projects of the respondents, approval and information delays do accompany V.Os and are problematic for respondents.

6.7.3 Processing and administration of V.Os

Respondents were asked whether processing and administration of V.Os require considerable effort on the part of site managers. 98% of respondents either agreed or strongly agreed. Furthermore, respondents were asked whether the processing and administration of V.Os interfere with the planning and coordination responsibilities of contractors’ site management. 95% of respondents either strongly agreed or agreed that the processing and administration of V.Os do interfere with planning and coordination responsibilities of site management. Hence, the processing and administration of V.Os are a cause for concern in terms of the effort it demands and its interference with other important tasks of site management.
6.7.4 Impact on changed activities

Respondents were asked whether delays accompanied with V.Os interrupt affected activities on their projects. 89% of respondents indicated that delays accompanied with V.Os do interrupt changed activities more frequently than seldom. Hence, there is a high likelihood for respondents responding to the impact on changed work by applying control actions.

6.7.5 Control actions

The delays accompanied with V.Os normally disrupt changed activities causing labourers assigned to the changed activity to idle. Respondents were asked whether they apply "stop-and-go operations" and "out-of-sequence work" to avoid losses due to idle time. 96% of respondents indicated that they do, more frequently than seldom. Hence, "stop-and-go operations" and "out-of-sequence work" are commonly applied as control actions by most respondents to limit or avoid losses.

Respondents were asked to comment on the following statement: "Although both "stop-and-go operations" and "out-of-sequence work" can be disruptive, "out-of-sequence work" tends to be the more disruptive as it often results in sequence changes from logical and economical to illogical and non-economical. Therefore, it is believed that out-of-sequence work is often a forced decision." The purpose of this question was to test whether working in an illogical and non-economical way is as disruptive to projects as it sounds to be. Also, if it is the case then certainly one would expect the control action "out-of-sequence work" to be a forced decision. 98% of the respondents either agreed or strongly agreed that even though "out-of-sequence work" is the most commonly applied of the three methods. When contractors apply it, it is often a forced decision. In other words, they often have no choice but to work "out-of-sequence" due to disruption in circumstances. It was concluded that the respondents apply the same control actions as noted in Section 5.

6.7.6 Portfolio effects

Four portfolio effects were presented to respondents asking them to indicate whether they have encountered any of it on past projects. The first portfolio effect (Portfolio Effect 1) is where numerous delays and disruptions gradually shifted weather sensitive work to be executed in bad weather. 59% of respondents indicated that this has occurred on past projects and 50% of
respondents indicated that it occurs more frequently than seldom. Hence, this portfolio effect does happen and it happens more frequently than seldom.

The second portfolio effect (Portfolio Effect 2) is where numerous delays and disruptions gradually shifted expensive activities to be executed at the same time. 83% of respondents indicated that this has happened on past projects and 28% indicated that it occurs more frequently than seldom. Hence, this portfolio effect does happen but not frequently. The third portfolio effect (Portfolio Effect 3) is where numerous delays and disruptions gradually deteriorate original programs, causing the scheduling to become a function of drawing release instead of normal construction logic. 80% of respondents indicated that this has happened on past projects and 55% of respondents indicated that it occurs more frequently than seldom. Hence, for a large number of respondents, delays and disruptions have deteriorate original programs and more than 50% of respondents indicated that it happens more frequently than seldom.

The last portfolio effect (Portfolio Effect 4) is where numerous delays and disruptions cause the original contract work to fall behind schedule. 77% of respondents indicated that this has happened on past projects and 68% indicated that it happens more frequently than seldom. Hence, for a large number of respondents numerous delays and disruptions cause original contract work to fall behind schedule and more than 60% of respondents indicated that it happens more frequently than seldom.

It can be concluded that for each of the portfolio effects, at least 50% of respondents indicated that they have encountered them on past projects. This indicates that the four portfolio effects occur on the projects of respondents. Furthermore, from all four portfolio effects, Portfolio Effect 4 is the one indicated to have happened more frequently on respondents’ projects.

6.7.8 Acceleration methods

When a project experiences a critical delay, contractors normally result to acceleration methods. Portfolio Effect 4 explains that delay and disruption events triggered by V.Os may cause the original contract work to fall behind schedule in which case an E.O.T is required. Instead of granting the E.O.T a client might instruct the contractor to accelerate. Respondents were asked to indicate whether this has happened on past projects. 98% of respondents indicated that this does happen and 87% of respondents indicated that it happens more frequently than seldom. It can be concluded that the majority of respondents have more frequently than seldom experienced this to be the case on projects.

6.7.9 Questionnaire conclusions
As evident from the high percentage rates it can be concluded that the main delay and disruption events contaminant to V.Os do occur on the projects of the respondents. Hence, the comprehensive and systematic overview summarised in Section 5 is valid and more importantly it is valid for the projects of South African contractors today.

7. CONCLUSIONS AND RECOMMENDATIONS

The study concludes that the secondary impacts of V.Os are:

- unforeseen at the start of the construction project and also during the construction project
- a synergistic effect
- the effect of all V.Os
- a loss of productivity on the work that is not included in the V.O (unchanged work)
- a trigger of multiple delay and disruption events on construction projects
- the impact on human factors such as morale, self-esteem, motivation and the cause of difficult working conditions
- disruption that prevent project activities and events from starting and ending at the planned time
- disruption that prevent contractors from executing activities as planned

The cost due to the secondary impact is a combination of increased labour cost and also the increased cost of completing the unchanged work. The secondary impact of V.Os does play a role in construction projects and needs to be pro-actively managed. It is therefore recommended that contractors:

1) Understand what the secondary impact of V.Os is;
2) Be aware of the different delay and disruption events V.Os trigger;
3) Understand how the delay and disruption events impact productivity;
4) Prepare for the secondary impact of V.Os by having mitigation strategies and plan of actions in place and by monitoring and controlling labour productivity;
5) Keep record of all of the above by documenting it religiously. Use it to learn from;

8. REFERENCES
General Conditions of Contract for Construction Works, 2nd edition (2010), SAICE.

Implications of irregular tender evaluation practices in public procurement on construction quality

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ABSTRACT AND KEYWORDS

Purpose of this paper
The aim is to enhance public procurement processes by investigating whether quality or functionality is evaluated adequately by tender evaluation committees and determine whether there are irregular or corrupt practices that create barriers in the objective awarding of tenders and achieving of construction quality.

Design/methodology/approach
A survey was conducted among quantity surveyors, construction project managers and architects in KwaZulu Natal, utilising questionnaires.

Findings
The key findings suggest that; the awarding of contracts does not always follow the procurement policy of the client departments; financial offer and preference is the most commonly used method of evaluating tenders; corruption is a common occurrence in construction procurement and corruption negatively impacts on quality of construction.

Research limitations/implications (if applicable)
The empirical study was limited to a single province and therefore further research is recommended to include other geographical areas and a larger sample.

Practical implications (if applicable)
Quality is not always adequately evaluated and the irregularities in tender procedures compromise the attainment of quality and value for money.

What is original/value of paper. The paper contributes to the conference theme of construction malpractices. Tender procedures need to ensure that contracts are awarded to appropriate contractors who will be able to deliver the required quality and value for money.

Keywords: Construction quality, tender evaluation, procurement practices, public sector

1. INTRODUCTION

Since 1994, there have been many changes in government legislation governing the public procurement processes and procedure in South Africa. Various pieces of legislation set out a number of criteria to be used by Bid Evaluation Committees to score firms tendering for public sector contracts and it is on the basis of this scoring that recommendations are made for the selection of a particular service provider [Construction Industry Development Board (CIDB), 2006]. Section 217 of the Constitution provides that procurement should be based on the following five pillars; value for money, open and effective competition, ethics and fair dealing, accountability and reporting and equity (South Africa, 1996).

Unfortunately, value for money is not always achieved and dissatisfaction with the quality of construction projects is quite common (CIDB, 2010). There are many factors which affect quality, related to the design, procurement or actual construction. Procurement related factors emphasise time and budget, shortened project periods, lack of prequalification, competitive tendering and awarding of contracts primarily on price, political interference, cronyism, fraud and more corruption (CIDB, 2011). Ambe & Badenhorst-Weiss, (2012) also indicate the main challenges in public procurement in South Africa to include lack of proper knowledge, skills and capacity, non-compliance with Supply Chain Management (SCM) policy and regulation, unethical behaviour, fraud and corruption. The Commission for Africa (CFA, 2005) report singles out public procurement in general as one area which suffers particularly severely from corruption. The report states that corruption adds at least 25% to the costs of government
procurement, frequently resulting in inferior construction and unnecessary purchases.

The key questions addressed in the present study are: how adequately is quality evaluated by the tender evaluation committees and does corruption contribute to the irregularities in the tender evaluation processes and to what extent are the recommendations of the evaluation committees followed by the client departments? The paper takes the view that the criteria and procedures used in evaluating bids and making final awards are inconsistent and affect the awarding of contracts negatively. Secondly, that the recommendations of evaluation committees are sometimes overruled when making the final decisions to award a contract which undermines quality.

2. LITERATURE REVIEW

2.1 SA Guidelines for Procurement

CIDB guidelines for procurement provide three criteria for evaluation of tenders namely; price, preference and functionality/quality (CIDB, 2006). Different public sector clients place different priority on these criteria. It was found that financial offer and preference were the only criteria considered for a large percentage of tenders of the national departments (45%), metropolitan councils (54%) and regional / district councils (56%) (Marx, 2012). These findings suggest that quality, defined as capability, training, performance and track record of the contractors is often not viewed to be as important when selecting a contractor (Marx, 2012). Meland, Robertson and Hannas (2011) propose that the selection criteria and the importance of incorporating qualitative factors in tender evaluation are central to the success and failure of projects. The CIDB notes that key factors in the procurement process that have an impact on construction quality are the ability to match a contractor’s capabilities to the project requirements and political interference, cronyism and fraud and corruption (CIDB, 2011).

Consultants are often appointed to assist the Bid Evaluation Committees (BEC) to evaluate tenders for large infrastructure projects of high financial value. This is because they can provide the technical expertise required to assess functionality and thus improve the chances of attaining a good match between contractor and project requirements. After the BEC has evaluated the tenders, they produce a tender evaluation report which contains their recommendations. The decision makers are then supposed to review the evaluation and ratify the recommendation for the award of the contract (CIDB, 2006). However, this is not always the case. The Provincial Departments of KwaZulu Natal (KZN), Gauteng and Limpopo were found to have overruled tender recommendations in 68%, 33% and 31% of their tenders respectively (CIDB, 2011). Similarly, Metropolitan Councils in...
Limpopo overruled tender recommendations for 44% of all their awarded tenders (CIDB, 2011).

The CIDB Standard for Uniformity in Procurement (2010) prescribes four methods for evaluation of tenders namely, financial offer, financial offer and preferences, financial offer and quality and financial offer, quality and preferences (CIDB, 2010). In a survey done in South Africa in 2009, it was found that clients are either neutral or dissatisfied with the quality of construction on approximately 20% of all their projects. Approximately 12% of the projects that were included in the survey had defects that were unacceptable (CIDB, 2011). Contractors have a great influence on the success of a project so it is critical to select a qualified contractor to do the project (Huang, 2011). Current legislation provides little guidance on the different factors that the bid evaluation committees should consider in order to determine whether contractors qualify to participate in a tender. The National Treasury guidelines instruct bid evaluation committees to, among other things verify the capability or ability of bidders to execute the contract, but there is little guidance in legislation on what is meant by capability or ability of a contractor (Bolton, 2008). In many instances the procuring agencies prioritise price over quality, even though the lowest price is not always an advantage as the quality and duration of the project may be compromised (Huang, 2011).

Bolton (2008) identifies a number of factors that have a role in determining qualification yet are not provided for adequately in legislation. These include the nature, quality and reliability of the product, the experience or track record of a contractor, the ability of the contractor to comply with the delivery schedule, the contractor’s record of business ethics and integrity, the technical knowledge and capacity of the contractor, the availability of tools and equipment in the contractor’s organisation, and the financial and economic standing of a contractor. The South African National Standard (SANS) 294 and the CIDB Standard for Uniformity attempt to give a guideline on how to ensure that quality is assessed during the procurement process. In addition to these measures, SANS 294 (2004) and the CIDB Standard for Uniformity (2010) specify that quality criteria shall not include inter alia matters relating to basic capability or capacity to execute the contract (CIDB, 2010; CIDB 2004). These two documents also state that where quality is going to be evaluated, there must be at least three people who are fully conversant with the technical aspects of the project. These are usually consultants who are requested by government client departments to assist with the evaluation.

2.2 Corrupt and irregular practices in Construction

Corruption in the South African construction industry is ranked as one of the most significant barriers to quality (CIDB, 2011). Corruption does not only involve financial bribes but also takes the form of political interference during the tender process, cronyism and nepotism among other forms. These
interferences with the tender process often leads to the appointment of contractors that do not have the necessary capabilities to deliver the quality that is required (CIDB, 2011). Corruption is a hidden activity and as such it is difficult to measure and define due to its complexity. Basically, corruption is the abuse of public office for private gain. Public office can be abused for private gain when officials accept, solicit or extort bribes or when private agents actively offer bribes (World Bank, 2007). The issue that compounds it is not its secrecy or hidden nature, but the fact that stakeholders know that it is rampant but choose to say nothing (Shakantu, 2006).

Public works contracts and construction ranked number one worldwide on the Transparency International 2008 Bribe Payers Index (BPI) for bribery of public officials (COST & CIDB, 2011). Corrupt practices are found at every stage of construction. In a study on corruption in South African construction, 71% of the respondents indicated that they thought corruption was widespread in the construction industry (Bowen, Edwards & Cattell, 2012). There is corruption during the procurement in the awarding of contracts, as well as during the actual construction process (Ameh & Odusami, 2010). Even as early as inception and feasibility phase, corruption occurs in the form of falsification of cost, time and return on investment estimates (Shakantu, 2006). The planning and organisation stage can be plagued by bid rigging, bribery, false declaration of capability, while the construction phase can experience use of substandard materials, and compromising of health and safety. The closing phase can sometimes see covering up of project failure (Shakantu, 2006). Tender rigging and collusion were found to be the most prevalent, followed by fronting, kickbacks and conflicts of interests (Bowen et al, 2012).

Practices such as collusion lead to an uncompetitive market and tender prices can be highly inflated. The government then has to spend more money than necessary for a project thereby diverting money from other much needed development projects and adversely affects their quality (South Africa, 1997). Corruption has a devastating effect on the poorest people in society because the development projects that it diverts money from are usually service delivery projects that the poor need the most. It also means that the emerging businesses, instead of being supported and empowered, will spend higher percentages of their income on bribes (CFA, 2005). Government officials in projects where the government is the client, were found to be the stakeholders most frequently involved in corruption, followed by contractors and sub-contractors (Bowen et al, 2012) and the stages found to be most post prone to corrupt activities were the tendering stage and bid evaluation stage.

In addition to the public officials, consultants who evaluate tenders also solicit bribes for recommending award of contracts to specific contractors (COST & CIDB, 2011). Bribery can also occur during the construction phase in the form of bribes for overvaluing work performed (Shakantu, 2006). The CIDB has acknowledged the occurrence of corruption in construction procurement. In a media statement released in July 2012, the CIDB was investigating contractors that were suspected of bribing a former employee of

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the CIDB to fraudulently give companies higher grades on the Register of Contractors (CIDB, 2012). The falsified grades were used to obtain tenders from government departments and this kind of corruption would result in the government departments being misled concerning the capabilities of the contractors, and potentially poor quality work could result in loss of money for the government.

There have been disturbing reports of collusion and construction cartels with reports of decades of formal kickbacks and price fixing among leading construction companies (Pauw, 2013). This alleged fixing of state construction contracts was alleged to have amounted to fraud worth R30 billion. This presents a challenge to the promotion of a fair, transparent and competitive environment for tendering. The four types of collusive bidding practices are predatory, identical, territorial and rotational bidding (Shakantu, 2006).

The impact of corruption is difficult to quantify as it is more than just a financial impact. It comprises of other factors which are not as tangible and due to its secretive nature, it is not possible to know exactly when and where it happens. When corruption leads to poor quality construction or if corruption supports an environment where economic return of investment can be reduced by poor project selection, it can carry high human costs in terms of injury and even death (World Bank, 2007). It has been observed that different forms of corruption have different impacts. For example, the impact of stealing one dollar’s worth of supplies from a road construction project could be as much as four times the impact of a dollar increase in contract costs due to collusion. If corruption diverts expenditure towards low-return projects or it reduces expenditure on maintenance, the multiplier effect in this case is even higher (World Bank, 2007). Weak institutional processes have allowed corruption to thrive.

3. RESEARCH METHODOLOGY

The empirical study used a survey whose study population consisted of quantity surveyors, architects and project managers in KwaZulu Natal. The respondents were identified through professional registration bodies namely; the Association of South African Quantity Surveyors, South African Council for Project and Construction Management Professions and the South African Institute of Architects and through word of mouth referrals using the snowballing technique. The margin of error for this study was set at 10% (0.1) and the desired confidence level was 90%. The population size was estimated at 683 and therefore the required sample size was 62. The sample of respondents is shown in Table 3.1.
Table 3.1: Sample size according to professional category

<table>
<thead>
<tr>
<th>Profession</th>
<th>Number</th>
<th>Total Population</th>
<th>Percentage of population</th>
<th>Total required in sample</th>
</tr>
</thead>
<tbody>
<tr>
<td>Architects</td>
<td>132</td>
<td>683</td>
<td>19.33%</td>
<td>12</td>
</tr>
<tr>
<td>Quantity Surveyors</td>
<td>208</td>
<td>683</td>
<td>30.45%</td>
<td>19</td>
</tr>
<tr>
<td>Project Managers</td>
<td>343</td>
<td>683</td>
<td>50.22%</td>
<td>31</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>62</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Quota sampling was used first whereby the proportion of each group of professionals in the population was determined. Each professional group was then assigned quotas of the sample which corresponded with their distribution in the study population. Simple random sampling was used for the Quantity Surveyors and purposive / snow balling was used for Architects and Project Managers as their location was not easily identifiable from their professional bodies’ data bases. A questionnaire was designed and sent to the 62 the sampled subjects via email. A response rate of 56.45% was achieved as 35 questionnaires were returned. All the participates had more than 5 years industry experience and almost 69% had more than 16 years’ experience. Only 5 respondents (14.2%) had never sat on a tender evaluation committee.

4. RESULTS PRESENTATION AND DISCUSSION

4.1 Tender evaluation, corruption and quality

In response to the question whether all contracts are awarded in accordance with departmental procurement policy, 8 respondents (22.86%) answered “no”. Not all the respondents went further to state what the deviations were. One respondent reported the deviation as single sourcing. Another said that sometimes people were awarded contracts because of who they know. One respondent answered “yes” to this question but went on to say that sometimes projects are awarded under an “urgent” delegation of authority due to risk of damage to property or life. Respondents were asked to what extent the recommendations of the bid evaluation committee are adhered to. The results are shown in Table 4.1. The 3 respondents who answered that they did not know, were he ones who also indicated that they have never sat on a bid evaluation committee. So this is consistent.
Table 4.1: Adherence to recommendations of bid evaluation committees

<table>
<thead>
<tr>
<th>Response</th>
<th>Number</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Never</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Sometimes</td>
<td>19</td>
<td>54.29%</td>
</tr>
<tr>
<td>Always</td>
<td>13</td>
<td>37.14%</td>
</tr>
<tr>
<td>Do not know</td>
<td>3</td>
<td>8.57%</td>
</tr>
<tr>
<td>Total</td>
<td>35</td>
<td>100</td>
</tr>
</tbody>
</table>

More than half (54.29%) indicated sometimes meaning that recommendations are not always adhered to. This study was not able to determine the percentage of recommendations that are overruled, as this would be a question better answered by the client or the client’s agent. The respondents could only answer based on their experience from the tender evaluations that they have sat in on as they were not privy to the reasons of the awarding committees. While overruling the recommendations may not be always a negative thing, it does raise concerns, as the evaluation committees include technical experts who are qualified to assess the needs of the project. However, in view of concerns raised earlier in the literature, of consultants who are involved in corrupt practices of accepting bribes from tenderers in return for recommending the tenderers for the award of the contract, it makes it difficult to trust that the recommendations of the evaluation committees are always made in good faith. At the same time, overruling of a tender recommendation may be as a result of political interference (CIDB, 2011).

The next question asked what methods are most commonly used for evaluating tenders. The responses were in rank order, from 1 to 4, where 1 was most commonly used and 4 was least commonly used as shown in Table 4.2. Results indicate that 34.43% of the respondents thought that Financial offer and preference was the method most commonly used, financial offer the least used. As literature shows, that the lowest price method is not really the best method of selecting the most competent contractor for a project.

Table 4.2 Commonly used methods for evaluating tenders

<table>
<thead>
<tr>
<th>Method</th>
<th>Rank</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Financial offer and preference</td>
<td>1</td>
<td>34.34</td>
</tr>
<tr>
<td>Financial offer, quality and preference</td>
<td>2</td>
<td>27.89</td>
</tr>
<tr>
<td>Financial offer and quality</td>
<td>3</td>
<td>19.67</td>
</tr>
<tr>
<td>Financial offer</td>
<td>4</td>
<td>18.08</td>
</tr>
</tbody>
</table>

The next open ended question asked which criteria were used to measure quality. Five themes emerged namely; experience with previous work of a similar nature (40%); references (31%); no criteria for quality (5.7%); experience of key personnel (14%) and project completion record (9%). 40% of the participants reported that the most commonly used criteria for evaluating quality in tenders is previous work experience and 31% reported that references from previous clients was the most commonly used criteria.
Previous work experience and references from clients are very closely related. It is not clear how the previous work experience is assessed – whether it is solely the report of the contractor or whether this report is then corroborated by speaking to the contact persons on those projects, in which case these would now be references.

When asked if the CIDB grading was an adequate indicator of a contractor’s ability to deliver the required quality, only one respondent answered yes. Majority of respondents (94%) answered “no” and 2 (6%) did not answer but gave explanations. One explained that projects differ in nature and complex projects need to be evaluated differently. The other said that it is only an adequate indicator for for grades 1 to 6 contractors. The next question asked to what extent there were construction errors, cost overruns and delays caused by poor choice of contractor. Responses were plotted on a scale of 1 to 5, where 1 was no link and 5 was a very strong link. The results are shown in Table 4.3.

<table>
<thead>
<tr>
<th>Response</th>
<th>Number</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>3</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>4</td>
<td>11</td>
<td>31.43%</td>
</tr>
<tr>
<td>5</td>
<td>24</td>
<td>68.57%</td>
</tr>
<tr>
<td>Total</td>
<td>35</td>
<td>100</td>
</tr>
</tbody>
</table>

All the 35 responses were between 4 and 5, with 5 scoring 68.57%. A very strong link was perceived between construction errors, cost overruns and delays, and poor choice of contractor. This is also supported by literature where for example, Duncan, as cited in Okumbe, Marx and Verster (2012) stated that delays caused by contractors are partly due to construction errors caused by a lack of expertise such as labour and management skills. Barriers to quality will prevent the attainment of value for money. Value for money is a sensitive point, when it comes to accountability for spending of public funds. Therefore it is critical that issues of quality or lack of it in construction are interrogated thoroughly.

Another question listed possible indicators that could be used to evaluate quality and requested the respondents to rank them from 1 to 10, with 1 being the most important and 10 being the least important. The responses are shown in Table 4.4. The respondents rated the record of business ethics and integrity as least important (10). Availability of skills to manage and execute the contract ranked the most important (1) followed by experience (2).
Table 4.4: Indicators of quality in rank order

<table>
<thead>
<tr>
<th>Indicator</th>
<th>Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>Availability of skills to manage &amp; execute the contract</td>
<td>1</td>
</tr>
<tr>
<td>Experience &amp; track record on projects of a similar nature</td>
<td>2</td>
</tr>
<tr>
<td>Experience &amp; track record of a contractor in general</td>
<td>3</td>
</tr>
<tr>
<td>Financial &amp; economic standing of a contractor</td>
<td>4</td>
</tr>
<tr>
<td>Technical knowledge of a contractor</td>
<td>5</td>
</tr>
<tr>
<td>Contractors quality assurance systems ation</td>
<td>6</td>
</tr>
<tr>
<td>Size of contractors organization</td>
<td>7</td>
</tr>
<tr>
<td>Availability of tools &amp; equipment in contractor’s organis</td>
<td>8</td>
</tr>
<tr>
<td>Current workload</td>
<td>9</td>
</tr>
<tr>
<td>Record of business ethics and integrity</td>
<td>10</td>
</tr>
</tbody>
</table>

Respondents’ opinion on whether corruption is common in construction procurement was also sought as shown in Table 4.5. The majority (34/35) respondents answered ‘yes’ and only 1 answered ‘no’. This echoes concerns worldwide about corruption in this sector. The negative impact of corruption on quality was felt to be very strong.

Table 4.5: Opinion on commonality of corruption in construction procurement

<table>
<thead>
<tr>
<th>Profession</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>Architects</td>
<td>5</td>
<td>1</td>
</tr>
<tr>
<td>Project Managers</td>
<td>14</td>
<td>0</td>
</tr>
<tr>
<td>Quantity Surveyors</td>
<td>15</td>
<td>0</td>
</tr>
<tr>
<td>Total</td>
<td>34</td>
<td>1</td>
</tr>
</tbody>
</table>

When asked about their view of the extent to which corruption impacts negatively on quality of construction on a likert scale from 1 to 5, with 1 being no impact and 5 being very strong impact, the majority (22/35) rated it as a 5. The respondents were given a list of 5 practices and asked to rank them in order of frequency of occurrence, where 1 = least common and 5 = most common:

1. Withdrawal of bid submission
2. Bid cutting
3. Cover pricing
4. Compensation of tendering costs
5. Collusion.

The rankings in Table 4.6 show that withdrawal of bid submission was viewed as being least common while cover pricing is viewed as being most common. Cover pricing appears to be a widespread practice both locally and abroad.

Table 4.6: Corrupt practices ranked in order of frequency
The respondents were asked at which stage they thought most corrupt practices were likely to occur. Table 4.7 shows that most respondents (54%) indicated that corruption occurs most during tendering followed corruption occurring both at tendering stage and during construction (46%). This finding corroborates the opinions of most researchers that corruption takes place throughout the construction process, from planning right through the actual construction.

Table 4.7: Stage at which most corrupt practices occur

<table>
<thead>
<tr>
<th>Stage</th>
<th>Response</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tendering</td>
<td>19</td>
<td>54%</td>
</tr>
<tr>
<td>Construction</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Both equally</td>
<td>16</td>
<td>46%</td>
</tr>
<tr>
<td>Neither</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Total</td>
<td>35</td>
<td>100%</td>
</tr>
</tbody>
</table>

The last question posed an incomplete statement with a number of possible endings and asked respondents to indicate their level of agreement on a scale of 1 to 4, 1 being strongly disagree and 4 being strongly agree. Table 4.8 shows the results.

Table 4.8: Fairness of current bid evaluation practices –

<table>
<thead>
<tr>
<th>Statement</th>
<th>Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>The current procurement or bid evaluation processes are fair since...</td>
<td></td>
</tr>
<tr>
<td>All parties involved comply with applicable legislation and regulations</td>
<td>3</td>
</tr>
<tr>
<td>All parties involved follow standard procedures</td>
<td>3</td>
</tr>
<tr>
<td>All parties involved have anti-corruption measures in place to ensure transparency and minimise corruption</td>
<td>2</td>
</tr>
<tr>
<td>Unethical behaviour and tender process manipulation are recognised and exposed</td>
<td>2</td>
</tr>
<tr>
<td>Functionality/quality outweighs all other factors</td>
<td>2</td>
</tr>
</tbody>
</table>
when scoring tenders

The results range between 2 and 3 suggesting that most respondents do not have faith in the fairness of current bid evaluation practices. They could not answer any of the statements that supported the fairness of bid evaluation practices with any strong conviction.

5. CONCLUSION AND RECOMMENDATIONS

The study set to investigate tender evaluation practices and how they affect quality of construction. The main findings included that the awarding of contracts do not always seem to follow the procurement policy of the client departments and the recommendations of the bid evaluation committee are not always adhered to. The study concludes that the criteria and procedures used in evaluating bids and making final awards are inconsistent. Further, the recommendations of the evaluation committees are sometimes overruled when making the final decisions to award a contract. The study also highlights that quality is not being adequately evaluated and corruption contributes to the irregularities in the tender evaluation process. These irregularities lead to poor choice of contractor and impacts negatively on quality.

The following recommendations are made:

1. While recognizing the importance of preference when evaluating tenders, the CIDB needs to strengthen the requirements for the award of contracts based on quality requirements.
2. The CIDB needs to look into introducing a requirement for integrity in construction procurement which involves a more rigorous investigation into past practices.
3. The CIDB should have separate grading or sub-grades under the general building (GB) grade. Currently GB covers too many trades or speciality areas.
4. Corruption must be investigated more thoroughly, with prosecution of offenders and better protection of whistle blowers.

This study was limited to one province of South Africa, that being KwaZulu Natal. The study population was also limited to a small number of quantity surveyors, project managers and architects. Therefore, a larger sample with inputs of the clients and other stakeholders in the procurements process, such as supply chain management might have added greater value to the study. This would have enabled the question such as the extent to which bid evaluation committees’ recommendations are followed by the client departments to be answered better. Further research is recommended to
investigate reasons why bid award committees overrule the recommendations of the bid evaluation committees.

8. REFERENCES


Commission For Africa (CFA). 2005. Our Common Interest. [s.l.]: CFA.


Construction Malpractices: A Case of adherence to the testing mechanisms in the Zambian Construction Industry

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ABSTRACT
Purpose of this paper
Adherence to testing mechanisms is important to ensure quality and that set standards of work are met. The study therefore is aimed at assessing the adherence to testing mechanisms in the Zambian Construction Industry.

Design/methodology/approach
The adherence to standards and testing mechanisms was assessed through the use of a questionnaire survey to construction professionals and manufactures of construction materials to find out the testing mechanisms employed. In addition tests on selected materials were done to assess conformity to set standards.

Findings
The results indicated that the highly tested materials are concrete and its products and least tested is glass. Further, it was found that testing mechanisms are not effectively employed hence substandard materials are used.

Research limitations/implications (if applicable)
Only a few selected materials could be tested.

Practical implications (if applicable)
Effective testing mechanisms and holist material testing should be employed by consultants and contractors on projects.
KEY WORDS: Testing mechanisms, quality, consultants, and compliance.

1. INTRODUCTION

The construction industry plays an imperative role in supporting the social and national economic welfare as it contributes to the development of housing, institutions and other infrastructure. It is therefore saddening that, the performance of the construction industry has been a concern in many commissioned reports and academic research publications (Warsame, 2006; Ashworth, 2010). This is due to the fact that buildings of poor quality have been constructed (Mitia, 2013; Ashworth, 2010). The prevalence of defective constructed works have often been an economic setback as they result in cost overruns, delays, collapsing of buildings not to mention the negative psychological and social aspects. The importance of the industry lies in the desired function of its products to meet the clients' requirements. Based on these concerns it was inevitable that an investigation is made to ensure that buildings are soundly constructed by exploring utilising testing mechanisms as a means to ensure quality.

1.1 Background

Defects in construction projects are a persistently worrying problem despite continually improving technology and education (Ashworth, 2010). The Zambian Construction Industry is not an exception. Zanis, (2010) as cited in Ali et al., (2012) reported that the schools constructed in Zambia are of poor quality due to poor workmanship by the contractors. Quality of construction is determined by the management and operative capabilities of the contractor, and by the supervisory capabilities provided by the designer with regard to the standards required. This is implied in contractual documents such as the Joint Liaison Committee (JLC, 1972), FIDIC red book (1999) and General conditions of Contract (GCC, 2013). The required standard can be assessed by effective testing mechanisms. Testing by definition (Oxford, 2010) is taking a measure to check the quality, performance and reliability of something before putting it into widespread use or practice, while a mechanism is a natural or established process by which something takes place or is brought about. Therefore in the context of this research testing mechanisms refer to established processes used to check the quality, performance and reliability of building materials before putting them into use.

Buildings are designed to support and withstand loads and environmental conditions without deformity. Building experts have attributed failure of the aforementioned on poor quality materials, ineffective supervision and poor workmanship. Other causes of building defects are man's negligence such as inadequate tests, defective designs, contractors' failure to build in accordance with specifications and corruption (Oloyede et al., 2010). The skill, experience and personal ability of workmen is
therefore of utmost importance (Suvo, 2009). Poor quality materials if not detected can undermine the structural integrity of buildings (ICAC, 1999). As much as various causes of defects have been pointed out the importance of effective testing of building materials cannot be over emphasised for the very simple reason that incorrect assessment of material would harm the users and the environment. Hence the quality of materials should be assessed by using standard methods of testing.

Malpractices refer to negligence or misconduct by a professional person (Oxford, 2010). The failure to meet a standard of care or standard of conduct that is recognised by a professional is malpractice. Overlooking the importance of standard of care or to failure to devote the attention and care necessary to ensure that it is executed properly, exposes the project to a risk of significant disruptions, delays, losses and damage to its users both during and after construction is completed (Larson, 2014). He further cites the following as some of negligent practices by professionals:

- Engaging of unqualified personnel and improper supervision of personnel.
- Disregard of the client’s programme or instructions.
- Failure to check compliance with applicable codes, standards and regulations.
- Failure to satisfy the terms and conditions of the applicable engagement agreement.

For durable buildings to be constructed, it is fundamental that building materials are tested for their performance. Although there is too much reliance on modern structural materials yet the manufacturing faults may exist even in the most dependable structural materials (Hossain, 2009). It is for this reason that standards and specifications are designed to encourage and promote the use of high quality materials and to distinguish inferior quality items (Taylor, 2002). Quality is the yardstick the construction industry needs to earn the reputation it deserves as a result professionals must ensure that quality is attained.

Important concepts in enhancing testing mechanisms are Quality control (QC) which refers to using operational techniques or procedures to check that products conform to specification (Ashworth, 2010), quality assurance (QA) which is defined as a management process designed to inspire confidence in the product or process (Taylor, 2002) and lastly supervision. Supervision of the work in progress is a vital last link in the chain of quality planning and administration of QA (Harlow, 1992). Supervision involves control over what will be accepted into the works (Clarke, 1984). In the absence of such supervision, poor workmanship and the omission of important details can occur.
1.2 Testing Mechanisms in the Construction Industry

Various tests can be carried out on materials; these may be control tests, record test and/ or compliance tests. According to Clarke (1984), Compliance testing: is carried out to ensure that materials satisfy the requirements of the specifications such as the cube strength for concrete and moisture contents of materials. In the initial stages of construction compliance testing is frequently done to establish a satisfactory basis for evaluating and accepting materials, particularly those coming from the source outside the works. At the later stage compliance testing becomes control testing unless the material is outside the specification. Control testing: is carried out to ensure that satisfactory standards which have already been established are maintained and record testing: is carried out to establish comprehensive review of the quality and/or performance of all the material provided or used in executing the works. The focus of this research is compliance testing.

Some of the testing mechanisms commonly used include soil tests which encompass sieve analysis, moisture content tests and bearing capacity tests (BS 1377). Additionally, rammed earth construction is one of the greenest approaches to construction and promising techniques for current use (Taylor, 2002). Rule of thumb tests have been used to ascertain the suitability of the material such as the role test. For concrete tests, mix design determines the most economical and practical combination of available materials. Sieve analysis is use to determine the particle size distribution for normal aggregates. Workability of concrete is assessed by the slump test and the flow table test for high workability concretes. The strength of concrete is assessed by the cube test and non-destructive tests which include the Schmidt rebound hammer and Ultrasonic pulse rate velocity. Brick quality testing should conform to ISO 9001: 2000 standards which comprise tests for strength, absorption, structure, soundness, hardness and compression. Bending test and tensile testing can be done on steel (ASTM E8). Glass can be tested by using a three (3) point bend test. The table below shows the testing mechanisms employed in the construction industry on a selected list of materials.

<table>
<thead>
<tr>
<th>Material</th>
<th>Testing mechanism</th>
<th>Aim of test</th>
<th>Instrument for testing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soil</td>
<td>Sieve analysis</td>
<td>Grain size of soil</td>
<td>Sieves</td>
</tr>
<tr>
<td></td>
<td>Liquid limit</td>
<td>Moisture content tests</td>
<td>Casagrande’s apparatus</td>
</tr>
<tr>
<td></td>
<td>Plastic limit</td>
<td>Moisture content tests</td>
<td>Glass plates and hands</td>
</tr>
<tr>
<td></td>
<td>Linear shrinkage</td>
<td>Shrinkage by clayey material –</td>
<td>Mould and steel ruler</td>
</tr>
<tr>
<td></td>
<td>California bearing</td>
<td>Bearing capacity tests</td>
<td>Metal rammer</td>
</tr>
<tr>
<td>ratio</td>
<td>Plate bearing test</td>
<td>Bearing capacity tests</td>
<td>Plates, Hydraulic jack, gauges and</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>reference beams</td>
</tr>
<tr>
<td>------------------------------------------------</td>
<td>------</td>
<td>------------------------------------------------</td>
<td></td>
</tr>
<tr>
<td>Proceedings 8th Built Environment Conference</td>
<td></td>
<td>27-29 July 2014</td>
<td></td>
</tr>
<tr>
<td>Durban, South Africa</td>
<td></td>
<td>To Testing Mechanisms In The Zambian Construction Industry</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Test</th>
<th>Purpose/Description</th>
<th>Equipment/Materials</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rammed construction test - roll test</td>
<td>Plasticity for suitability of soil for earth construction tests</td>
<td>Cylinder and table</td>
</tr>
<tr>
<td>Seive analysis</td>
<td>Aggregate size</td>
<td>Sieves</td>
</tr>
<tr>
<td>Slump test</td>
<td>Workability of concrete</td>
<td>Mould (cone) and steel ruler</td>
</tr>
<tr>
<td>Compacting factor test</td>
<td>Workability of concrete</td>
<td>Compacting factor apparatus (hoppers and cylinder)</td>
</tr>
<tr>
<td>Vebe consistometer</td>
<td>Workability of concrete</td>
<td>Vebe consistometer apparatus</td>
</tr>
<tr>
<td>Flow table test</td>
<td>Workability of concrete</td>
<td>Square board and cone</td>
</tr>
<tr>
<td>Ball penetration test</td>
<td>Workability of concrete</td>
<td>Ball penetration apparatus (steel cylinder and shaft)</td>
</tr>
<tr>
<td>(Destructive test) Cube test</td>
<td>Compressive strength</td>
<td>Compression testing machine</td>
</tr>
<tr>
<td>Non-Destructive tests (NDT)</td>
<td>tensile strength (Physical characteristics of concrete - composition, density and structural integrity)</td>
<td>Radiation source and radiation detector</td>
</tr>
<tr>
<td>X-ray (Gamma radiometry) nuclear testing method</td>
<td>Corrosion rate of reinforcement steel</td>
<td>Multi depth sensor (other instruments - 3LP device and guard electrode)</td>
</tr>
<tr>
<td>Linear polarisation method (LPM)</td>
<td>Tensile strength</td>
<td>Physical and chemical characteristics of mortar</td>
</tr>
<tr>
<td>Petrographic analysis</td>
<td>Uniformity and compressive strength</td>
<td>Schmidt rebound hammer</td>
</tr>
<tr>
<td>Rebound Hammer Test</td>
<td>Uniformity of concrete, cavities, cracks, defects and modulus of elasticity</td>
<td>Transducers (ultrasonic)</td>
</tr>
<tr>
<td>Ultrasonic Pulse Velocity (UPV) test</td>
<td>Compressive strength</td>
<td>Rotating cutting tool and observation</td>
</tr>
<tr>
<td>Core Extraction (semi-destructive test)</td>
<td>Load bearing (compressive) strength</td>
<td>Compression testing machine</td>
</tr>
<tr>
<td>Ground penetration radar (GPR)</td>
<td>Concrete cover measurement</td>
<td>Ground penetration radar equipment</td>
</tr>
<tr>
<td>Concrete cover measurement</td>
<td>Concrete cover Measurement and rebar</td>
<td>Rebar detector and concrete cover meter</td>
</tr>
<tr>
<td>Dropping test (from height of m)</td>
<td>Strength</td>
<td>No instrument</td>
</tr>
<tr>
<td>Clays and bricks</td>
<td>Brick quality test for absorption</td>
<td>Scale, oven and water</td>
</tr>
<tr>
<td>Crushing (compressive) test</td>
<td>Brick quality test for structure</td>
<td>Observation of broken brick</td>
</tr>
<tr>
<td>Water absorption test</td>
<td>Brick quality test for soundness</td>
<td>2 bricks</td>
</tr>
<tr>
<td>Soundness test</td>
<td>Tensile strength</td>
<td>Universal testing machine</td>
</tr>
<tr>
<td>Steel</td>
<td>Bending strength</td>
<td>Universal testing machine</td>
</tr>
<tr>
<td>3 point bending test</td>
<td>Bending strength</td>
<td>Universal testing machine</td>
</tr>
<tr>
<td>Glass</td>
<td>3 point bending test</td>
<td>Universal testing machine</td>
</tr>
</tbody>
</table>
1.2 Professionals Responsible for Testing Mechanisms

Roles of the consultant's team: It is the consultants’ responsibility to include in the contract documentation the tests to be carried or the standard to be inherent in a given material for use (Hackett et al, 2007). Supervision of building projects and conformation of tests are performed by the project consultants. Supervising consultants should monitor the contractor’s materials, methods, workmanship closely and carry out their own assessment as soon as work is completed, thereby ensuring that the project adheres to specifications (Ashworth, 2006). This is done through the Clerk of Works who has the power to inspect the works throughout the execution phase. Moreover, the clerk of works is obligated to test and submit tested results for materials used in works (Harlow, 1992). Practically the clerk of works can inspect any material and any part of the building under construction at any time to ensure compliance with specifications.

Roles of the contracting team: Among the duties of contractors during construction are compliance to Quality Control and control of performance of construction works to persons who fulfil ordinance requirements for performance of such works (Duncan, 1990; Exforsys Inc., 2010). Shortcomings may be overcome by experiences and individual effort (Taylor, 2002). Quality and conformity to specifications should be the primary consideration as opposed to the cost of materials. It is the duty of supervisors to ensure that work is conducted in a way that should be maintained at a recognised standard so that the standards set are maintained in future (Forster, 1989).

2. RESEARCH METHODOLOGY

In order to conduct the research, laboratory tests were carried out on soil, concrete, common blocks and steel. These materials were chosen because they form the major components of most of the buildings and were also the most commonly used material. The experiments were done to facilitate the analysis of data from both the theoretical and practical aspect. Sieve analysis, liquid limit and plastic limit were carried in order to assess the soil type moisture content and plasticity of the soil, respectively. The Californian bearing ratio (CBR) was done to ascertain the bearing capacity of the soil. The slump test and cube tests were also conducted on concrete. Other tests carried out were compressive tests on blocks, and the tensile and bending tests on steel.

Furthermore, questionnaires and interviews were used for field data research. Questionnaires comprised both open ended and closed questions. Questionnaires were administered to consultants from public
and private sectors (86), building and civil works contractors (68) from grades one to four (large scale grade 1-2, with an annual turnover of Over K25bn, and between K10bn to K15bn and medium scale grade 3-4 with an annual turnover of between K10bn to 15bn and 2bn to 10bn respectively), manufacturers of building materials (44) and laboratory technicians (63).

The research was confined to Copperbelt and Lusaka provinces, owing to time and budget, and the spread of construction projects currently. These areas comprise the largest cities in Zambia and most of the construction activities take place in these areas. The statistical package SPSS was used to calculate the means and standard deviations for experiments and questionnaire analysis.

3. RESULTS AND DISCUSSIONS

EXPERIMENTS

Soil tests: The two soil samples tested were sand and gravel. Sample TPI-gravel had a higher cumulative percentage passing, a higher liquid limit, a higher plastic limit and linear shrinkage than sample TP2-gravel as shown in table 2. Moreover, sample TP1 which was harder, required 97 blows to reach 900mm than the later which needed 41 blows. In addition, sample TP1 had a higher California Bearing Ratio (CBR) than sample TP2 as indicated in table 2.

<table>
<thead>
<tr>
<th>Tests</th>
<th>Total</th>
<th>Mean</th>
<th>Standard Deviation</th>
<th>Standard Error Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cumulative passing</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(TP1) VAR00001</td>
<td>16</td>
<td>62.50</td>
<td>65.55</td>
<td>16.39</td>
</tr>
<tr>
<td>(TP2) VAR00002</td>
<td>16</td>
<td>62.19</td>
<td>60.38</td>
<td>15.20</td>
</tr>
<tr>
<td>Liquid limit</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(TP1) VAR00001</td>
<td>5</td>
<td>25.4</td>
<td>4.72</td>
<td>2.11</td>
</tr>
<tr>
<td>(TP2) VAR00002</td>
<td>5</td>
<td>24.4</td>
<td>3.51</td>
<td>1.57</td>
</tr>
<tr>
<td>Plastic limit</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(TP1) VAR00001</td>
<td>3</td>
<td>19.67</td>
<td>0.58</td>
<td>0.33</td>
</tr>
<tr>
<td>(TP2) VAR00002</td>
<td>3</td>
<td>21.67</td>
<td>3.51</td>
<td>2.03</td>
</tr>
</tbody>
</table>

The cumulative passing for samples TP1 and TP2 indicated wide variations for both the mean and the standard deviation. Therefore, there is no uniformity in both samples of the soils. The liquid limit tests indicated statistically small variations in the means and the standard deviations. Plastic limit variations were smaller in sample TP1 than in TP2. As can be
seen from table 2, the figures for the mean and standard deviation were close to zero compared to sample TP2 which had higher values.

Table 3 shows results for the CBR for samples TP1 and TP2.

<table>
<thead>
<tr>
<th>PIT NO.</th>
<th>DEPTH (mm)</th>
<th>DCP</th>
<th>CBR</th>
</tr>
</thead>
<tbody>
<tr>
<td>TP1</td>
<td>900</td>
<td>97</td>
<td>28.7</td>
</tr>
<tr>
<td>TP2</td>
<td>900</td>
<td>41</td>
<td>11.6</td>
</tr>
</tbody>
</table>

The Dynamic Cone Penetrometer (DCP) readings were converted into in-situ CBR by using the following formula:

\[ \log_{10}(CBR) = 2.48 - 1.057 \log_{10}(\text{mm/blow}) \]

Concrete tests: In the analysis, only the cast in-situ and premix concrete at 28 days were compared. The compressive strength at 28 days should be getting stronger. The means for both cast in-situ concrete and premix concrete were above 25 MN/mm\(^2\) which was found to be compliant. However, it can be seen from table 4 that there were variations in the means for both cast in-situ and premix concrete. The variations in the standard deviations for the cast in-situ concrete and premix concrete were statistically small as shown in table 4.

Table 4 shows the average compressive strength for concrete

<table>
<thead>
<tr>
<th>Type of concrete</th>
<th>Age for concrete</th>
<th>Mean compressive strength (MN/mm(^2))</th>
<th>Standard Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cast in-situ</td>
<td>7 days</td>
<td>20.3</td>
<td>2.97</td>
</tr>
<tr>
<td>Cast in-situ</td>
<td>28 days</td>
<td>29.82</td>
<td>4.20</td>
</tr>
<tr>
<td>Pre-mix</td>
<td>28 days</td>
<td>26.75</td>
<td>3.42</td>
</tr>
</tbody>
</table>

The slump test for in-situ concrete was within the marginal error which implies that the workability of concrete was acceptable. The compressive strength values for cast in-situ concrete cubes tested at 28 days strength were within the marginal error as they were not less than 25 MN/mm\(^2\). The average compressive strength of the cubes was 29.82 MN/mm\(^2\) which was acceptable. The values of premix concrete at 28 days were also acceptable but for the last two figures. Nevertheless, the average compressive strength of the cubes was 26.75 MN/mm\(^2\) which was acceptable. Therefore, cast in-situ concrete at 28 days had a higher compressive strength than premix concrete, at 28 days.

Concrete blocks tests: The blocks indicated little variations in the compressive strength since the values were 0.46 N/mm\(^2\) and 0.55 N/mm\(^2\). The standard deviation was statistically small and close to zero being 0.046. Nevertheless, all the concrete blocks were found to be sub-standard. The required standard for load bearing blocks with dimensions of 390 x 190 x 140mm is 3.5N/mm\(^2\) (ZS 007:1973). Using such blocks can result in poor quality buildings.
Steel tests: There were variations in the tensile strength of mild steel with the standard deviation of 7.351 as shown in table 5. However, there were little variations in the elongation at peak with the standard deviation of 0.48, which was uniform. The variations were small for the strain at break which is indicated by the standard deviation of 4.46.

Table 5 shows results for mild steel

<table>
<thead>
<tr>
<th>Sample No.</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>Mean</th>
<th>Standard Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tensile strength (N/mm²)</td>
<td>280.19</td>
<td>279.83</td>
<td>286.03</td>
<td>271.79</td>
<td>285.68</td>
<td>267.90</td>
<td>278.57</td>
<td>7.351</td>
</tr>
<tr>
<td>Elongation at peak (%)</td>
<td>7.895</td>
<td>7.622</td>
<td>8.892</td>
<td>8.454</td>
<td>8.690</td>
<td>8.284</td>
<td>8.306</td>
<td>0.480</td>
</tr>
<tr>
<td>Strain at break (%)</td>
<td>10.792</td>
<td>19.324</td>
<td>22.539</td>
<td>22.120</td>
<td>22.165</td>
<td>20.109</td>
<td>19.508</td>
<td>4.46</td>
</tr>
</tbody>
</table>

There were variations in the tensile strength of torsteel with the standard deviation of 12.21 as show in table 6. Nonetheless, the variations were small for the percentage elongation with the standard deviation of 1.36.

Table 6 shows Torsteel or unquenched steel

<table>
<thead>
<tr>
<th>Lot No.</th>
<th>17</th>
<th>18</th>
<th>21</th>
<th>22</th>
<th>Mean</th>
<th>Standard Deviation</th>
<th>Sample 01</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tensile strength (N/mm²)</td>
<td>612.58</td>
<td>600.60</td>
<td>585.68</td>
<td>589.06</td>
<td>596.98</td>
<td>12.21</td>
<td>707.53</td>
</tr>
<tr>
<td>Elongation (%)</td>
<td>25.00</td>
<td>23.33</td>
<td>23.33</td>
<td>21.67</td>
<td>23.33</td>
<td>1.36</td>
<td>25.00</td>
</tr>
</tbody>
</table>

Grade 250 steel should have a minimum elongation gauge length of 22 % and grade 275-460 should have a minimum elongation gauge length of 16 % (ZS 25433: 2005 and ICS: 77. 140.15). BS EN 10002 requires grade 250 and grade 275-460 to have the percentage elongations of 0.33 and 0.43 respectively. However, mild steel from the tabulated results shows percentage elongations of less than the required percentage. The marginal error should be within 460-620 N/mm². Y20 sample 01 had a high tensile strength of 707.53 N/mm², which can affect the bending stress. The bending test was fine for the other samples as there were no cracks. The bending test is essential for prevention of sudden collapse of a structure.

4. QUESTIONNAIRES SURVEY RESULTS AND DISCUSSIONS

Challenges faced by Consultants in verifying results
The challenges faced by consultants in verifying results from the contractors include: 1. Manipulation of results, 2. Delays in obtaining results.
3. Samples are brought back after backfilling, 4. Confirmation of tests takes long, 5. lack of access to samples or tested results, 6. contractors swap similar result, 7. lack of facilities to verify results., 8. inconsistent reports for tested materials and tested results and 9. there is usually no proof that materials are tested and tested samples are not readily available. It can be established that there is lack of transparency in the way contractors handle the results and most of the results from contractors are unreliable. This indicates a possibility of malpractices with regard to testing mechanisms.

Tests carried out on Materials

The types of tests done on soils. The survey indicated that the most common test conducted on soil is the sieve analysis test (32%), and followed by In-situ dry density (22%). The least performed tests are liquid limit (12%) and linear shrinkage (10%). Despite the tests being important, they are not all conducted. Important test such as the bearing capacity tests which need to be done on ideally all projects is not always done. Therefore there is no certainty on the bearing capacity of the soils.

Tests done on concrete. The study reviewed that the majority (81 percent) of the respondents perform the cube test on concrete and other included the slump test (61%), compacting factor test (62%), core extraction for compressive strength (21%). The Schmidt rebound hammer test was not indicated by any of the respondents. Tests are only done by half of the respondents on concrete which is one of the fundamental materials used in buildings.

Tests done on Brick and blocks: The compressive strength test for bricks was the most frequently performed test indicated by 48%. Other tests were only performed by few respondents such as the sound test (9%), Drop test (27%), Absorption test (11%) and the hardness test done by (13%). This indicates that bricks and blocks were rarely tested by contractors. It can be deduced that in the absence of rigorous tests on bricks and blocks, there is a likelihood of using substandard blocks and bricks.

Types of tests done on steel: Very few respondents tested steel. Only 24% of the respondent’s carryout the bending tests and 11 percent carry out the tensile tests on steel. It can therefore be concluded that tests on steel are rarely done.

The types of tests done on aggregates: The research revealed that very few respondents carry out test on aggregate with the common test being the bulk density test indicated by 23% of the respondents, tests such as the flakiness index, moisture content buoyancy meter test, aggregate crushing value test and the sieve analysis all has a response rate of 14% and the Los Angeles test was also indicated by some respondents. Therefore, aggregates are rarely tested. This brought the quality of concrete made from these aggregates into question. From the results its can be concluded that the concrete produced could be of low quality.
Test on Glass and Timber: The drop test is conducted on glass indicated by 9% of the respondents. Tests on timber were not indicated by any respondents Therefore contractors do not test the material despite the fact that timber is often used for structural members such as beams.

5. CONCLUSION

The research established that there were disparities in the tested results of soil, steel, concrete and blocks samples. The tests carried out on materials established that materials quality varies. For instance soil samples results taken from the same location may differ. It was also highlighted that all the tested blocks were substandard signifying that some manufacturers cannot be relied upon. The study also revealed that very few material tests are done. From the few tests done, the most tested material is concrete then bricks/blocks, followed by soil, aggregates and steel. While the least tested material was glass, and timber is not tested at all. Poor quality of works in the construction industry can therefore be attributed to non-application of testing mechanisms. This indicates the presence of malpractices in the construction industry by its professionals when it comes to testing materials. It is therefore important that materials are tested before they are incorporated in construction works in order to ensure that quality buildings are constructed and to avoid the use of substandard materials in construction. For further research, it is recommended that an investigation be carried out to establish why testing mechanisms are not holistically conducted.

6. REFERENCES


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The lack of management commitment to HIV and AIDS in the South African construction industry

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ABSTRACT AND KEYWORDS

Purpose of this paper
The construction industry is particularly vulnerable to the threats presented by HIV and AIDS because of its large unskilled labour force, high labour turnover and the migratory nature of the workforce. But the industry is not doing enough to combat HIV and AIDS. The study reported in this paper highlights the lack of management commitment HIV and AIDS.

Design/methodology/approach
The aim of the study was achieved in two stages. The first stage involved an extensive literature review to determine the industries response and the consequences of inertia. A questionnaire emailed to members of the Masters Builders Association formed the second stage of this research. Three hundred and eleven contractors responded to the questionnaire.

Findings
Thirty two years after HIV was first discovered the response from the construction sector is still dismal. The majority of the respondents (80%) reported that they did not have a HIV and AIDS policy or programme in place.
and that in most cases the most been done to combat the disease was the use of brochures/pamphlets/flyers.

Practical implications (if applicable)
This study can be used for further research to assist the construction industry in helping fight HIV and AIDS.

What is original/value of paper.
This study provides the construction industry with ways in which it can get involved in this fight against HIV and AIDS.

Keywords: Construction industry, South Africa, HIV and AIDS

1. INTRODUCTION

Human Immunodeficiency Virus (HIV) and Acquired Immunodeficiency Syndrome (AIDS) are among the greatest challenges facing the world (International Labour Organization (ILO), 2010) in terms of its workforce and its skills as well as economic and social development (Barnett & Whiteside 2006; Bloom, Bloom, Steven & Weston, 2006; Dickinson, 2005; Whiteside & Sunter 2000). AIDS claimed its first two known South African victims in 1982 (Fourie, 2006) and 32 years later scientists have reportedly still not found a cure. Statistics in South Africa (SA) with regard to HIV and AIDS paints a bleak picture (Dickinson & Innes, 2004) because South Africa is currently at the epicenter of the AIDS pandemic with approximately 5.7 million (11.4%) HIV positive people out of a total of nearly 49.9 million people (South African Institute of Race Relations 2010).

With reportedly the largest antiretroviral therapy programme in the world, South Africa is experiencing substantial public health benefits associated with improved treatment access (UNAIDS, 2010). Unfortunately for every two people who start antiretroviral therapy, five individuals are newly infected with HIV (ibid).

The sustainability of companies is at risk due to the threats posed by HIV and AIDS. The concentration of the pandemic on the economically active population has grave implications for the workforce (Dickinson & Innes, 2004) in a country that is already suffering from acute skills shortages (Fourie, 2006; Whiteside & Sunter, 2000). The death of this working population (Bloom, Bloom, Steven & Weston, 2006) leaves a huge gap in businesses by destabilising the quantity and quality of the labour force in the South African economy (Dickinson, 2005).

The consequences of ignoring the threat that HIV and AIDS poses to the construction industry can be catastrophic if the industry continues to ignore the warning signs. The need for a comprehensive response by the construction industry to HIV and AIDS is significant given the contribution it makes to gross domestic product and the large number of employees in the
industry. However the construction sector has not done enough in order to limit or prevent the impact of HIV and AIDS on its employees. If the construction industry wants to do well financially, they need a healthy, productive workforce. This study looks at the lack of management commitment to HIV and AIDS and addresses the business case for action by the construction sector.

2. SLOW RESPONSE BY THE CONSTRUCTION INDUSTRY

HIV and AIDS is a pandemic with serious implications for South Africa in general, and the South African construction industry in particular (Meintjes, Bowen & Root, 2007). According to the Department of Public Works (2004) the construction industry has the third highest incidence rate of HIV and AIDS per sector in South Africa. The epidemic threatens to reduce the overall construction labour force, increase labour turnover, shift the age structure and change the skill composition of the construction labour supply (Haupt, Munshi & Smallwood, 2005). In addition to increasing costs and dwindling profits (Ahwireng-Obeng & Akussah, 2003), construction enterprises can expect declining output, diminishing quality and quantity of labour supplied (Barnett & Whiteside, 2006).

The workplace is generally not associated with the transmission of HIV and AIDS (Haupt et al., 2005), but it provides an ideal platform to reach workers through the development and implementation of workplace policies and programmes on HIV and AIDS (ILO, 2010). However the important role that companies play in addressing the pandemic has not been optimally utilised. In fact the response of corporate South Africa to HIV and AIDS has been slow, partial and erratic (Dickinson, 2004). Over 30 years since the first discovery of HIV and AIDS, the majority of companies still feel AIDS is not their problem. A survey conducted by BER/SABCOHA showed that the construction industry was one of the least responsive industries (BER/SABCOHA, 2004). In a study conducted by Harinarain & Haupt (2010) it was found that only 10% of 123 building contractors in the KwaZulu-Natal province of South Africa had a HIV and AIDS policy in place despite the province having the highest prevalence rate. A survey by Bowen, et al. (2010) of construction firms in the Western Cape found that most organisations had awareness policies in place but prevention and treatment policies were less common.

The vulnerability of the construction industry was highlighted by Harinarain & Haupt (2012) and includes factors such as the fragmented nature of the industry; the numerous companies of various sizes that discourages permanent employment by encouraging subcontracting and labour only subcontracting; the lack of leadership and the slow response in acknowledging and addressing the disease; the constantly changing labour force that work on short-term contracts; permanent employees who move between projects across the country and in other countries; the predominant
The lack of management commitment to HIV and AIDS in the South African construction industry

The construction industry needs to understand that it makes good business sense to address HIV and AIDS in the workplace because failure to do so results in (Barnett & Whiteside, 2006; Dickinson & Innes, 2004; ILO, 2010; Fourie, 2006; Nattrass, 2004; Rosen, et al., 2000; Whiteside & Sunter, 2000)

- high morbidity (sick employees who have to take sick leave) and mortality (death) rates;
- increased absenteeism as employees take time off to care for sick family members or to attend funerals of friends, colleagues or family members who have died of AIDS;
- increased labour turnover through death or early retirement, resulting in increased training costs;
- low staff morale with employees resenting taking on, or refusing to take on, additional responsibilities for colleagues who are sick;
- a culture of stigma and fear of infection, further lowering staff morale as employees refuse to work with colleagues infected with HIV;
- loss of productivity due to high morbidity, absenteeism and mortality in the workplace;
- decrease in work performance due to the loss of experienced skilled workers who are difficult and expensive to replace;
- increased cost of employee benefits (such as health and medical aid);
- higher production costs stemming from higher health-related expenses;
- increased number of accidents due to fatigue and illness; and
- declining profits. These impacts on the workplace are depicted in Figure 1 and this clearly indicates that it makes good business sense to address HIV and AIDS in the workplace.
Figure 1. The impact of HIV and AIDS on enterprises (Adopted ILO, 2002: module 1:10)

2.1 Failure to respond can be more costly

HIV and AIDS have a significant impact on South African business in terms of profits, the workforce and markets. An increased prevalence of employees with AIDS may result in increased costs. The costs of HIV and AIDS to businesses depends on the organisation, the skills levels of infected employees and how replaceable they are, the benefits it provides and the sector the organisation operates in. All these costs lead towards a loss in profit with a vicious spiral effect on businesses throughout the supply chain.

In order see exactly how costly HIV and AIDS can be, Figure 2 illustrates the three types of costs incurred by a company, namely direct costs such as increased financial outlays by the company, indirect costs in the form of reduced productivity and systemic costs that result from the cumulative impact of multiple HIV and AIDS cases (Dickinson & Innes, 2004; Rosen, Simon, Thea & Vincent, 2000; Whiteside & Sunter, 2000).

Direct costs are company expenses that usually appear on the income statement and are easy to quantify. Direct costs include:

- medical costs;
- pension and provident fund contributions;
- service gratuities;
- death or funeral benefits; and
- recruitment and training of replacement employees.

Indirect costs are more significant and substantive but are harder to quantify. These costs include

- reduced productivity;
- reduced efficiency of a workforce due to less experience and less skill;
- recruitment and training costs;
- production disruption;
- increasing staff turnover;
- ill-health retirements;
- increased leave;
- decreasing employee morale;
- increased supervisor's time in managing the ill employee;
- the costs to production until a replacement is hired and initially lower productivity of the new employee;
- disruption of work teams;
- increased absenteeism from work due to morbidity and attendance at funerals;
- loss of experience as individuals are forced to leave their jobs;
- costs of ensuring occupational health and safety standards are adequate;
- dealing with prejudice among staff when some are HIV-positive;
- ensuring that staff members’ HIV status remains confidential; and
- diverted management attention from strategic and operational issues and an imposed burden on managers who must cope with high workforce morbidity and mortality.

Indirect costs also arise from absenteeism which could potential account for 52% of the costs as a result of illness, funerals, and family responsibility and from lower productivity when at work, commonly known as ‘presenteeism’. An average of 35.4 more sick days were taken by employees who died of AIDS related causes and an average of between 7 and 25 days were spent

Figure 2. The costs incurred by companies (Whiteside & Sunter, 2000:112)
by supervisors assisting each affected employee in their last year of service. Costs rose consistently with job level, that is the costs associated with someone in a managerial position was much more than unskilled worker. Most of these were hidden costs and in some cases they only became apparent when the disease was further advanced. Finally, systemic costs arose from less tangible losses of social capital, reduction in morale, loss of experience and skills in the workforce and institutional memory (Barnett & Whiteside, 2006; BER/SABCOHA, 2004; Dickinson & Innes, 2004; ILO, 2002, 2010; Meintjes, et al., 2007; Nattrass, 2004; Rosen, Simon, Thea & Vincent, 2000; Whiteside and Sunter 2000).

Given these serious factors, HIV and AIDS poses a grave threat to the South African construction industry and according to Bowen, et al. (2010) the construction industry in South Africa could, and must, do more.

3. RESEARCH METHOD

This was a quantitative study. Questionnaires were used because of their advantages which include the fact that they are cheap to administer and saves time because a large number of people from a wide geographical area can be sent the questionnaire (via post, fax or email) at one time. The anonymity that questionnaires provide allows for sensitive questions to be asked (Leedy & Ormrod, 2010).

Construction firms in South Africa were identified from the Master Builders Association (MBA) websites for the nine provinces. The MBA was selected as it contains lists of registered building contractors and is of a manageable size. The total population size of contractors registered with the MBA for the provinces were 1,046. The entire population was emailed the questionnaire but only 934 email addresses were valid. Three hundred eleven completed questionnaires were received, indicating a response rate of 33.3%.

A pilot study was carried out with 10 members from the construction industry. The pilot study was conducted to ensure that the instructions were clear and understandable, that the participants understood their role, to remove ambiguities and to determine the timeframe.

4. RESULTS AND DISCUSSION

Most of the respondents were quantity surveyors (35%), closely followed by project managers (27%), human resource managers (18%) and other staff (20%). The majority of the firms (68%) were general contractors, 16% subcontractors, 12% home building contractors and 4% as other. Seventy three percent of the firms were regarded as small firms as they employed less than 100 employees. There were 23% of responses from medium (between 100 – 500 employees) firms and 4% responses from large (> 500 employees) firms. The majority of firms (86%) were registered in grades 2
to 6 of the CIDB register of contractors. The industry is still male dominated with firms employing between 80-99% male employees.

An overwhelming majority (80%) of the respondents reported that they did not have a HIV and AIDS policy or programme. The reasons given were, namely:

- cost;
- time constraints;
- lack of resources and
- HIV and AIDS is being considered a low business priority.

This finding also ties in with findings from Ala (2004); BER/SABCOHA (2004); Bowen, et al. (2010) and Van Dyk (2008). Due to most of the respondents being small firms, this finding is not surprising.

The respondents were then asked who was responsible for HIV and AIDS education/information in their respective firms. Twenty six percent of the firms reported that the human resources manager was responsible for HIV and AIDS programme and 5% other people such as the director or health and safety office. The important point to note is that 69% of firms reported having no one responsible for these programmes.

Sixty one percent of the respondents felt that HIV and AIDS had a moderate to high impact on the morale of the workforce. This finding could be attributed to the fact that they did not have a HIV and AIDS policy and therefore were not aware of the true extent or impact that HIV and AIDS was having on their workforce. This assumption was confirmed when 81% of the respondents did not believe that they had done enough to assist their employees in terms of HIV and AIDS. Some of the reasons given by the respondents were that they had:

- "no information on HIV and AIDS programmes whatsoever";
- "none of our employees make their status known" and
- "there are too many other pressures to consider".

HIV and AIDS programmes were only presented in 7 of the 11 official languages in South Africa (Afrikaans, English, Tshivenda, isiXhosa, isiZulu, Sesotho, Xitsonga). Most programmes were presented in English and isiZulu. Fifty one percent of the firms did not carry out any HIV and AIDS programmes.

Thirty two percent of the respondents used brochures/pamphlets/flyers to combat HIV and AIDS in their firms as depicted in Table 1. The other commonly used interventions were induction programmes, posters and toolbox talks.

Table 1. Interventions used to combat HIV and AIDS.

<table>
<thead>
<tr>
<th>Interventions to combat HIV and AIDS</th>
<th>Responses</th>
</tr>
</thead>
<tbody>
<tr>
<td>Provision of condoms</td>
<td>61</td>
</tr>
<tr>
<td>Awareness education (speaker)</td>
<td>12</td>
</tr>
<tr>
<td></td>
<td>N</td>
</tr>
<tr>
<td></td>
<td>Percent</td>
</tr>
<tr>
<td></td>
<td>11.1%</td>
</tr>
<tr>
<td></td>
<td>2.2%</td>
</tr>
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</table>
Finally, two hundred and fifty respondents (48%) believed that there should be a compulsory, industry-wide initiative funded via levies which included education, testing and treatment programmes in order to assist them in implementing a HIV and AIDS programme. Thirty five percent also believe that the CIDB should assume a leadership role in order to provide unifying action and 17% believe that there should be formal certification as part of the completion of work certification process.

### 4.1 How can companies get involved?

Business can make a tremendous contribution in the fight against HIV and AIDS (Ala, 2004). The workplace is an ideal platform to launch HIV and AIDS prevention and care programmes. Despite the fact that workers have different cultural and social backgrounds and different first languages, at the workplace all employees share the same organisational culture, with the same goals, vision and rules (Van Dyk, 2008). To achieve this contribution workplace strategies are necessary. The workplace can be regarded as a community where people come together (ILO, 2002).

HIV and AIDS workplace strategies aims primarily to manage the risk to affected employees by prevention or reducing the number of new infections, managing the current HIV infection and AIDS prevalence and providing treatment, care and support which ensures a healthy workforce, increases productivity and reduces absenteeism (Ala, 2004; Rosen, et al., 2000a).

One of the most effective ways of reducing and managing the impact of HIV and AIDS in the workplace is through the implementation of an HIV and AIDS policy that guides the employer and employee on their rights and responsibilities.

Firms should also develop and implement a workplace HIV and AIDS programme which includes the prevention of new infections such as awareness, education and training, male and female condom promotion and distribution, treatment and care and support for employees (Van Dyk, 2008).

Business could also contribute to reducing the spread of HIV and AIDS by:

- addressing stigma and discrimination;
- providing their problem-solving expertise;
- company leadership- business holds positions of authority in individuals’ lives;
- mass communication skills;
- financial power;

<table>
<thead>
<tr>
<th>Wellness management e.g. counselling</th>
<th>30</th>
<th>5.5%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Posters</td>
<td>84</td>
<td>15.3%</td>
</tr>
<tr>
<td>Induction programmes</td>
<td>85</td>
<td>15.5%</td>
</tr>
<tr>
<td>Newsletters</td>
<td>34</td>
<td>6.2%</td>
</tr>
<tr>
<td>Toolbox talks</td>
<td>68</td>
<td>12.4%</td>
</tr>
<tr>
<td>Brochures/pamphlets/flyers</td>
<td>176</td>
<td>32.0%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>550</td>
<td>100.0%</td>
</tr>
</tbody>
</table>
- create a positive corporate image;
- improve staff morale;
- the involvement of people living with HIV and AIDS to help in reduce stigma and discrimination in organisations;
- using business relationships to encourage sub-contractors to adopt effective HIV and AIDS workplace programmes;
- incorporating best practice from inside and outside the company;
- have outcomes that are consistent, legal, and fair;
- keep the negatives negative;
- public-private partnerships among business, labour, governments, and non-profit organisations
- conducting an institutional HIV and AIDS audit; and
- combining managerial capacity with bottom-up initiatives and enthusiasm (Bloom, Bloom, Steven & Weston, 2006; Haupt, et al., 2005; Rosen, et al., 2000; Whiteside & Sunter, 2000).

The benefits that could be gained from companies by taking action include productivity gain, increased life expectancy and reduced morbidity, time for drug prices to fall, skills development, improved morale and workplace cohesion, healthier workforce and community, decreased absenteeism due to illness and caring for sick family members, destigmatises disease for employees, reduces the time managers and supervisors must spend coping with employee deaths and high turnover rates, improved sustainability of company operations and sustained operations which ensured continued growth (Rosen, et al., 2000).

5. CONCLUSION

The construction sector within South Africa has been criticised for its lack of activities aimed at mitigating the impact of HIV and AIDS on its employees (George, et al., 2009). A majority of the respondents reported that they did not have a HIV and AIDS policy or programme because of cost and time constraints. The respondents did not believe that they had done enough to assist their employees in terms of HIV and AIDS because of lack of information and other pressing business issues. The workplace can be the most important place for the transference of information on prevention, treatment and care of employees. However the construction sector has not done enough in order to limit or prevent the impact of HIV and AIDS on its employees. If the construction industry wants to do well financially, they need a healthy, productive workforce. This in itself should be reason enough to take part in this fight against HIV and AIDS. By actively participating in this fight against HIV and AIDS, the construction industry can protect itself, improve the quality of life its employees and also assist the community.

6. REFERENCES


Procurement Fraud Prevalence, Causes, Responses and Challenges in the Zambian Construction Industry

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ABSTRACT AND KEYWORDS

Purpose of this paper
The research investigates the prevalence, causes, response to and challenges in dealing with fraud in the construction industry in Zambia.

Design/methodology/approach
The study is based on convenient sampling of construction consultants, construction company’s management staff and Government ministries and institutions from the Copperbelt and Lusaka provinces and data collection through a structured questionnaire.

Findings
Opportunity, level of competition, inadequate remuneration for tender evaluation staff are some of the elements causing fraud in Zambia. Respondents felt that the prevalence of procurement fraud is high while there are hardly any measures put in place to combat the vice. Implementing and actively monitoring control mechanisms to combat procurement fraud are difficult to achieve.

Research limitations/implications
The research data was drawn conveniently from construction sites in two provinces along the line of rail in Zambia.

Practical Implications
The study highlights areas where policy in fraud prevention can be directed

1. INTRODUCTION

Fraud and corruption have been found to be fairly highly prevalent in both developed and developing nations (Osei-Tutu et al., 2009; Venter, 2007 citing KPMG, 2005). While developed nations have taken measures to address the prevalence of these vices in companies operating both abroad and within their nations (Yangu, 2013; World Compliance, 2010; Santangelo et al., 2007), developing nations have been criticised for not doing enough to discourage the vices (Yangu, 2013; Otusanya, 2011 citing Bakore, 2007). Research in the area of fraud and corruption in developing countries is therefore necessary to inform on policy direction to address the vice.

This paper presents a literature review and questionnaires survey to establish the prevalence levels of procurement fraud in Zambia, the causes of procurement fraud, the responses to procurement fraud and also some of the challenges Zambia is facing in combating the problem of procurement fraud. The literature review starts by providing a description of fraud and corruption and shows that fraud is one of the elements making up corruption. The effects of fraud and corruption on society are then established and are found to include, inter alia, loss of taxes and even a decline in life expectancy. Fraud and corruption are found to be prevalent in both developed nations and developing nations alike with developing nations being criticised for not doing enough to combat the prevalence of corruption. The paper also establishes the perpetrators and causes of procurement fraud and finds that project participants are the main perpetrators while opportunity and pressure to commit fraud are the main causes of procurement fraud. Solutions for combating procurement fraud are established to include, inter alia, procurement audits, specific investigations by management and internal controls. Other suggested solutions include situational crime prevention and forensic accounting. Literature suggests further research on the relationship
between gender and fraud and corruption. The questionnaire survey establishes that the level of prevalence of procurement fraud in Zambia is fairly high. Further, the causes of procurement fraud are found to be opportunity, the difficult of securing tenders, inadequate remuneration of tender evaluation staff and stiff competition. The responses so far initiated in Zambia in the fight against procurement fraud and the challenges facing the fight against procurement fraud are also investigated. It is found that hardly any measures have been initiated to combat procurement fraud and that it is difficult to implement and actively monitor control mechanisms to combat procurement fraud.

2. LITERATURE REVIEW

Fraud is an element of corruption which involves deceitful conduct intended to create one's own or a third party's benefit (Otusanya, 2011). The other elements that together make up the concept of corruption are embezzlement, favouritism, intimidation, insider trading, conflict of interest, receiving an unlawful gratuity, illegal contributions, money laundering, identity theft, white-collar crime, abuse of power, nepotism, extortion and bribery (Otusanya, 2011).

Corruption, including fraud has been shown to cause a lot of adverse effects to the public in general. Some of the adverse effects include loss of taxes, public revenues, economic devastation, lack of investment in public goods, a poor quality of life and even a decline in average life expectancy (Otusanya, 2011). It has also been shown to lead to hunger, poverty and hinder social development (Otusanya, 2012; Ampratwum, 2008). It also hinders economic growth by reducing private investment (Otusanya, 2011 citing Mauro, 1995). Illegal proceeds from fraud and corruption are usually banked overseas thereby perpetuating capital flight (Otusanya, 2012; Ampratwum, 2008).

Corruption and fraud in particular is prevalent in both developed and developing nations. In a survey on the prevalence of corrupt practices in public infrastructure projects in Ghana, Osei-Tutu et al. (2009) established that corrupt practices are severe in both the public and the private sectors of Ghana. The vices reported in the Ghana infrastructure industry include bribery, embezzlement, kickbacks, tender manipulation and fraud (Osei-Tutu et al., 2009). Fraud was also reported to be extremely high in South Africa in a 2005 Africa Fraud and Misconduct Survey conducted by KPMG (Venter, 2007 citing KPMG, 2005). Fraud and errors have been shown to cause organisations losses of up to 9% (Button et al., 2012).

Within the infrastructure sector, the perpetrators of corruption are the participants of the project such as political influencers, public servants, clients, consultants, contractors and suppliers (Osei-Tutu et al., 2009). Due
to the huge sums of money involved in infrastructure projects, the participants usually see an opportunity to earn extra money from the projects.

Literature has shown that procurement fraud is mostly caused by the opportunity for it (Peltier-Rivest and Lanoue, 2012; Otusanya, 2011 citing Graff, 2007 and Rose-Ackerman, 1978). Opportunity is created when the expected advantages of the corrupt activities out-weigh the expected disadvantages (Otusanya, 2011 citing Klitgaard, 1988 and Rose-Ackerman, 1978). In this scenario, offenders feel that there is a low chance of being caught and convicted and that a light sentence will follow if caught while there is a high chance of obtaining a huge sum of money or gain (Ampratwum, 2008). Lenient punishment for fraudulent and corrupt practices promotes the opportunity for corruption and therefore calls for reflection on existing sentencing practices (Ampratwum, 2008). Opportunity therefore emerges as the prominent cause of fraud and corruption.

Pressure from low income also motivates fraudulent and corrupt practices. Mbaku (1991 cited in Otusanya, 2011) showed that when civil servants remuneration is relatively low, a good part of their income is derived from corrupt activities. It follows that if the remuneration for tender evaluation staff is low, part of their income is likely to come from corrupt activities. Low remuneration coupled with the opportunity to raise some money from fraudulent tender evaluations is likely to create pressure to engage in corruption.

In a 2005 Africa Fraud and Misconduct Survey conducted by the independent auditing firm KPMG, it was reported that 76% of the respondents felt that their employees (excluding managers) were involved in fraud while 32% believed that management is also involved (Venter, 2007 citing KPMG, 2005). While only 32% of the respondents felt that managers are also involved in fraud, literature has shown that managers are very likely to be involved in corrupt practices owing to the opportunity created by their positions which gives them an opportunity to ignore internal controls (Gottschalk, 2011; Venter, 2007; Peltier-Rivets and Lanoue, 2012). When involved in fraud Venter (2007) established that managers are likely to use their position to either overlook controls or collude to circumvent them. Other than managers, persons in the purchasing and procurement departments have been found to be the most likely to be involved in fraud (Venter, 2007; Gottschalk, 2011). Their position in purchasing and procurement provide them with the opportunity while the other project participants create pressure on them to engage in fraud.

While top management are best suited to prevent fraud given their level of authority, they are also the most vulnerable to commit fraud owing to the greater opportunity offered by their level of authority to bypass an organisations internal controls (Peltier-Rivest and Lanoue, 2012; Gottschalk, 2011). High positions in the purchasing and procurement department are most vulnerable (Gottschalk, 2011). Therefore, organisations should
strengthen their internal controls at the higher levels of authority to reduce the risk of fraud (Hemraj, 2004). This can be achieved even through simple control measures such as segregation of duties and anonymous reporting hotlines (Peltier-Rivest and Lanoue, 2012).

Sound procurement systems are one of the elements that may control corruption (Osei-Tutu et al., 2009). Other fraud and corruption control measures include whistle-blower hotlines, internal audits, surprise audits, management review of internal controls, rewards for whistle-blowers and mandatory job rotation (Bierstaker, 2009). Improving anti-corruption and pro-social equity policies which should subsequently lead to good governance will also lead to less corruption (Osei-Tutu et al., 2009).

Cressy (1971, cited in Osei-Tutu et al., 2009) suggested three factors that perpetuate corruption and these are opportunity for it, the pressure to commit it and rationalisation of the act. These have been dubbed Cressy’s Triangle (Osei-Tutu et al., 2009 citing Cressey, 1971). Osei-Tutu et al. (2009) suggested fraud control measures around Cressys’ triangle. The opportunity for fraud can be countered with sound and strong governance, transparency and control processes while the pressure to commit fraud can be countered by empowering people to report corruption, improved and fair workplace conditions, pressure against accepting corruption (Osei-Tutu et al., 2009). The rationalisation of fraud can be countered by cultural change, training and awareness about the impact of corrupt practices, leadership examples that condemn corruption, legislation and prosecution against corruption (Osei-Tutu et al., 2009).

Some of the most effective detection methods for fraud include internal audit reviews, specific investigation by management, employee notification internal controls and accidental discovery (Hillison et al., 1999; Ziegenfiss, 1996). Internal auditors are more likely than independent auditors to prevent, deter and detect fraud (Hillison et al., 1999). In a survey in New Zealand Owusu-Ansah et al. (2002) established that the likelihood of independent auditors to detect fraud increases with experience. Otherwise, independent auditors are not likely to detect fraud (Owusu-Ansah et al., 2002). Internal audits are particularly important to the control of fraud because fraudulent financial reporting was more prevalent in companies which had fewer audit committees, fewer audit committees composed entirely of outside directors, fewer audit committee meetings, fewer board of directors with a majority of outside members and where internal audit functions were not performed (Makkawi and Schick, 2003).

Governments in developing countries have been criticised for not doing enough to bring perpetrators of corrupt activities to justice due to poor regulation, ineffective sanctions and weak institutions (Yangu, 2013; Otusanya, 2011 citing Bakore, 2007). Some developed countries on the other hand have gone so far as to grant their court’s jurisdiction over corrupt practices by their multi-nationals committed outside their countries. The
United States of America (USA) for instance enacted the Foreign Corrupt Practices Act (FCPA) in 1977 following disclosure by some large USA multinationals that they made illicit pay-outs to some foreign government officials (Santangelo et al., 2007). The FCPA is a federal law that prohibits US companies from making illicit payments to foreign political figures and government officials in order to obtain business (World Compliance, 2010). The United Kingdom (UK) also has its version of legislation which deals with cases of bribery abroad by UK companies and their associates in the UK Bribery act of 2010 (Yangu, 2013).

Opportunity in the immediate environment has a causal influence on crime events (Graycar and Sidebottom, 2012). Situational Crime Prevention (SCP) has been suggested to inform the analysis and prevention of corruption (Graycar and Sidebottom, 2012). SCP seeks to identify practical ways to reduce crime (or harms produced by crime) by removing or reducing opportunities which permit criminal behaviour (Graycar and Sidebottom, 2012). Further research is required to establish whether SCP can effectively contribute to the fight against fraud and corruption.

Other areas that may require further research include the relationship between gender and fraud and corruption. Gottschalk (2012) reported that out of 161 convicts surveyed, 153 were male while only eight were female representing 4% of the sample. More research is required to establish that this observed association is significant. More research is also needed to investigate the effect of culture on organisations anti-fraud programmes and controls that may be most effective in curbing corruption (Bierstaker 2009). Forensic accounting has also been suggested as a measure against fraud and corruption (Prabowo, 2013). Notwithstanding these suggested measures against fraud and corruption and the other controls highlighted above, Salifu (2008) suggests that it is unlikely that efforts to combat corruption will be entirely successful.

3. RESEARCH METHODOLOGY

Structured questionnaires were used to collect data from construction industry consultants, government agencies and building construction firms from the National Council for Construction (NCC) registered grades from grade 1 to 4. NCC grades 1 to 4 are the largest to medium sized construction companies in Zambia with a maximum annual turnover in any one year during the past five years exceeding USD4.00m for grade 1, between USD2.40m and USD4.00m for grade 2, between USD1.60m and USD2.40m for grade 3 and between USD0.32m and USD1.60m for grade 4 companies. This demography was selected because Osei-Tutu et al. (2009) established that perpetrators of corruption are the participants of the project such as political influencers, public servants, clients, consultants, contractors and suppliers. Consultants, contractors, public servants and government agency clients are
therefore covered in the choice of respondents. Political influencers on the other hand are rather difficult to sample and are such not included in the sample. Suppliers were also conveniently omitted.

Due to time and financial constraints, the research area was conveniently chosen to be towns on the Copperbelt province and Lusaka province. These provinces both lie on the line of rail which is the most urbanised area of Zambia and house provincial offices for government ministries and agencies. The majority of construction consultants and medium to large construction firms are also concentrated in these provinces.

A total of 57 questionnaires were administered; 18 questionnaires were administered to government ministries and agencies, 16 questionnaires to consultants and 23 questionnaires to building and civil engineering contractors. A total of 39 completed questionnaires were collected representing a response rate of 68%. Collected responses from government ministries and agencies are 12 (67%), 9 (56%) from consultants and 18 (78%) from building and civil engineering contractors.

The self completing questionnaire was divided into five sections. These are the demographic information, causes of procurement fraud, prevalence of procurement fraud, fraud responses and fraud challenges. Opportunity, being one of the major cause of fraud and corruption (Peltier-Rivest and Lanoue, 2012; Otusanya, 2011 citing Graff, 2007 and Klitgaard, 1982), difficulty in securing tenders, adequacy of remuneration and competition for contracts having been established as causes of fraud and corruption were the four constructs investigated to establish whether they are perceived as contributing to fraud in the ZCI. The prevalence rate of procurement fraud was also investigated to establish whether respondents felt that the problem was endemic in the ZCI. The industry’s response to procurement fraud was examined to find out if the industry had initiated any measure to combat the vice. Lastly, respondents were asked to identify challenges encountered in controlling fraud. The resulting data was analysed using Microsoft excel where descriptive statistics were computed.

4. RESEARCH FINDINGS

4.1. Causes of Procurement Fraud

Of the 39 respondents, 90% either strongly agreed or agreed that there is a big opportunity for procurement fraud in Zambia. While 10% disagreed, none of the contractors disagreed that the opportunity for fraud is big while 17% of Government Ministry respondents and 22% of consultants disagreed that the opportunity for procurement fraud big.

On whether securing tenders is difficult in Zambia, 51% of the respondents agree that it is difficult while 49% either disagree or strongly disagree. Most Government Ministry respondents feel that it is not difficult to secure tenders with 83% of them either disagreeing or strongly disagreeing.
and also most consultants sharing this view with 67% of them disagreeing that securing tenders in Zambia is difficult. Contractors on the other hand feel that securing tenders is difficult with 83% of them agreeing.

Respondents disagreed that tender evaluation staff are adequately remunerated with 72% of the respondents either strongly disagreed or disagreeing to the statement. Contractors disagree the most that the tender evaluation staff are adequately remunerated with 85% of them disagreeing and 75% of Government Ministry respondents either strongly disagreeing or disagreeing that the staff are adequately remunerated. Consultants on the other hand feel that the remuneration is adequate with 66% agreeing.

It is unanimously agreed by all parties that competition for construction contracts is stiff in Zambia with everyone either agreeing or strongly agreeing. Contractors where the most respondents who strongly agreed at 67% followed by consultants at 33% and Government Ministry respondents at 25%. The rest simply agreed.

4.2. Prevalence of Procurement Fraud

It is felt that the prevalence of procurement fraud is high with 74% of the respondents agreeing to this. All the contractors (100%) agreed that procurement fraud is highly prevalent while 67% of consultants and 42% of Government Ministry respondents agreed.

The respondents felt that some contractors acquire contracts fraudulently with 75% either agreeing or strongly agreeing. Government Ministry respondents felt most strongly about some contractors acquiring contracts fraudulently with 92% of them either agreeing or strongly agreeing while 83% of contractors and 78% of consultants also either agreed or strongly agreed.

All the respondents agreed that procurement fraud is a big problem in Zambia. Incidences of procurement fraud are thought to be fairly high with 82% of the respondents either agreeing or strongly agreeing that the incidences are rampant. All the contractors and 90% of the consultants responded that the incidences are rampant while only 42% of Government Ministry respondents felt that the incidences are rampant.

4.3. Responses to Procurement Fraud

While 49% of all respondents expressed awareness of measures put in place to detect procurement fraud, only 22% and 28% of consultants and contractors respectively are aware of any such measures and all (100%) of Government Ministry respondents are aware. The majority of consultants and contractors are either not aware of any measures to detect fraud or they are not sure.

On whether the respondents are aware of anyone trained in the detection of procurement fraud, 26% responded expressed awareness while the rest either did not know or were not sure. Only 11% of consultants and
contractors each and 58% of Government Ministry respondents were aware of any person trained in the detection of procurement fraud.

Procurement audits have been performed by 26% of the respondents. Most of the audits have been performed by Government Ministry respondents with 58% of them indicating that they have performed an audit while none of the consultants have performed any audit and 17% of contractors have performed an audit.

The majority of the respondents (82%) are aware of procurement audits being performed and 18% are either not aware or not sure of these audits. All (100%) Government Ministry respondents and 78% and 72% of consultants and contractors respectively are aware of procurement audits being performed.

While 33% of the respondents feel that fraud mitigation measures are effective, 67% feel that these efforts are not effective. Consultants are the most pessimistic about the effectiveness of the methods used to mitigate procurement fraud with 77% indicating that the measures are not effective and 72% of contractors.

4.4. Fraud Challenges
Implementing and actively monitoring control mechanisms for procurement fraud is difficult to achieve as seen by 64% of the respondents. Only 36% of the respondents either disagree or strongly disagree that monitoring control mechanisms for procurement fraud is difficult to implement.

5. DISCUSSION OF FINDINGS
Some of the major causes cited for procurement fraud include the opportunity for it, the difficult of securing tenders, inadequate remuneration of tender evaluation staff and stiff competition. The construction industry in Zambia is characterised by quite a high level of competition which creates an opportunity for procurement fraud to be rife. Relatively low remuneration for tender evaluation staff also creates an environment where the likelihood of procurement fraud is high. Therefore, a stiff competitive environment coupled with relatively low remuneration creates a fairly high opportunity for procurement fraud.

The high opportunity for procurement fraud is often exploited by the project participants thereby creating an environment where the prevalence level of procurement fraud in the ZCI is fairly high. Respondents agreed that procurement fraud is a fairly big problem in Zambia.

While some measures have been initiated to detect procurement fraud, hardly any contractors nor consultants are aware of any such measures. On the other hand, all Government ministry respondents are aware of the measures initiated to detect procurement fraud. The measures
for fraud detection were initiated by the public sector and the private sector is largely unaware of these measures.

Hardly any of the respondents are aware of anyone trained to detect fraud with just over half of the Government respondents being aware of people trained in detecting procurement fraud. Procurement audits are the most common fraud intervention measures initiated and the majority of respondents are aware of procurement audits being performed. However, notwithstanding that fraud audits are performed, the respondents felt that these are not entirely effective in combating procurement fraud.

The majority of respondents felt that implementing and actively monitoring a control mechanism for procurement fraud is difficult to achieve. This presents a challenge to measures aimed at controlling procurement fraud.

6. CONCLUSIONS

The opportunity for procurement fraud is very high in the ZCI. This is exacerbated by very high competition for construction contracts and perceived inadequate remuneration for tender evaluation staff. The great opportunity for fraud created by competition and low remuneration for tender evaluation staff is usually exploited and therefore creates a fairly high prevalence rate for procurement fraud in the ZCI. The best way to mitigate against the high opportunity for fraud is to initiate a sound and strong governance, transparency and control processes which literature has suggested can lead to a reduction in the opportunity for fraud.

While the Government has initiated some measures to try and detect, mitigate or control procurement fraud, the private sector is largely unaware of these measures. For example, any measures by the public sector to train people to detect fraud are not reaching the private sector and are therefore not making much impact as can be seen from the high prevalence levels of procurement fraud. There is need to publicise measures aimed at detecting fraud as this will create a deterrence for anyone considering to engage in procurement fraud. Literature has shown that when offenders feel that there is a low chance of being caught against a good chance of making a huge sum of money, they feel motivated to engage in fraudulent activities. Therefore, by publicising measures aimed at mitigating procurement fraud, potential offenders are alerted to the possibility of being caught and thus deterred from engaging in the activity.

Procurement audits are the most common measures against procurement fraud in the ZCI. Clearly the procurement audits have not yielded much result. Forensic accounting, which has been suggested as a solution to procurement fraud, coupled with fraud auditing may present a more effective measure in combating procurement fraud. Other measures suggested, which need to be considered in the ZCI include internal controls.
7. REFERENCES


Collaboration as a Strategy of Student-Centered Learning in Construction Technology

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ABSTRACT

Purpose: Student centered learning has been deemed to be a catalyst for students to generate knowledge in different disciplines in comparison to lecturer/teacher centered learning process. The main objective of this paper was to observe the collaboration of students towards learning construction technology 3 at the University of Johannesburg via group work.

Research methodology: Observation was undertaken as a means of gathering data in during construction technology group work/assignment presentation. A total of ten groups were formed from the class register. A common group work was posted to the students via their ulink, an online technology for lecturers to communicate academic information with students at the University of Johannesburg. The information consisted of students’ instructions, the questions, date and venue for the presentation.

Findings: The students asked questions to the groups that had presented their group work. Furthermore, working in groups led to class involvement of the students.

Limitations: The use of observation in this study was a limitation.

Practical implication: This research study provides the basis of understanding that collaboration via group work would influence the students to be involved and understand their academic work.
Value: The findings indicate that students were involved in learning as they asked questions after the group discussions. However, the strategy is time consuming especially with large classes.

Keywords: Collaboration, construction technology, student centered-learning,

1. INTRODUCTION

Lectures originated as a necessary component of the oral tradition. Even when the printing press made it possible to collect information within bound volumes, these books were rare, precious, and expensive items well beyond the access of most students. When printing and copying techniques became more accessible and affordable in the 20th century, information rapidly became more accessible to students, yet was rarely sufficient without an instructor’s guidance. The deployment of the internet in the late 20th century dramatically expanded both the amount and types of information readily accessible to both students and faculty. This effectively reduced the information divide between lecturers and students (Lom, 2012).

Even with this evolution of information access, instructors continue to be necessary components of the learning process by organizing, explaining, and contextualizing relevant information. Technology has increased lecturer’s delivery options to make images, animations, and videos common in today’s lectures (Craig and Amernic, 2006). At some institutions lectures are routinely recorded and then subsequently made available as podcasts and/or videos so that students have the opportunity to review the lecture (Owston et al., 2011; Vajoczki et al., 2011). Consequently, experiences that were traditionally ephemeral can now be recorded and stored in perpetuity. Not only has technology made information more available, it has also made people to be more available. Students in a lecture hall can interact with guests via videoconferencing, Skype, and other technologies. Inviting an expert to class, interviewing a scholar, or collaborating with students at another institution, greatly expands the walls of modern classrooms in exciting new ways (Lom, 2012).

For centuries, professors appropriately taught through traditional lectures because students could not practically obtain full access to content central to the course. Today information is rarely the limiting factor in a student’s education. Thus, modern pedagogy is gradually shifting the professor’s role from “sage on the stage” to “guide on the side” where helping students manage their information is critical to learning (King, 1993; Saulnier, 2009).

In addition to the evolution in information access and delivery, in recent years numerous studies have demonstrated that traditional lectures that rely
on passive learning are not as effective as active, student-centered learning strategies (Tanner, 2009).

2. STUDENT-CENTERED LEARNING vs TRADITIONAL APPROACH

Student-centered approaches are often defined by contrasting them with traditional instructional approaches characterized by greater teacher direction (Cuban, 1983). Key differences between the two approaches include goals, roles, motivational orientations, assessments, and student interactions, as discussed hereto:

*The goal of student activity:* In teacher-directed instruction, students work to meet the objectives set by the lecturer/teacher. In contrast, in student-centered learning, students work to provide a response to a central question. Since students must sort out for themselves what they need to do and know in order to develop this response, student-centered approaches are more likely to promote student ownership over their process and learning than do teacher-directed approaches (Pedersen and Liu, 2003).

*The role of the lecturer/teacher:* In teacher-directed instruction, the teacher sets learning objectives, and then plans a set of activities designed to help learners meet those objectives. In student-centered learning, the teacher presents the central question (issue, case, problem), and then works as a facilitator as students determine the nature of the response they will develop, and then formulate and carry out a process to develop that response. Teachers help students to work through the difficulties they encounter by questioning them and helping them to identify alternative paths or resources, but they do not resolve these difficulties for the students (Pedersen and Liu, 2003).

*Students’ motivational orientation:* Teacher directed approaches often depend, at least in part, on extrinsic motivators, such as grades, degrees, or other rewards, to motivate students’ efforts to learn. In student-centered approaches, teachers attempt to present a question that is interesting enough to motivate students to take ownership of the process of developing a response. As a result, students’ actions are driven by the goals they have set for themselves rather than external rewards promised by a teacher or institution (Pedersen and Liu, 2003).

*Assessment:* In teacher directed instruction, teachers use assessments to determine grades, which in turn are used to motivate students and provide parents with information about their children’s progress (Kohn, 1994). Assessment is often based on objective tests, which, Shepard (2000) pointed out, is consistent with a model of education based on a social efficiency curriculum and behaviourist theory, but which is at odds with the principles of constructivism that currently guide efforts to develop student-centered learning activities. Shepard instead recommended the use of open-ended assessment techniques that are designed to involve students in
examining their own learning, focusing their attention on their learning needs and changing understanding rather than on a grade.

**Student Interaction:** The success of the cooperative learning movement according to National Center for Educational Statistics, (1999) has resulted in an increase in the amount of interaction between students during teacher-directed instruction. This interaction, however, is frequently under teacher control, with teachers determining group membership, the nature of the interactions between the members, and even the role each member of the group plays. Lecturers/teachers intervene in the group process when there are difficulties, and hold the group accountable for individual learning.

Bruffee (1995) argued that the structure and vigilance teachers provide during cooperative learning tends to undermine students’ control over their own process. Instead, student-centered approaches, which also assume a great deal of student interaction, are more in keeping with collaborative learning than cooperative learning. Collaborative learning emphasizes students’ self-governance of their interactions, allowing them to make decisions about with whom they work, and how. As students negotiate their relationships with each other, they must articulate their ideas, and engage in a disciplined social process of inquiry; these activities are in keeping with constructivist principles and the goals of student-centered learning.

3. **THE MAJOR CHALLENGES IN IMPLEMENTING STUDENT-CENTRED LEARNING APPROACHES**

According to Na (2012) the learning and instructional models show some common challenges in implementation, namely;

- Traditional teaching and learning models can be robust, and it is difficult for the students and teachers to change their roles. The constructivist and student-centred learning models are even more difficult to implement in cultures where transmissive instructional models are pervasive.
- Although a variety of educational objectives are emphasized in the curriculum guidelines across cultures, the lack of guidance and ambiguity of the implementation strategies, and the inexperience of school and/or (college) staff and teachers might lead to superficial implementation.
- Many factors such as age-related constraints need to be addressed in implementing these learning approaches, and these need to be included in the articulation documents.
- Although emerging technologies provide opportunities for implementing various constructivist and student-centred learning models, they may not be effectively and appropriately used in the classroom due to the inexperience of curriculum designers and lecturers and teachers.
Furthermore, according to Keengwe, Onchwari and Onchwari, (2009) while active learner-centered pedagogy is desirable in current educational practices, issues such as time could affect its successful implementation in the classroom.

4. COLLABORATIVE STRATEGY TO STUDENT CENTERED-LEARNING

In curriculum reform collaborative teaching was a transformational method emphasizing teaching innovation. It overthrew the traditional belief of teachers being senior to students. Following the learning goals, with a variety of learning methods, better learning effectiveness can be achieved by giving students more opportunities to be guided. Moreover, with remedial teaching, students of different levels could be modulated. In student-teacher interactions, the ability to solve problems and make logical thinking would be developed. Therefore, it is believed that collaborative teaching has more positive influences on learning effectiveness than individual teaching does (Bullough, Young, Birrell, Cecil & Winston, 2003; Hoogveld, Paas & Jochems, 2003; Vidmar, 2005).

It is also believed that collaborative teaching can provide teachers more opportunities to get involved, overcoming teaching difficulties, stimulating the growth of professional knowledge and abilities and learning from each other. In addition, integrated teaching activities could bring up students’ interest, so they could start further discussions on certain topics, to achieve learning goals and to help them create a more pluralistic space (Moran, 2007; Trent, Driver, Wood, Parrott & Martin, 2003; Huffman & Kalnin, 2003; Rathgen, 2006). The key factors of collaborative teaching’s success are teachers’ experiences, personalities, working styles and attitudes toward learning (Garcia-Morales, Lopez-Martin & Llamas-Sanchez, 2006; Perry & Stewart, 2005).

4.1 Difficulties and Suggestions

The difficulties of implementing collaborative teaching include: personnel organization, space and equipment, lack of specialized skills required in the related fields, collaborative teaching schedule arrangement, constant interruption at work site, time pressure, extra burdens and lack of support from school administration. These problems are waiting to be solved (Chen, 2005; Guo, 2006). Secondly, it takes time to coordinate conflicts and problems among teachers, so that teachers with different cultural backgrounds can be blended to come up with a more pluralistic teaching method (Carless, 2006; Darling-Hammond & Snyder, 2000; Pugh & Zhao, 2003).

Suggestions for the implementation of collaborative teaching include: Schools should encourage teachers to adopt collaborative teaching in a
single subject to build a collaborative environment. A group of 3-6 teachers must leave behind individualism to create a culture of collaboration among teachers and stimulate each other’s professional growth (Jang, 2002; Lai, 2004; Su, 2003). Through collaborative teaching, both teachers and students could learn the importance of cooperation and teachers can demonstrate their professional specialties. Of course, any insufficiency could also be patched by other teachers. Thus the relationship among teachers would be improved. Therefore, it is suggested to look for more and better ways of applying collaborative teaching patterns to meet the needs of different types of students (Moran, 2007; Rathgen, 2006; Vidmar, 2005). This strategy of active learning was introduced for Construction Technology 3 students at the University of Johannesburg.

4.2 Construction Technology

Construction Technology is one of the three major subjects for undergraduates pursuing National Diploma in Building at the University of Johannesburg. The subject is very practical and requires the students to visualise drawings in 3 dimensions and understand how different parts of a building are assembled. This has been a challenge to students pursuing this qualification at the tertiary institution. The group discussion topic assigned to the students was suspended ceiling and drywall partitions. The questions formulated were:

- Describe the components that are required in assembling a suspended ceiling and draw a suspended ceiling with a grid layout of 600mm x 600mm in a room which is 3600mm x 1800mm
- Describe with the aid of drawings three types of bulkheads
- Describe the different types of access floor panels
- With the aid of drawing describe access floor understructures
- With the aid of drawings describe drywall partition systems

Based on the above discussions, so far there has been little research on collaboration strategy via group work as a catalyst to assist students in learning construction technology at the university. In order to achieve the stated problem the specific research objectives delved into were:

- To observe the students active involvement in learning construction technology 3 using collaboration strategy of group work; and
- Determine the challenges in using collaboration strategy of group work in student centered learning.

4. RESEARCH METHODOLOGY

A qualitative approach based on case study was used for this study. The case study was 3rd years National Diploma Building students registered construction technology subject. Observation was used to collect data. This
Collaboration as a strategy of student-centered learning in Construction

The approach was deemed appropriate as the researcher (lecturer) was part of the research process. Ten groups were formed from a class register of 90 registered students. This process was met with challenges from students as they were used to their friends and found it difficult to accept this method of group formulation.

The breakdown of the assignment was discussed in class prior to sending it to the students via the ulink process. Ulink is an online technology for communicating academic information between the lecturer and the students registered for a particular subject at the University of Johannesburg. This online technology allows lecturers to post study materials, assignments, notices etc. to the students.

5. RESULTS AND DISCUSSIONS

5.1 Descriptive statistics on demographic information

All the 90 students who took part in the group discussions attended the class presentations. They were inclusive of all races i.e. Africans, whites and Indians. The male and female students were equally divided.

5.2 Findings of group work presentation

The group work was presented in class. The lecturer acted as a facilitator and observer, not a “sage on the stage”. It can be indicated that the students were involved in the learning process as they asked questions and gave comments to add to the discussion once the second group had finished their presentation. One student commented that “there is another method used to assemble suspended ceiling which they found in there group” this was an additional method from the two that were presented by the first group.

In line with the students’ involvement in each group, the group members indicated those who were actively involved in preparing the work as this was reflected in their attendance list per group during their preparation. This attendance register per group could assist the lecturer to know the members who were actively involved and those who were not, hence the group members could award marks for each individual member. It is quite interesting to note that students in the groups that presented supported one another in discussions and answering the questions.

Before the presentations of the group work, a member of one group that presented their work, came to inquire about the drywall partitions, i.e. if they had the correct information and if the presentation was correct. As the facilitator/lecturer, I did not give the answer to the student, but gave the student direction and hints. This is in line with the recommendation of Pedersen and Liu, (2003) on student-centered learning approach, where the lecturer is a facilitator and directs the students.
In terms of technology usage on the presentation, the students were technologically savvy. The power point presentations were presentable and easy to follow and read.

5.3 Challenges in implementing group work

This study also established different challenges these were: time constraint to ensure that each group presented their work. The time for each presentation including questions and comments was 35 minutes each period lasts for 1 hour 30 minutes. This time frame scheduled in the time table was not enough for all the ten groups to present their discussions. Furthermore, the venue for presentation was year marked as an exam venue, hence it was locked. As a lecturer I had to find an alternative venue which consumed on the allotted time for the lesson. These observations were in line with the findings of Chen, (2005) and Guo, (2006).

Furthermore, the students were hesitant to ask questions at the beginning, but with motivation from the lecturer who was the facilitator they were able to ask and give comments. This might have been due to the fear that members from one group want to challenge members from other groups.

6. CONCLUSIONS AND RECOMMENDATIONS FOR FUTURE STUDY

Through observation, this study established that students were involved in their learning process as they were actively involved in their group work and class presentation. They asked questions and gave comments based on their peers’ presentation. Furthermore, the lecturer acted as a facilitator during the process of class presentation and also out class environment. The students also had the sense of enhancing their technology ability and this was verified by the student ability of being computer savvy. However, time constraint due to lack of venue was a key challenge to allow all the groups to present their work.

Further research is advocated based on students’ survey in order to establish the benefits of using collaboration via group work as a strategy for student centered-learning for construction technology. The researchers are also advocating for the students to be interviewed.

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Creating a Collaborative Classroom: A Partnership Between Industry and Academia

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ABSTRACT AND KEYWORDS

Purpose of this paper
This study describes the process of creating a collaborative classroom through the shared efforts of students, faculty, industry, and the university administrators.

Design/methodology/approach
This paper is a case study analysis of the process of designing, funding and constructing a classroom equipped to meet both the physical and technology needs of a collaborative learning environment.

Findings
Both students and industry professionals found the collaborative classroom a rich learning environment. Instructors found their classroom role changed from lecturer to facilitator.
Research limitations/implications
This study was limited to the analysis of a single case in which a traditional classroom was remodeled into a collaborative classroom with industry specific computer technology.

Practical implications
A collaborative classroom shifts teaching methodologies to self-directed and project based learning while students gain experience working in teams.

Originality/value:
This paper presents a transformational upgrade for design and funding of future educational classrooms.

KEYWORDS
Built Environment, Collaborative Classroom, Construction Education, Construction Technology, Project Based Learning

Response to conference theme and outcomes:
Work in the Built Environment is becoming more collaborative in nature. The collaborative classroom is a unique method of integrating built environment students with both industry and industry professionals using current industry technology.

1. INTRODUCTION

Minnesota State University, Mankato, USA has adopted the following five Strategic Action Steps (Our Strategic Vision: 2010-2015, 2014):

1. Change the world by collaboratively addressing our planet’s most challenging problems
2. Foster the thriving and robust academic culture of a university with applied doctoral programs
3. Greatly expand the reach of our extended learning programs
4. Reinvigorate our physical home and build the campus of the future
5. Measure and continuously improve our work to ensure excellence in all that we do
The design, construction and use of the collaborative classroom advances four of the five strategic action steps adopted by the university. Only Step 2, concerning doctoral programs, is not addressed with the project.

Step 1, “Change the world by collaboratively addressing our planet’s most challenging problems” is the most significant Strategic Action Step addressed by the Collaborative Classroom project. The project was an effort that involved the participation of the Construction Management Department, the Construction Management students, the Construction Management Advisory Board, and Minnesota State University, Mankato.

The collaborative effort addressed the relevance of current educational pedagogy. The New Media Consortium (NMC) Horizon Report: 2014 Higher Education Edition (Johnson, 2014), states that keeping education relevant is one of the “Wicked Challenges: Those that are complex to define, much less address.” The international report emphasized that, “The paradigm [lecture style education] that has worked for over a century is gradually becoming obsolete” (Johnson, 2014).

A significant amount of the management work in the current Built Environment industry is collaborative work. Industry professionals develop design, estimating, planning and scheduling, project management, and project controls requirements for projects. Their work is typically performed in teams, with industry professionals often located in diverse areas.

Traditional classrooms, with multiple rows of students facing the instructor, are not conducive to exercises related to collaborative work. Classrooms that enable students to work in a collaborative environment, developing communication skills and presentation skills along with the technical skills that are highly valued in industry, give students a more realistic environment in which to train for their future work.

Michaelson, Knight, and Fink (2002), write extensively about team based learning, the use of small groups to shift education from lecture by instructor to student application of concepts. One of the significant challenges addressed by Fink is maintaining the involvement of all group members. The authors recommend use of the “flipped classroom” method. The key to a “flipped classroom” is the assignment of reading in advance of the class and then a two-step quiz process when students come to class. The first quiz is an individual quiz with the second quiz a group quiz. Both quizzes count toward grades (Michaelson, Knight, & Fink, 2002). The flipped classroom is but one example of a shift in pedagogy from the traditional lecture oriented method of teaching.

The Minnesota State University, Mankato Construction Management program helps to educate and train the world’s current and future
professional constructors. In doing so, the use of effective and proven pedagogy such as active learning, the flipped classroom, collaborative, peer, and team-based learning activities is paramount. This collaborative classroom is a transformational upgrade that will lead to better learning experiences by helping students learn to work in teams, solve problems and think critically in preparation for their careers in the built environment.

Action Step 3, “Greatly expand the reach of our extended learning programs” is addressed through the use of technology. One exciting concept is the use of the individual table monitors to create a Skype-like interface at each table in order to connect to students at other campuses, either close to home or globally.

Opportunities to work in teams across the internet abound. The classroom renovation advances Strategic Action Step 4 by replacing an outdated classroom environment with the newest and arguably highest available level of teaching and learning technology. State-of-the-art and discipline-specific technologies are very relevant to the future of both teaching and learning. In fact, the teaching of technology is instrumental to the university providing the best education possible. Recent student feedback clearly indicates a need to incorporate more current technology and pedagogy into the courses. The collaborative classroom space will increase self-directed learning and place the instructor in a role of facilitator rather than the traditional teacher.

Strategic Action Step 5, “Measure and continuously improve our work to ensure excellence in all that we do” is addressed through expected student learning outcomes. The collaborative classroom is expected to improve communication skills as measured in the department assessment plan, improved national professional exam scores, and improve results from interscholastic student competitions.

2. PROJECT DESIGN

Previously, the classroom in Wiecking Center 349 on the campus at Minnesota State University, Mankato was set in a very traditional manner. Rectangular shaped tables were in rows and 39 chairs faced the instructor. The classroom had a white board with markers and a VGA connection for a faculty laptop with a ceiling mounted classroom projector. There were cabinets on one side of the room with a functioning utility sink built into the countertop, all leftovers from previous remodels of the room.

The first step in the visioning process was to solicit feedback from senior level students on the potential project. A faculty member used the
idea as a classroom project and assigned groups of students to creatively design the space into what they would want in a classroom. Four different concepts were put forward by the groups of students. After review by their peers, the Construction Management Department faculty, and by the Facilities Management staff, the design in Figure 1 was put forward to the Construction Management Advisory Board. The Advisory Board is a group of industry experts which advises the department on a regular basis.

The Advisory Board supported the concept of a collaborative classroom. As representatives of the construction industry, they were aware of the need for a forum in which to practice communication and presentation skills. The group also pledged to raise $40,000 to help with the costs of the classroom.

![Figure 1. Best of class student design](image)

With support from the Advisory Board in hand, the Department submitted an application to the University for Strategic Priority Funding. Strategic Priority Funding is a competitive process within the University. Groups who would like funding for specific projects apply for the funding, the projects are peer reviewed and prioritized, and the university administration funds the projects as money is available. The collaborative classroom was
chosen to receive $70,000 in funding from the Strategic Priority Funding initiative.

The project was also supported through the College of Science, Engineering and Technology with an Institutional Equipment grant of $45,000 which helped fund the technology infrastructure for the room. The Information Technology Services for the university also agreed to contribute $25,000 to the project.

At the same time as the funding proposals were being written, the Construction Management Department chose to pay a local architect to draw plans for the classroom. When funding was approved through the multiple sources, the design was modified to incorporate an additional hallway and office space into the new classroom. Figure 2 is one of the final drawings from the architect prior to construction.

The bid process, controlled by the Facilities Management Department, used a traditional design, bid, and build method. The bid solicitation was sent out for the approved contractors and bids were opened according to university policy. The general contractor then selected the subcontractors to work on the project.

![Figure 2. Classroom design drawings from architect](image-url)
Construction began early in the summer of 2013, with the General Contractor doing the demolitions in the room. Asbestos abatement followed, along with the air monitoring for dust. The electrical service was updated, the wired internet service was upgraded, a new wireless internet system was installed and new lighting was installed. Walls were refinished, new carpeting installed and a new door with electronic access was installed. Figure 3 is a construction photo.

![Construction photo after demolition](image)

Figure 3. Construction photo after demolition

The room was ready for use at the beginning of fall semester 2013. Figure 4 is a photo of the room upon substantial completion, a point where classes could safely be held in the space. Most of the courses scheduled in the room are senior level classes with 25-30 students. The room is spacious, allowing for groups to work at their tables without undue disruption of other groups of students. The monitors on the wall give each group of students access to a close-up view of the documents shown by classmates for their group work, by the instructor for all to view, or by any one of the groups for all of the other groups to view. There are no desktop computers in the room.
As part of the vision from the Construction Management Department, the decision was made to make the space more collaborative and also friendly to the “bring your own device trend.” The classroom is a computer lab that allows all types of classes to use it. However, there are no desktop computers in the classroom. The room organizes the students into groups and enables the teacher to more easily use collaboration, peer learning, active learning, and project based learning.

The classroom is designed with 7 collaborative workspaces each seating 5-6 students. Each table has a wall mounted 40” screen at the end of the table and a control module that has both HDMI and CAT 6 laptop connections for each student, allowing the student to use his or her own laptop. The instructor station has a touch screen control panel that allows selection of either or both of the front-facing projectors, the overhead document camera, or any of the student screens. The faculty member is able to take any one of the student screens and show them on the classroom screens and also show his or her screen to each of the other groups of students.
3. FINDINGS

During fall semester 2013, two students (Starke & Meyers, 2013) submitted a poster presentation to the Undergraduate Research Symposium at the university. The purpose of the project was to determine student opinions of the new classroom. Figure 5 shows both the questions and the results of the survey. Two classes, totally 48 students, were surveyed. The first question in the survey was, “Did the classroom, during the first semester of use, meet the needs and expectations of the students?” From the students surveyed, 80% felt the classroom environment provided an improved learning experience. For Question 2, when asked about how the classroom affected working in groups, 95% responded that the new classroom made working in groups more efficient. Student responses for Question 3 were 75% affirmative that their learning was improved by the use of the classroom. Only 60% of the students responded in the affirmative for Question 4, about using the room to its full potential. Question 5, a follow up to Question 4, indicated that the reason the room was not used to its full potential was that the professors needed to understand the technology better.

Figure 5. Starke and Meyers (2013) survey results

Final Question: How can the new classroom be used to its full potential?
The technology needs to be better understood by the professors themselves
One student response also included:

“The new classroom gave our class the opportunity to estimate a project easily in groups of five and turn in bid packages competitively on ‘bid days,’ with each group presenting in front of the class on the large projectors. The large room allowed us, as students, enough space to work without disturbing each other. The tables themselves were large enough for all members to examine full size plan sets. The technology allowed every student to not only show his/her work to the group, it also allowed every student to follow along with class lectures.”

Twelve Industry Advisory Board members were surveyed about the classroom. Responses were 100% positive. Each individual felt the classroom was a good investment of time and money. It was agreed that teaching current technology to the students was necessary as part of their program. The one caution was that use of technology should not substitute for either industry specific technical knowledge or personal communication and presentation skills. Industry representatives also found the room could be useful as a setting for certification training, for collaborative project meetings, and for video conferencing.

4. PRACTICAL IMPLICATIONS

The space has already impacted the students and the faculty in very positive ways. It is much more flexible and allows the professor to adjust his or her teaching style to meet the needs of the students and their future work environments. Students have an exciting and engaging atmosphere in which to learn. The renovation is a significant step toward a campus of the future, where students are able to receive the best possible education, become critical thinkers, and change the world for the better. This re-designed classroom will start a new wave of teaching, learning and function within the built environment courses at Minnesota State University, Mankato. The courses designed to be taught in a collaborative setting, including virtual design and construction, building information technology, estimating, scheduling and project management, will better enable students to be prepared for transition to their professional roles in industry.
Noted by the Starke & Meyers (2013) survey, the competency of the faculty with technology is a serious concern. That concern is echoed in the NMC Horizon Report (2014). In the section titled, “Solvable Challenges: Those that we understand and know how to solve,” is a portion addressing digital fluency of faculty. The report states, “This challenge is exacerbated by the fact that digital literacy is less about tools and more about thinking.”

The newer collaborative-style classrooms require significant investment dollars for infrastructure. With today’s tight education budgets, it is difficult to acquire funding for new initiatives. The collaborative classroom was a result of matching funds from the university, the college, the IT service division, the Construction Management Department and the Construction Management Advisory Board. Funding for future classroom development will likely follow a similar collaborative model, with many partners opting to contribute to the project.

The redesign and remodel of the classroom provides the capacity to ensure that students and faculty are placed in a rich learning environment that will positively impact the outcome of students entering careers in the Built Environment.

5. REFERENCES


APPENDIX A One page summary of the project from Oleson & Hobbie Architects
Wiecking Center - Construction Management
Collaborative Classroom 349

MINNESOTA STATE UNIVERSITY, MANKATO
WIECKING CENTER CLASSROOM 349 REMODEL

PROJECT INFORMATION
YEAR
2013

SIZE & SCOPE
1,480 sf remodel

RESPONSIBILITIES
Architecture
Interior Design
Engineering

CONSTRUCTION COST
$67,304.00

CLIENT CONTACT
Dr. Leah Roue
Construction Management Department
Minnesota State University, Mankato

PROJECT DESCRIPTION
MSU, Mankato and the Construction Management Department commissioned Oleson + Hobbe Architects to create a new classroom from three existing spaces in the Wiecking Center. The new classroom was to be a unique, innovative technology classroom that could be used for 35 plus students in a collaborative construction management learning environment. The Big Idea behind the design of the space incorporated collaborative learning tables that use technology to connect a student to the team to the classroom and beyond. The room itself became a learning environment and an educational tool by exposing the roof structure and decaying for students to observe through the existing ceiling suspension grid.

OLESON + HOBBE ARCHITECTS
A Framework for Quantity Surveyors’ Educational Training: Nigerian Perspective

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ABSTRACT AND KEYWORDS

Purpose of this paper
The purpose of this paper is to develop a framework for quantity surveying educational training.

Design/methodology/approach
Delphi survey research approach was adopted for the study. This involved a survey of panel of experts, constituted among registered quantity surveyors in Nigeria, and obtaining from them a consensus opinion on the issues relating to quantity surveying education. Twenty seven out of the shortlisted thirty eight member panel provided valid results in the two rounds of Delphi survey conducted.

Findings
The findings provide consensus on the admission requirements, requirements for award of degrees and curriculum for quantity surveying in Nigeria.

Research limitations/implications (if applicable)
The research, which is limited to quantity surveying profession, has far reaching implications on the Nigeria construction industry.

Practical implications
The practical implication of the research is demonstrated in the suitability of the proposed framework as a basis for admission requirements, requirements for award of degrees and curriculum development for quantity surveying.

**Originality/value of paper.**
The outcome of the paper has proposed a new direction for quantity surveying education in Nigeria.

**Keywords:** Educational training, quantity surveying, curriculum, Nigeria

1. **INTRODUCTION**

The quantity surveying profession has a long history in the building industry. The profession faces threats to its traditional roles and function as a result of changing client needs and advances in technological drive (Matzdorf, *et al.*, 1997). Moreover, globalization has led to increased information flow. New challenges and opportunities availed by the highly competitive environment and new technology calls for adoption of new strategies by organisations. The construction industry is changing and the advent of ICT poses a lot of challenge to construction professionals. The answer to these challenges will be through a pragmatic view of the current curricula which form the basis for the training of quantity surveying in Nigeria. Calls are being made for a richer conception of curriculum which nurtures the personal competencies and skills to enable quantity surveyors to continue to learn and navigate the complex information and cultural landscape of a globalised world. In light of this, Ogunsemi (2004) examined the weakness of the existing quantity surveying curriculum in the face of emerging challenges in national economic development. He discussed the yardsticks as well as the current challenges in a growing economy like Nigeria and went further to assess the level of performance of the current quantity surveying curriculum being run in higher institutions. He established the need for new areas where knowledge must be advanced so as to meet with the challenges of our time.

The main objective of this paper thereof is to establish a framework for educational training of quantity surveyors in Nigeria with a view to meeting the current challenges. This is with emphasis on admission requirements, requirements for award of degrees and curriculum for quantity surveying degree awarding institutions. The findings of the Delphi survey, conducted on a panel of expert, investigating these requirements are presented. The paper starts with a review of relevant literature followed by a description of the research method and presentation of the research findings. The main findings are discussed and conclusions drawn with appropriate recommendations.
2. LITERATURE REVIEW

Concept of Educational Training

Educational training can be considered an integral part of organisation learning and change. The primary rationale for educational training is to adapt employee qualifications to job requirement (Krogt and Warmerdam, 1997), but it can also act as a conduit for linking organisational strategies and goals (Porter, 1985; Andrews, 1987; Sleezer, 1993). From education and training perspective, Buckley and Caple (2004) have stressed the need to understand the differences and similarities between education and training. It can be argued that there is no clear ‘dividing line’ between education and training. However, Buckley and Caple (2004) highlighted some distinctions between education and training in respect of process, orientation, content and the degree of precision. While the process of education tends to manifest over a long-term period, training provide observable short-term outcomes. In terms of precision, training usually involves the acquisition of behaviour, facts, ideas, and is more job-oriented whereas education is claimed to be person oriented and less amenable to precise definition. The definition of educational training in the context of this paper involves a comprehensive package prepared to equip an individual with specialized skills to function in a particular context. This is different from professional training often regarded as continuing professional development – a form of adult education albeit for highly-educated individuals (Ariffin and Torrance, 2008) which involves learning new skills, and/or updating existing knowledge and skill.

In many countries of the world, the construction industry suffers from a lack of high quality profile status. This has been attributed to the difficulty in recruiting high-quality entrants direct from secondary school (Birch et al., 2005). Even at the primary and secondary school levels, often is the school curriculum taught in the context of construction. Whilst some professions have natural links from subjects studied at school, e.g. Economics to Financial Services, Law to Legal profession and Biology to Medicine, construction generally enjoys no such links. For the construction professionals, there are certain basic and important skills and knowledge that are expected of them. These skills and knowledge are better learned at academic institutions and preferable, at tertiary institutions (Chan et al., 2002). In essence, they needed to be placed in a more appropriate educational framework to ensure their continuing relevance. With the recent developments in the industry and the recent explosion of information technology, the academic institutions are finding it almost impossible to disseminate all pertinent and available information and skills relevant to these
professions. Alshawi et al. (2007) captioned this very well in that traditional training and education models currently in use are often criticized for the lack of coordination between the industry needs and the actual education training delivered.

In this context, educational establishments need to tailor the specific content of their provision to meet the needs of employers through a set of tangible advantages – the remit of which requires close collaboration between the academic community, industry and professional institutions (Tener, 1996; NWDA, 2004). In this regard, education is required to give students exposure to more than the academic aspects of the construction process. A proactive approach should therefore, be initiated to make education curricula more adaptable to the ever "changing-needs" of the built environment, thereby embracing the capabilities needed by graduates.

**Need for Review of Quantity Surveying Educational Training Programme**

In a complex and dynamic industry environment the role played by the various professions is likely to fluctuate and change. New techniques may make some traditional roles obsolete and others may be greatly altered in scope and responsibilities (Hardie et al., 2005). Brummer (2004) showed that trends in the construction industry are continuously changing and innovative procurement systems are part of the reality of future services.

The quantity surveyor must improve his basic services. He needs to transform his estimating role from a compiler of past cost data to an analyst and a forecaster in the construction market. He needs to rely more on the market knowledge and supply chain and be more innovative to re-assert his value in his estimating and accounting roles. To create extra value, it is not sufficient that the quantity surveyor expand the range of service, but he needs to be able to drive and influence the team at a more strategic level to achieve better results. Ajanlekoko (2012) emphasized this in the need for quantity surveyors to move away from being a “thermometer” (reader of temperature) to being a “thermostat” (controller of event) in the 21st century. If this is going to be, he called for a culture change and attitudinal development of quantity surveyors. He needs to re-package and market his services, which must cater for the market needs, and relate them to the benefits for the client (Hiew and Ng, 2007).

It is however patently clear that some very relevant developments may influence the future. The stakeholders in the profession should understand this and be prepared to participate in a pro-active manner. By understanding these future scenarios, the cost engineer or quantity surveyor will develop the skills to play a role in the changing world and may therefore survive and grow a professional (Le Roux, 2004). Whilst many have
An Overview of Existing Quantity Surveyors’ Educational Training in Nigeria

There have been calls for the improvement of the current quantity surveying programme in order to meet up with the challenge of time. Ogunesmi (2004) advocated for pragmatic overhaul and review of the current curricula that form the basis for quantity surveyors’ training in Nigeria. In Nigeria, the National University Commission (NUC) specify the minimum academic standards for undergraduates programme in the Universities while the National Board for Technical Education (NBTE) stipulates the minimum standards for all diploma programmes in Polytechnics. A cursory look at the specified current standards, as they relate to admission requirements, requirements for award of degree as well as programme curriculum, reflect some lapses which need to be improved upon.

To be eligible for admission to undertake a degree programme in polytechnic and university, candidates must have at least five credits in the Senior Secondary Certificate or its equivalent in English Language, Mathematics and three subjects from Physics, Chemistry, Fine Art, Technical Drawings, Economics, Geography, Further Mathematics and Biology. The inclusion of Fine Art and Biology is seen as not necessary as they have no bearing with quantity surveying profession. Direct entry of students from National Diploma (ND) and Higher national Diploma (HND) programmes to university is another problematic area. There has been a lot of argument and dichotomy on whether a HND holder be admitted to part three or part four in the university. This has created a serious debacle in the profession and there is a dare need to streamline this for the betterment of the profession.

In the area of curriculum, the ND, HND and B.Sc. programmes are centered majorly on general studies, foundational courses and professional courses. Courses such as management/leadership, entrepreneurship, communication, process/heavy engineering, operation research, risk management, project management and value engineering were down played. Another important area is environmental economics and social accounting. These include the examination of the repercussions of decisions as they affect amenities and human activities beyond the boundaries of the project.
under examination. Complex environmental problems such as deforestation, desertification, erosion and pollution control as well as coastal protection are areas the profession must be able to provide cost advice most especially now that issues like this had continued to attract funding from international organisations (Ogunesmi, 2004).

From the foregoing, it is pertinent to look for pragmatic way of looking at these shortcomings and make a frantic effort for improvement. For the modern day quantity surveying educational to meet the challenges of dynamic economic development globally, there is dare need for the review of the existing training process.

3. RESEARCH METHOD

Delphi survey method was adopted in this research. The method involves survey of group of experts in a particular field and obtaining from them a consensus opinion by a series of intensive questionnaire interspersed with controlled opinion feedback. With the iteration of the questionnaire over a number of rounds, the individuals are given the opportunity to change their opinions and judgments without fear of losing face in the eyes of the (anonymous) others in the group. Occasionally, additional information may also be provided, such as arguments from individuals whose judgments fall outside certain pre-specified limits. Delphi process can be continuously iterated until consensus is determined to have been achieved (Hsu and Sandford, 2007). Worthen and Sanders (1987) stated that "iterative procedure can continue for several more rounds, but the payoff usually begins to diminish quickly after the third round. In this research, two iterations were conducted to obtain valid results. Majority voting was adopted as an alternative that can generate reliable findings without pressing for consensus in the few items where consensus were not reached after the second iteration. Ali (2005) adopted the same principle in his search for empirical measures of local planning agency power.

For the purpose of selecting appropriate experts involved in the survey, a panel of expert was constituted. A nomination letter was sent to each shortlisted participant to inform them of their nomination, the essence and process of the study and confirmation of their consent to be part of the survey. The panel was drawn from the Nigerian Institute of Quantity Surveyors (NIQS) and the institutions offering quantity surveying in Nigeria. The Chairmen of the functioning 27 state chapters were included in the sampling frame. Fifty percent (50%) of these (14 numbers) were randomly selected to be part of the panel. The numbers of public institutions offering quantity surveying in Nigeria are: 12 universities and 17 polytechnics. The Heads of Department of these institutions were listed in alphabetical order and seventy five (75%) of these (22 numbers) were randomly selected and invited to be
included in the panel (private institutions are excluded because their programmes are relatively young). The Chairmen of the Education Committee and Professional Development Committee of the NIQS were also included. In all, the total numbers of the panel of experts involved in the survey were 38. Two rounds of the survey were conducted to obtain valid results. A well-structured questionnaire was designed for the first round and another one designed, based on responses to the first round, for the second round. Both rounds were conducted via registered courier post and follow-up e-mail and text messages were used to remind and encourage prompt responses to the questionnaire. Round one started with a letter of confirmation and expression of appreciation to panelist for agreeing to participate. The letter also reiterated the purpose of the exercise and gave the guidelines for panelists’ response. This was mailed to the participants for them to comment on the proposed issues relation to the identified four aspects germane to the training and practice of quantity surveying in Nigeria. Twenty-nine out of the thirty-eight shortlisted panels responded to this round.

Round two informed the participants of the findings of the analysis of responses to the questionnaire of round one, and requested their final affirmation/comments on revised and added/suggested comments on the various aspects of the questionnaire. Twenty-seven out of the twenty-nine that responded to round one was retained. To examine the credibility of findings produced by majority voting, an interview was conducted on two quantity surveyors (one practitioner and another one in the academic) who did not participate in the survey and have decades of experience. The two interviewees attested to the credibility of the outcome of each aspect of the survey.

4. ANALYSIS AND DISCUSSION

Panel of Experts’ Information

Out of the thirty-eight member panel nominated, a total number of thirty-three shortlisted panelists responded to their nomination. Thirty-two of this agreed to participate while one declined. A total number of five shortlisted participants did not respond to their nomination. The information from the panelists indicates that majority (57.89%) of the panelists are head of quantity surveying departments of various institutions offering quantity surveying, 36.84% are chairmen of state chapter of the NIQS while 5.26% are drawn from the National Executive Council of the NIQS. This also indicates that the panelists were drawn from quantity surveyors in academic, private and public practice and this gives the guarantee of diversity in the experiences of the participants. With these categories and calibres of
quantity surveyors involved in the survey, there should not be any doubt in the outcome of the survey. Before any quantity surveyor can be the chairman of a state chapter, he/she must have acquired a lot of experience overtime and he/she must have been actively involved in the activities of the profession. Also, before somebody can be the head of quantity surveying department of any institution, he/she must have gone through the academic rigor and gather enough experience over time about the educational training of quantity surveyors. The involvement of two members of the National Executive Council is also seen to give high credibility to the outcome of the survey.

Majority of the panelist (55.17%) were M.Sc. degree holders, 17.24% have Ph.D. while only 10.34% had B.Sc. and HND qualifications. From the analysis of the professional qualification of the panelist, 75.86% of the panels are associate members of the Nigerian Institute of Quantity Surveyors while 24.14% are fellows of the institute. They are therefore adjudged qualified and competent to provide the needed information for the study and the information so provided can be relied upon. Further analysis shows that 75.86% of the panelists have more than 20 years practice experience, 13.79% have between 16 and 20 years of experience and 10.34% have between 11 and 15 years. The average practice experience of the panelists is 19 years. Together, on these general background results, it seems plausible to contend that the experts, who participated in the survey, are sufficiently experienced in issues relating to quantity surveying and this should give credibility to the data collected.

Educational Training of Quantity Surveyors

This section discusses the findings on quantity surveyors’ educational training. Firstly, it provides the admission requirement for entering the profession, followed by the requirement for the award of various degrees in quantity surveying. Findings on the syllabus for HND/B.Sc. curriculum and that of the ND in quantity surveying are also presented. The findings were established from the summary of the results of the final round of the survey.

Admission Requirements

From the result of the final round of the Delphi survey, there was a consensus on the admission requirements for the different categories of entrance to quantity surveyor profession are presented in Table 1.

The results give the minimum requirement as 5 credit pass in Senior Secondary Certificate Examination/National Examination Council (SSCE/NECO) or its equivalent in English Language, Mathematics, Physics, and any 2 subjects from Economics, Chemistry, Geography, Technical
Drawings and Further Mathematics. This result is not farfetched as quantity surveying requires the elementary knowledge of mathematics and physics which are needed for courses like engineering and technology. Specifically, Physics is needed in terms of house heating, lighting and ventilation. English language, of course, is regarded as basic for effective communication. Knowledge and background of Economics will be needed for construction economics, knowledge of Chemistry will be needed for some building materials components such as paint and cement; while the knowledge of Geography will be required for building components reaction to varying weather conditions and sustainable development. Technical Drawing and Further Mathematics are also needed for building designs and morphology. These requirements give a robust base to starting a career in quantity surveying.

<table>
<thead>
<tr>
<th>ND</th>
<th>HND</th>
<th>B.Sc.</th>
</tr>
</thead>
<tbody>
<tr>
<td>• At least 5 credit pass in SSCE/NECO or equivalents in: English Language, Mathematics, Physics and 2 subjects from Economics, Chemistry, Geography, Technical Drawings and Further Mathematics</td>
<td>• Requirements for ND in Quantity Surveying to be considered</td>
<td>• Requirements for ND in Quantity Surveying and Building to be considered</td>
</tr>
<tr>
<td>• Requirements for ND in Quantity Surveying to be considered</td>
<td>• Minimum of 1 year post ND cognate work experience in the construction industry.</td>
<td></td>
</tr>
<tr>
<td>• Only candidates with ND in Quantity Surveying to be considered</td>
<td></td>
<td>Candidates for direct entry (200 level):</td>
</tr>
<tr>
<td>• Minimum of Lower credit pass in ND examinations</td>
<td></td>
<td>• Requirements for ND</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Score at least 60% overall average in the ND examinations</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Only candidates with ND in Quantity Surveying and Building to be considered.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Candidates for direct entry (300 level):</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Requirements for ND</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Score at least 60% overall average in the HND examinations</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Only candidates with HND in Quantity Surveying to be considered.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Candidates for direct entry (400 level):</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• In addition to the requirements for direct entry (300 level), candidates with HND (Distinction) to be admitted to 400 level</td>
</tr>
</tbody>
</table>

Table 1: Admission Requirements
In addition with the admission requirement for ND, for any candidate to be eligible for admission into HND programme, such candidate must possess ND in quantity surveying with a minimum of Lower Credit Pass. A minimum of 1 year cognate industrial experience is also required. This is contrary to what obtains presently. Presently, a ND degree in Building is qualified for admission into HND programme of quantity surveying. This new finding of streamlining HND admission strictly to holders of ND in quantity surveying is surprising; this however, may be due to the need for students to be focused right from the ND programme. It can be argued on the other way that the curriculum of quantity surveying and building at the ND level is almost the same. In fact, in some institutions, they are being run together. More so, the requirement of direct admission to 200 level for B.Sc. programme allows for ND holders from both quantity surveying and building. As such this provision may still be subject to debate before adoption as a matter of policy.

Table 1 also gives the admission requirement for B.sc. programme. The minimum requirement is as stipulated for that of ND requirement. In addition, candidates are expected to score at least 60% overall average in the ND examinations. Holders of HND in quantity surveying can be admitted directly into 300 level of B.Sc. programme. The results also show that a holder of HND with Distinction can be admitted directly to 400 level of B.Sc. programme. This is seen as a good development for the holder of HND with distinction to almost be at par with their B.Sc. counterpart. More so, most university requires only a minimum of 2 academic sessions for a degree to be awarded. This will give the holder of HND with Distinction the opportunity to be awarded B.Sc. degree within 2 years academic session. It will also serves as a great encouragement for those running HND programme to work harder and strive for excellence.

Requirements for Award of Degrees

Table 2 sets out the requirements for the award of various degrees in quantity surveying. For both the ND and HND degrees, a minimum of 72 credit units covering general studies/education, foundation and professional courses including project dissertation are required. The programmes should also be run for four semesters each of 17 weeks duration comprising of 15 contact hours per week. For ND programme, at least 2 industrial visits per semester are stipulated while in the HND programme, emphasis should be placed on professional courses. For B.Sc. programme, a minimum of 160, 155 and 119 credit units; comprising of compulsory courses, restricted and special electives, Students’ Industrial Work Experience and Project Dissertation; are stipulated for the admission into 100 level, direct entry to 200 and 300 levels respectively.
Generally, continuous assessment (comprising field works and test) and examinations are stipulated on ratio 40:60 basis for all the programmes. This gives room for the inculcation of more filed and practical works in the programmes.

Table 2: Requirements for Award of Degrees

<table>
<thead>
<tr>
<th></th>
<th>ND</th>
<th>HND</th>
<th>B.Sc.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Minimum of credit load of 72 credit unit (comprising of General Studies/Education, Foundation Courses, Professional Courses and Project Dissertation).</td>
<td>Minimum of credit load of 72 credit unit (comprising of General Studies/Education, Foundation Courses, Professional Courses and Project Dissertation).</td>
<td>Minimum of credit load of 160 credit unit (comprising of compulsory courses, restricted electives, special electives, Students’ Industrial Work Experience (SIWES) and Project Dissertation).</td>
</tr>
<tr>
<td></td>
<td>Four Semesters, each of 17 weeks duration made up of 15 contact hours per week involving lectures, tutorials, Laboratory work, studio designs, workshops and practical.</td>
<td>Four Semesters, each of 17 weeks duration made up of 15 contact hours per week involving lectures, tutorials, Laboratory work, studio designs, workshops and practical.</td>
<td>18 – 20 units per semester of 30 – 35 contacts hour per week involving lectures, tutorials, Laboratory work, studio designs, workshops and practical.</td>
</tr>
<tr>
<td></td>
<td>At least 2 industrial visit per semester with assignment on site visited.</td>
<td></td>
<td>Candidates for direct entry (200 and 300 level):</td>
</tr>
<tr>
<td></td>
<td>Course work to be assessed on: Continuous assessment, Field work, Test, - 40 Examinations - 60</td>
<td></td>
<td>Minimum credit units of 155 and 119 credit units respectively</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Course work to be assessed on: Continuous assessment, Field work, Test, - 40 Examinations - 60</td>
</tr>
</tbody>
</table>

Candidates for direct entry (200 and 300 level):
- Minimum credit units of 155 and 119 credit units respectively
- Course work to be assessed on: Continuous assessment, Field work, Test, - 40 Examinations - 60
Quantity Surveying Curriculum

Findings on the skill and competence areas to be covered by B.Sc./HND and ND Syllabi are presented in Tables 3 and 4. Table 3 gives the competence areas that the syllabi of both the HND and B.Sc. programme should cover. This ranges from construction knowledge; measurement of building and engineering works; tendering and estimating; cost planning; investment analysis and financial management; construction economics; professional practice; and information technology to other general requirements such as leadership/general management, communication skills, etc. These are regarded as basic skill and competence requirements any quantity surveyor must possess.

Table 3: HND and B.Sc. Syllabi

<table>
<thead>
<tr>
<th>Skill/Competence Area</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Feasibility Studies/Investment Analysis</td>
</tr>
<tr>
<td>• Building construction and Engineering Technology</td>
</tr>
<tr>
<td>• Measurement of Building and Engineering Works</td>
</tr>
<tr>
<td>• Tendering and Estimating</td>
</tr>
<tr>
<td>• Cost Planning and Control</td>
</tr>
<tr>
<td>• Building and Construction Economics</td>
</tr>
<tr>
<td>• Professional Practice</td>
</tr>
<tr>
<td>• Contract Administration</td>
</tr>
<tr>
<td>• Information Technology</td>
</tr>
<tr>
<td>• Application of Quantity Surveying Software</td>
</tr>
<tr>
<td>• Construction Law</td>
</tr>
<tr>
<td>• Construction/Project Management</td>
</tr>
<tr>
<td>• Financial Management</td>
</tr>
<tr>
<td>• Facility Management</td>
</tr>
<tr>
<td>• Marketing</td>
</tr>
<tr>
<td>• Leadership/ General Management</td>
</tr>
<tr>
<td>• Entrepreneurship Development</td>
</tr>
</tbody>
</table>
In order to create a comprehensive education curriculum, devising a firm understanding of foundational skills becomes very important. In most cases, employers often expect graduates to have adequate social and communication skills, information technology skills, high skill in both written and spoken English as well as leadership skills. This is often required aside the technical and professional skills. As such a good education curriculum should be able to incorporate all these aspects of training mentioned.

Traditionally, the profession of quantity surveying is concerned with financial probity in the planning, design and execution of construction projects, the competence requirements is therefore seen as aiming at equipping quantity surveying students with both theoretical base and practical skills to enable them think analytically, within a multidisciplinary field of study. Also for the fact, that the quantity surveyor occupies a central role of interacting with other members of the design and construction team calls for a multi-disciplinary knowledge of other related professional disciplines. The educational training should therefore embrace all facets of construction works and this is in line with the goal of quantity surveying professions to produce professionals with the necessary tools to collect data, analyse and present cost information on construction works.

The results in Table 4 indicate the area to be covered by ND syllabus. This ranges from general studies such as English, Geometry, Statistic, Communication, etc, to foundation courses within the built environment. Such include Building Technology; Soil Mechanics and Strength of Materials and Structure; Principle of Economic, Architectural Designs, Accounting; measurement of building and Engineering Works;
Tendering and Estimating; and Computer Application/Information Technology. These are seen as foundation requirements to be built upon in the HND and B.Sc. syllabus.

The aforementioned challenges have placed demands in the holistic re-evaluation of the existing quantity surveying education curriculum and its implementation, to qualify quantity surveying graduates to be integrated to quantity surveying profession and the construction industry at large. Hence, the curriculum needs to equip students with relevant skills so as to ameliorate the skill gap paradigm by leveraging the industry needs and expectations. This is corroborated by Massyn et al. (2009)'s submission that “academics at tertiary institutions are required to provide an education programme that both meets the expectation of industry and balances sound academic principles”. In this context, Alshawi et al. (2007) opined that the students will be made to acquire the necessary skills for a successful and rewarding career. The employer would also have a wide range of skilled graduate ready to work and as such effective curriculum will be seen as an investment which prepares organisations not only to adapt to the changing environment, but also to remain competitive. The curriculum developed for the three tiers of the degree awarding institutions for quantity surveying in Nigeria, in this research, consists of technical, business, interpersonal and intellectual competencies. This will ensure that the learning opportunity encompasses the multiple roles of quantity surveying profession.

**Table 4: ND Syllabus**

<table>
<thead>
<tr>
<th>Skill/Competence Area</th>
</tr>
</thead>
<tbody>
<tr>
<td>Use of English</td>
</tr>
<tr>
<td>Elementary Trigonometry, Calculus and Algebra</td>
</tr>
<tr>
<td>Communication Skill</td>
</tr>
<tr>
<td>Entrepreneurship Development</td>
</tr>
<tr>
<td>Statistics</td>
</tr>
<tr>
<td>Bricklaying, Concreting and Wood Work Practice</td>
</tr>
<tr>
<td>Building Technology</td>
</tr>
<tr>
<td>Soil Mechanics</td>
</tr>
<tr>
<td>Strength of Materials and Structures</td>
</tr>
<tr>
<td>Technical Drawing</td>
</tr>
<tr>
<td>Principles of Architectural Design</td>
</tr>
<tr>
<td>Principles of Economics</td>
</tr>
<tr>
<td>Principles of Accounting</td>
</tr>
<tr>
<td>Principles of Law</td>
</tr>
</tbody>
</table>
CONCLUSIONS AND RECOMMENDATIONS

In response to the needs of the society and global business, the construction industry worldwide has experienced significant changes. A lot of challenges are confronting the quantity surveying educational training process most especially in the developing economy such as Nigeria. Calls are being made for a richer conception of curriculum which nurtures the personal skills and competencies to enable quantity surveying graduates to be integrated to the profession for a successful and rewarding career. Hence, quantity surveying education curriculum will need to equip students with relevant skills so as to ameliorate the skill gag paradigm by leveraging the ever changing industry needs and expectations.

Based on the Delphi survey conducted on a “panel of expert” and the consensus reached on issues bordering on quantity surveyors’ educational training, the paper proposes a conceptual framework for the educational training of quantity surveyors in Nigeria with emphasis on admission requirements, requirements for award of degrees as well as the curriculum of quantity surveying degree awarding institutions.

The results of the study showed the minimum requirement as 5 credit pass in Senior Secondary Certificate Examination/National Examination Council (SSCE/NECO) or its equivalent in English Language, Mathematics, Physics, and any 2 subjects from Economics, Chemistry Geography, Technical Drawings and Further Mathematics. In addition with the admission requirement for ND, for any candidate to be eligible for admission into HND programme, such candidate must possess ND in quantity surveying with a minimum of Lower Credit Pass. A minimum of 1 year cognate industrial experience is also required. Holders of HND in quantity surveying can be admitted directly into 300 level of B.Sc. programme.
while a holder of HND with Distinction can be admitted directly to 400 level of B.Sc. programme.

For qualification for the award of degrees in quantity surveying, the results revealed that for both the ND and HND degrees, a minimum of 72 credit units covering general studies/education, foundation and professional courses including project dissertation are required. For ND programme, at least 2 industrial visits per semester are stipulated while in the HND programme, emphasis should be placed on professional courses. For B.Sc. programme, a minimum of 160, 155 and 119 credit units; comprising of compulsory courses, restricted and special electives, Students’ Industrial Work Experience and Project Dissertation; are stipulated for candidates admitted through 100 level, direct entry to 200 and 300 levels respectively.

The findings on the skill and competence areas to be covered by B.Sc./HND and ND Syllabi range from construction knowledge; measurement of building and engineering works; tendering and estimating; cost planning; investment analysis and financial management; construction economics; professional practice; and information technology to other general requirements such as leadership/general management and communication skills.

The proposed framework provides a measure by which quantity surveyors’ educational training can be improved upon and aligned with international standards. It is recommended that the NIQS and QSRBN, in collaboration with the academic institutions, should make a strong case for the review of existing curriculum. It is also recommended that the proposed framework be adopted, institutionalized and implemented. If this is done, the quantity surveying educational training would have been enriched to meet the current need of the industry. It will also make the Nigerian quantity surveying graduates marketable in the global market.

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Inquiry Based Education: Establishing a student Experience Baseline: A Preliminary Study

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ABSTRACT

Purpose of the paper

Criticism of the delivery of current construction education at higher education institutions has been intensifying given that the graduates from these programs are perceived to be unable to be gainfully employed. There is a need to investigate other forms of delivery that have been successful in other disciplines such as architecture, for example. Inquiry-based education is hypothesized to be an alternative that will produce 21st century construction professionals. However, to date no comparative studies as far as the authors are aware have been done between the traditional form of delivery and inquiry-based instruction. This paper attempts to establish a baseline for experiences of students in construction programs at a sample of South African universities.

Design/ methodology/approach

A survey was conducted of a purposive sample of students registered at selected South African universities to measure their experiences in construction education programs. Their responses were analyzed using the Statistical Package for Social Sciences (SPSS) version 22.
Findings

Students were less active participants on the lower order academic activities as against the higher order academic activities. They were assigned less academic activities work than would be expected for studying at university. Unlike inquiry-based approaches time spent with peers and self-study was very low. The use of computers was very low. Students spent very little time working either on or off campus. When they worked it was related to their career paths though. Most of the students’ studies were paid by their parents.

Students claimed to spend most of their time on their studies. In addition the students spent very little time doing either extra-curricular activities. Instructors at their university were perceived to have high expectations of them by holding them to high standards and striving to ensure that they achieved the learning outcomes of each course that they taught. Instructors were also perceived as being approachable, helpful and understanding. They had a positive regard for their universities.

Research limitations

The phase of the study reported on in this paper was limited to construction programs at a few universities offering traditional forms of delivery.

Practical implications

This study will serve as a baseline against which to compare the experiences of students in traditional construction programs with those in programs that use inquiry-based instruction.

What is the value of the paper?

No previous research has been undertaken in South Africa to measure the experiences of students in construction programs at universities.

KEY WORDS

Construction education, Constructivism, Inquiry-based education

1. INTRODUCTION

Criticism of the delivery of current construction education at higher education institutions has been intensifying given that the graduates from these programs are perceived to be unable to be gainfully employed. Consequently, several major South African contractors have developed their own management development programmes (MDPs) or graduate development programmes (GDPs) to better assimilate these
underprepared university graduates into their organizations. Given this criticism there is a need to investigate other forms of delivery that have been successful in other disciplines such as architecture, for example. Inquiry-based education is hypothesized to be an alternative that will produce 21st century construction professionals. However, to date no comparative studies as far as the authors are aware have been done between the traditional form of delivery and inquiry-based instruction. This paper attempts to establish a baseline for experiences of students in construction programs at a sample of South African universities.

Several studies have argued that an inquiry-based education approach founded on constructivist principles was more appropriate to educate and develop the construction professionals needed to perform in an ever-changing and dynamic increasingly global construction industry (Monson & Hauck, 2012a and 2012b; Monson, 2011; Beliveau & Peter 2002a and 2002b).

According to Beliveau & Peter (2002:b) a constructivist education model for construction students must include modes of learning that include experience, theory, experimentation and reflection. From Figure 1, the three principles of a constructivist learning environment should include recursive, participatory and reflective principles.

![Figure 1. Principles of constructivist learning environments](image)

Source: Adapted from Beliveau & Peter (2002b)

Within the constructivist learning environment, students are active learners that demands self-preparation for classes on their part (Beliveau & Peter 2002a). Constructivism further emphasizes the individual experiences that students brings to the learning experience. The Boyer Commission (1995) called for a general introduction of an inquiry-based first year for all
students. According to Monson (2011) the concepts of inquiry based education are linked to constructivist learning. Whereas constructivist learning is student centred inquiry-based methodologies are student directed.

In a discussion of the inquiry-based programmes implemented at Mississippi State University and California Polytechnic San Luis Obispo which use to varying degrees a series of consecutive construction studio or laboratories, students reported that they learnt more in the studios than in traditional lecture-based classes (Monson and Hauck (2012).

RESEARCH APPROACH

The sample of 261 construction students was drawn from four South African universities that offered construction programmes in the disciplines of construction management, quantity surveying and civil engineering. They were presented with a self-administered questionnaire survey instrument designed to extract data about their experiences in their various programmes. The data that was gathered was analyzed using the Statistical Package for Social Sciences (SPSS) version 22. For the purposes of this paper only descriptive statistics in the form of frequency distribution tables together with measures of central tendency and dispersion are presented.

SAMPLE PROFILE

From Table 1 it is evident that the majority of the students were second and third year students, namely 35.0% and 46.5% respectively. More male students than female students participated in the survey.

Table 1: Year of Study

<table>
<thead>
<tr>
<th></th>
<th>First (%)</th>
<th>Second (%)</th>
<th>Third (%)</th>
<th>Fourth (%)</th>
<th>Total (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Female</td>
<td>2 (2.3%)</td>
<td>30 (34.1%)</td>
<td>41 (46.6%)</td>
<td>15 (17.0%)</td>
<td>88</td>
</tr>
<tr>
<td>Male</td>
<td>3 (1.7%)</td>
<td>61(35.5%)</td>
<td>80 (46.5%)</td>
<td>28 (16.3%)</td>
<td>172</td>
</tr>
<tr>
<td>TOTAL</td>
<td>5 (1.9%)</td>
<td>91(35.0%)</td>
<td>121(46.5%)</td>
<td>42 (16.2%)</td>
<td>260</td>
</tr>
</tbody>
</table>

Table 2 shows the distribution of students according to their major course of study. It is evident that quantity surveying (QS) students (31.0%) outnumbered most of the other majors taken by students participating in the study. With the exception of Construction Management (CM) (12.5%)
and Property studies (14.8%), female students outnumbered the proportion of male students in each major.

Table 2: Major

<table>
<thead>
<tr>
<th></th>
<th>CM (%)</th>
<th>QS (%)</th>
<th>Property (%)</th>
<th>ND: Bldg. (%)</th>
<th>ND: Civ. Eng. (%)</th>
<th>ND: Chem. Eng. (%)</th>
<th>Total (100.0%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Female</td>
<td>11 (12.5%)</td>
<td>29 (33.0%)</td>
<td>13 (14.8%)</td>
<td>22 (25%)</td>
<td>11 (12.5%)</td>
<td>2 (2.3%)</td>
<td>88</td>
</tr>
<tr>
<td>Male</td>
<td>46 (26.6%)</td>
<td>52 (30.1%)</td>
<td>26 (15.0%)</td>
<td>30 (17.3%)</td>
<td>17 (9.8%)</td>
<td>2 (1.2%)</td>
<td>173</td>
</tr>
<tr>
<td>TOTAL</td>
<td>57 (21.8%)</td>
<td>81 (31.0%)</td>
<td>39 (14.9%)</td>
<td>52 (19.9%)</td>
<td>28 (10.7%)</td>
<td>4 (1.2%)</td>
<td>261</td>
</tr>
</tbody>
</table>

Of the 255 students who responded to this question, it is evident from Table 3 that males’ students in each classification made up more than 50% of the respondents with males having the largest proportion (84.0%) of White or Caucasian students. Most students were Black (53.7%) with White or Caucasian students being the next dominant group. Given the location of the universities in the sample this distribution is not unexpected given their regional demographic profile.

Table 3: Demographics

<table>
<thead>
<tr>
<th></th>
<th>Female (%)</th>
<th>Male (%)</th>
<th>Total (100.0%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Black</td>
<td>65 (47.4%)</td>
<td>73 (53.3%)</td>
<td>137 (53.7%)</td>
</tr>
<tr>
<td>Coloured</td>
<td>2 (40.0%)</td>
<td>3 (60.0%)</td>
<td>5 (2%)</td>
</tr>
<tr>
<td>Indian or Asian</td>
<td>4 (33.3%)</td>
<td>8 (67.7%)</td>
<td>12 (4.7%)</td>
</tr>
<tr>
<td>White or Caucasian</td>
<td>16 (16.0%)</td>
<td>84 (84.0%)</td>
<td>100 (39.2%)</td>
</tr>
<tr>
<td>TOTAL</td>
<td>87 (34.1%)</td>
<td>168 (65.9%)</td>
<td>255 (100%)</td>
</tr>
</tbody>
</table>

With respect to citizenship according to Table 4 most students (84.7%) in the sample were South African citizens.

Table 4: Citizenship

<table>
<thead>
<tr>
<th></th>
<th>Female (%)</th>
<th>Male (%)</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>South African</td>
<td>79 (35.8%)</td>
<td>142 (64.2%)</td>
<td>221 (84.7%)</td>
</tr>
<tr>
<td>Permanent Resident</td>
<td>3 (13.0%)</td>
<td>20 (8.07%)</td>
<td>23 (8.81%)</td>
</tr>
<tr>
<td>Non-South African</td>
<td>6 (35.3%)</td>
<td>11 (64.7%)</td>
<td>17 (6.5%)</td>
</tr>
<tr>
<td>TOTAL</td>
<td>88 (33.7%)</td>
<td>173 (66.3%)</td>
<td>261 (100%)</td>
</tr>
</tbody>
</table>
Table 5 shows that males made up almost two-thirds of the sample, namely 66.3%.

**Table 5: Gender**

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Female</td>
<td>88</td>
<td>33.7%</td>
</tr>
<tr>
<td>Male</td>
<td>173</td>
<td>66.3%</td>
</tr>
<tr>
<td>TOTAL</td>
<td>261</td>
<td>100%</td>
</tr>
</tbody>
</table>

Students had to indicate on a 4-point scale where 1= very little, 2=some, 3=quite a lot, and 4=very much how frequently they engaged in four critical academic activities. Their responses are shown in Table 6. It is evident when comparing the means that students engaged most frequently in applying theories or concepts to practical problems or new solutions (mean=3.20). The next most frequent activity engaged in was analysing the basic elements of an idea, experience, or theory, such as examining a particular case or situation in depth and considering its components (mean=2.74). The lowest means were relative to the higher order academic activities of making judgements about the value of information, arguments, or methods, such as examining how others gathered and interpreted data and assessing the soundness of their conclusions and synthesizing and organizing ideas into new more complex interpretations and relationships, namely 2.63 and 2.48 respectively. In all instances female students reported greater engagement in all the academic activities.

**Table 6. Participation in academic activities**

<table>
<thead>
<tr>
<th>Activity</th>
<th>Very Little (%)</th>
<th>Some (%)</th>
<th>Quite a bit (%)</th>
<th>Very Much (%)</th>
<th>Total (100%)</th>
<th>Mean</th>
<th>Std. Dev.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Analysing the basic elements of an idea, experience, or theory,</td>
<td>Female</td>
<td>9 (10.3%)</td>
<td>18 (20.7%)</td>
<td>37 (42.5%)</td>
<td>23 (26.4%)</td>
<td>87</td>
<td>2.85</td>
</tr>
<tr>
<td>such as examining a particular case or situation in depth and</td>
<td>Male</td>
<td>19 (11.0%)</td>
<td>43 (25%)</td>
<td>83 (48%)</td>
<td>27 (15.7%)</td>
<td>172</td>
<td>2.69</td>
</tr>
<tr>
<td>considering its components</td>
<td>Total</td>
<td>29 (10.8%)</td>
<td>61 (23.6%)</td>
<td>120 (46.3%)</td>
<td>50 (19.3%)</td>
<td>259</td>
<td>2.74</td>
</tr>
<tr>
<td>Synthesizing and organising ideas, information, or experiences into</td>
<td>Female</td>
<td>15 (17.2%)</td>
<td>29 (33.3%)</td>
<td>28 (29.9%)</td>
<td>17 (19.5%)</td>
<td>87</td>
<td>2.52</td>
</tr>
<tr>
<td>new, more complex interpretations and relationships</td>
<td>Male</td>
<td>25 (14.5%)</td>
<td>59 (34.3%)</td>
<td>73 (42.4%)</td>
<td>15 (8.7%)</td>
<td>172</td>
<td>2.45</td>
</tr>
<tr>
<td>Total</td>
<td>40 (15.4%)</td>
<td>88 (34%)</td>
<td>99 (38.2%)</td>
<td>32 (12.4%)</td>
<td>259</td>
<td>2.48</td>
<td>0.902</td>
</tr>
<tr>
<td>Applying theories or concepts to</td>
<td>Female</td>
<td>2 (16%)</td>
<td>16 (32%)</td>
<td>37 (37%)</td>
<td>87</td>
<td>3.20</td>
<td>0.819</td>
</tr>
</tbody>
</table>
practical problems or new solutions

<table>
<thead>
<tr>
<th>Activity</th>
<th>Male</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(5.2%)</td>
<td>(4.2%)</td>
</tr>
<tr>
<td></td>
<td>(30.2%)</td>
<td>(26.3%)</td>
</tr>
<tr>
<td></td>
<td>(42.4%)</td>
<td>(40.5%)</td>
</tr>
<tr>
<td></td>
<td>(22.1%)</td>
<td>(29.0%)</td>
</tr>
<tr>
<td></td>
<td>729</td>
<td>259</td>
</tr>
<tr>
<td></td>
<td>2.81</td>
<td>2.95</td>
</tr>
<tr>
<td></td>
<td>0.838</td>
<td>0.849</td>
</tr>
</tbody>
</table>

Making judgements about the value of information, arguments, or methods, such as examining how others gathered and interpreted data and assessing the soundness of their conclusions

<table>
<thead>
<tr>
<th>Activity</th>
<th>Female</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(10.3%)</td>
<td>(8.5%)</td>
</tr>
<tr>
<td></td>
<td>(29.9%)</td>
<td>(35.1%)</td>
</tr>
<tr>
<td></td>
<td>(37.9%)</td>
<td>(41.3%)</td>
</tr>
<tr>
<td></td>
<td>(19.5%)</td>
<td>(15.1%)</td>
</tr>
<tr>
<td></td>
<td>87</td>
<td>259</td>
</tr>
<tr>
<td></td>
<td>2.71</td>
<td>2.63</td>
</tr>
<tr>
<td></td>
<td>0.934</td>
<td>0.845</td>
</tr>
</tbody>
</table>

| Activity                                                                 | Male       | Total      |
|                                                                          | (7.6%)     | (5.4%)     |
|                                                                          | (37.8%)    | (26.9%)    |
|                                                                          | (43.0%)    | (41.3%)    |
|                                                                          | (11.6%)    | (15.1%)    |
|                                                                          | 172        | 259        |
|                                                                          | 2.59       | 2.63       |
|                                                                          | 0.794      | 0.845      |

Students were asked to indicate how many assigned written or reading academic activities they had completed during an academic year. Their responses are shown in Table 7. Less than half (43.8%) of the students reported that they tended to have completed five to ten assignments, textbooks or book length packs of course readings (mean=2.74). Slightly more than one-third (38.5%) had written papers or reports of 5 to 19 pages in length (mean=2.63). There was very little distinction between male and female students relative to assigned written and reading tasks.

Table 8 shows that most students (56.3%) reported spending between one and seven hours per typical seven-day week preparing for their classes. Male students (58.0%) reported that they spent more hours than their female counterparts (52.9%).

From Table 9 almost three-quarters of the students reported spending between one and seven hours per typical seven-day week in laboratories, workshops or practical sessions. There was little difference between the genders. Most students (28.9%) reported spending more than 23 hours per typical seven-day week attending classes. However, most male students (29.9%) reported spending between 17 and 23 hours per week attending classes.

Table 7. Assigned Academic Activities

<table>
<thead>
<tr>
<th>Activity</th>
<th>Gender</th>
<th>0 (%)</th>
<th>1-4 (%)</th>
<th>5-10 (%)</th>
<th>11-20 (%)</th>
<th>&gt;20 (%)</th>
<th>Total (100.0%)</th>
<th>Mean</th>
<th>Std. Dev.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of Assignments, textbooks, or book length packs of course readings</td>
<td>Female</td>
<td>5 (6.1%)</td>
<td>20 (24.4%)</td>
<td>31 (37.8%)</td>
<td>16 (19.5%)</td>
<td>10 (12.2%)</td>
<td>82</td>
<td>3.07</td>
<td>1.086</td>
</tr>
<tr>
<td></td>
<td>Male</td>
<td>8 (5%)</td>
<td>45 (28.1%)</td>
<td>75 (46.9%)</td>
<td>21 (13.1%)</td>
<td>11 (6.9%)</td>
<td>160</td>
<td>2.89</td>
<td>0.938</td>
</tr>
<tr>
<td>TOTAL</td>
<td></td>
<td>13 (5.4%)</td>
<td>65 (26.9%)</td>
<td>106 (43.8%)</td>
<td>37 (15.3%)</td>
<td>21 (8.7%)</td>
<td>242</td>
<td>2.74</td>
<td>0.896</td>
</tr>
</tbody>
</table>
### Table 8. Time spent on preparing for class

<table>
<thead>
<tr>
<th>Activity</th>
<th>Hours</th>
<th>0 (%)</th>
<th>1-7 (%)</th>
<th>8-16 (%)</th>
<th>17-23 (%)</th>
<th>&gt;23 (%)</th>
<th>Total (100.0)</th>
<th>Mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Preparing for class (studying, reading, writing, doing homework, or lab work, analysing data, rehearsing, and other academic activities)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>24 (29.3%)</td>
<td>19 (23.2%)</td>
<td>22 (26.8%)</td>
<td>11 (13.4%)</td>
<td>6 (7.3%)</td>
<td></td>
<td>82</td>
<td>2.46</td>
<td>1.249</td>
</tr>
<tr>
<td>Male</td>
<td>44 (27.2%)</td>
<td>66 (40.7%)</td>
<td>33 (20.4%)</td>
<td>12 (7.4%)</td>
<td>7 (4.3%)</td>
<td></td>
<td>162</td>
<td>2.21</td>
<td>1.060</td>
</tr>
<tr>
<td>TOTAL</td>
<td>68 (27.9%)</td>
<td>85 (34.8%)</td>
<td>55 (22.5%)</td>
<td>23 (9.4%)</td>
<td>13 (5.3%)</td>
<td></td>
<td>244</td>
<td>2.48</td>
<td>0.902</td>
</tr>
</tbody>
</table>

### Table 9. Time spent attending classes

<table>
<thead>
<tr>
<th>Activity</th>
<th>Hours</th>
<th>0 (%)</th>
<th>1-7 (%)</th>
<th>8-16 (%)</th>
<th>17-23 (%)</th>
<th>&gt;23 (%)</th>
<th>Total (100.0)</th>
<th>Mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Attend classes</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>1 (1.2%)</td>
<td>15 (17.4%)</td>
<td>19 (22.1%)</td>
<td>21 (24.4%)</td>
<td>30 (34.9%)</td>
<td></td>
<td>86</td>
<td>3.74</td>
<td>1.150</td>
</tr>
<tr>
<td>Male</td>
<td>0 (0.0%)</td>
<td>33 (19%)</td>
<td>44 (25.3%)</td>
<td>52 (29.9%)</td>
<td>45 (25.9%)</td>
<td></td>
<td>174</td>
<td>3.65</td>
<td>1.073</td>
</tr>
<tr>
<td>TOTAL</td>
<td>1 (0.4%)</td>
<td>48 (18.5%)</td>
<td>63 (24.2%)</td>
<td>73 (28.1%)</td>
<td>75 (28.9%)</td>
<td></td>
<td>260</td>
<td>3.67</td>
<td>1.094</td>
</tr>
<tr>
<td>Attend laboratory, workshop or practical sessions</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>17 (35.6%)</td>
<td>60 (71.4%)</td>
<td>4 (4.8%)</td>
<td>1 (1.2%)</td>
<td></td>
<td></td>
<td>84</td>
<td>1.94</td>
<td>0.717</td>
</tr>
<tr>
<td>Male</td>
<td>41 (24.0%)</td>
<td>124 (72.5%)</td>
<td>4 (2.3%)</td>
<td>1 (0.6%)</td>
<td>1</td>
<td></td>
<td>171</td>
<td>1.81</td>
<td>0.556</td>
</tr>
<tr>
<td>TOTAL</td>
<td>58 (22.8%)</td>
<td>184 (72.2%)</td>
<td>8 (3.1%)</td>
<td>2 (0.8%)</td>
<td>3</td>
<td></td>
<td>255</td>
<td>1.86</td>
<td>0.612</td>
</tr>
</tbody>
</table>
Table 10 shows that most students (67.5%) reported spending between one and seven hours per typical seven-day week studying with peers or other students. A larger proportion of male students (72.0%) than female students (58.6%) spent time studying with others. Further, most students (44.6%) reported spending one to seven hours per week studying by themselves. A larger proportion of male students (49.1%) reported studying by themselves for this amount of time.

<table>
<thead>
<tr>
<th>Activity</th>
<th>Hours</th>
<th>0 (%)</th>
<th>1-7 (%)</th>
<th>8-16 (%)</th>
<th>17-23 (%)</th>
<th>&gt;23 (%)</th>
<th>Total (100.0)</th>
<th>Mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Study with peers or other students</td>
<td>Female</td>
<td>17 (19.5%)</td>
<td>51 (58.6%)</td>
<td>13 (14.9%)</td>
<td>3 (3.4%)</td>
<td>3 (3.4%)</td>
<td>87</td>
<td>2.13</td>
<td>0.887</td>
</tr>
<tr>
<td></td>
<td>Male</td>
<td>22 (13.1%)</td>
<td>121 (72.9%)</td>
<td>14 (8.3%)</td>
<td>5 (3.0%)</td>
<td>6 (3.6%)</td>
<td>168</td>
<td>2.15</td>
<td>0.836</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>39 (15.3%)</td>
<td>172 (67.5%)</td>
<td>27 (10.6%)</td>
<td>8 (3.1%)</td>
<td>9 (3.5%)</td>
<td>255</td>
<td>2.13</td>
<td>0.848</td>
</tr>
<tr>
<td>Study by yourself</td>
<td>Female</td>
<td>0 (0.0%)</td>
<td>31 (35.6%)</td>
<td>30 (34.5%)</td>
<td>15 (17.2%)</td>
<td>11 (12.6%)</td>
<td>87</td>
<td>3.07</td>
<td>1.021</td>
</tr>
<tr>
<td></td>
<td>Male</td>
<td>0 (0.0%)</td>
<td>84 (49.1%)</td>
<td>60 (35.1%)</td>
<td>13 (7.6%)</td>
<td>14 (8.2%)</td>
<td>171</td>
<td>2.77</td>
<td>0.918</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>0 (0.0%)</td>
<td>115 (44.6%)</td>
<td>90 (34.9%)</td>
<td>28 (10.9%)</td>
<td>25 (9.7%)</td>
<td>258</td>
<td>2.86</td>
<td>0.960</td>
</tr>
</tbody>
</table>

Table 10. Time spent on studies outside of classes

From Table 11 it is evident that 65.0% of students spent between one and seven hours per week using a computer for their schoolwork. Unfortunately, it is not known whether this computer was their own or one used in the university computer laboratories.

<table>
<thead>
<tr>
<th>Activity</th>
<th>Hours</th>
<th>0 (%)</th>
<th>1-7 (%)</th>
<th>8-16 (%)</th>
<th>17-23 (%)</th>
<th>&gt;23 (%)</th>
<th>Total (100.0)</th>
<th>Mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Use a computer for schoolwork</td>
<td>Female</td>
<td>1 (1.2%)</td>
<td>52 (61.2%)</td>
<td>21 (24.7%)</td>
<td>4 (4.7%)</td>
<td>7 (8.2%)</td>
<td>85</td>
<td>2.58</td>
<td>0.931</td>
</tr>
<tr>
<td></td>
<td>Male</td>
<td>4 (2.3%)</td>
<td>115 (66.9%)</td>
<td>35 (20.3%)</td>
<td>11 (6.4%)</td>
<td>7 (4.1%)</td>
<td>172</td>
<td>2.46</td>
<td>0.823</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>5 (1.9%)</td>
<td>167 (65.0%)</td>
<td>56 (21.8%)</td>
<td>15 (5.8%)</td>
<td>14 (5.4%)</td>
<td>257</td>
<td>2.49</td>
<td>0.861</td>
</tr>
</tbody>
</table>

Table 11. Use of computers for schoolwork

Table 12 shows that 53.5% of students did not work on campus. However, 35.5% of students worked between one and seven hours per week off campus.
Table 12. Time spent working

<table>
<thead>
<tr>
<th>Activity</th>
<th>Hours</th>
<th>0 (%)</th>
<th>1-7 (%)</th>
<th>8-16 (%)</th>
<th>17-23 (%)</th>
<th>&gt;23 (%)</th>
<th>Total (100.0)</th>
<th>Mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Work on campus</td>
<td>Female</td>
<td>41</td>
<td>(51.3%)</td>
<td>26</td>
<td>6</td>
<td>2</td>
<td>5</td>
<td>80</td>
<td>1.80</td>
</tr>
<tr>
<td></td>
<td>Male</td>
<td>90</td>
<td>(54.5%)</td>
<td>54</td>
<td>11</td>
<td>6</td>
<td>4</td>
<td>165</td>
<td>1.67</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>131</td>
<td>(53.5%)</td>
<td>80</td>
<td>17</td>
<td>8</td>
<td>9</td>
<td>245</td>
<td>1.71</td>
</tr>
<tr>
<td>Work off campus</td>
<td>Female</td>
<td>31</td>
<td>(39.2%)</td>
<td>28</td>
<td>10</td>
<td>4</td>
<td>6</td>
<td>79</td>
<td>2.06</td>
</tr>
<tr>
<td></td>
<td>Male</td>
<td>55</td>
<td>(32.5%)</td>
<td>60</td>
<td>31</td>
<td>9</td>
<td>14</td>
<td>169</td>
<td>2.21</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>86</td>
<td>(34.7%)</td>
<td>88</td>
<td>41</td>
<td>13</td>
<td>20</td>
<td>248</td>
<td>2.17</td>
</tr>
</tbody>
</table>

From Table 13 it is evident that most female (72.7%) and male (69.1%) students were not working to pay for their studies. The majority of female (72.7%) and male (82.0%) students were not working to send money home to their family. More female students claimed to send money home than male students. Almost two-thirds (61.1%) of the students claimed that the work they did was related to their future careers. More male students (66.4%) than their female counterparts (50.7%) did work related to their careers.

Table 13. Student work experiences

<table>
<thead>
<tr>
<th>Earning money to pay for your studies</th>
<th>Gender</th>
<th>Yes (%)</th>
<th>No (%)</th>
<th>Maybe (%)</th>
<th>Total (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Female</td>
<td>15</td>
<td>48</td>
<td>3</td>
<td>66</td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>38</td>
<td>96</td>
<td>5</td>
<td>139</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>53</td>
<td>144</td>
<td>8</td>
<td>205</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Earning money to send home to your family</th>
<th>Gender</th>
<th>Yes (%)</th>
<th>No (%)</th>
<th>Maybe (%)</th>
<th>Total (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Female</td>
<td>14</td>
<td>48</td>
<td>4</td>
<td>66</td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>21</td>
<td>114</td>
<td>4</td>
<td>139</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>35</td>
<td>162</td>
<td>8</td>
<td>205</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Related to career goals</th>
<th>Gender</th>
<th>Yes (%)</th>
<th>No (%)</th>
<th>Maybe (%)</th>
<th>Total (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Female</td>
<td>34</td>
<td>32</td>
<td>1</td>
<td>67</td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>93</td>
<td>42</td>
<td>6</td>
<td>141</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>127</td>
<td>74</td>
<td>7</td>
<td>208</td>
<td></td>
</tr>
</tbody>
</table>
Table 14. Time spent on extra-curricular activities

<table>
<thead>
<tr>
<th>Do voluntary work</th>
<th>Female</th>
<th>0 (%) (53.1%)</th>
<th>1-7 (%) (35.8%)</th>
<th>8-16 (%) (7.4%)</th>
<th>17-23 (%) (2.5%)</th>
<th>&gt;23 (%) (1.2%)</th>
<th>Total % (33.2%)</th>
<th>Mean (1.63)</th>
<th>SD (0.812)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td></td>
<td>90 (52.7%)</td>
<td>66 (40.5%)</td>
<td>6 (3.7%)</td>
<td>1 (0.4%)</td>
<td>0 (0.0%)</td>
<td>163 (66.8%)</td>
<td>1.50</td>
<td>0.604</td>
</tr>
<tr>
<td>Total</td>
<td>133 (54.5%)</td>
<td>95 (38.9%)</td>
<td>12 (4.9%)</td>
<td>3 (1.2%)</td>
<td>1 (0.4%)</td>
<td>244 (100.0%)</td>
<td>1.54</td>
<td>0.688</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Spend time in a residence dormitory or hostel group</th>
<th>Female</th>
<th>34 (42%)</th>
<th>25 (30.9%)</th>
<th>11 (13.6%)</th>
<th>1 (1.2%)</th>
<th>10 (12.3%)</th>
<th>81 (100%)</th>
<th>2.11</th>
<th>1.313</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td>74 (45.1%)</td>
<td>57 (34.8%)</td>
<td>10 (6.1%)</td>
<td>3 (1.8%)</td>
<td>20 (12.2%)</td>
<td>164 (66.9%)</td>
<td>2.01</td>
<td>1.301</td>
<td></td>
</tr>
<tr>
<td>Sample</td>
<td>108 (44.1%)</td>
<td>82 (33.5%)</td>
<td>21 (8.6%)</td>
<td>4 (1.6%)</td>
<td>30 (12.2%)</td>
<td>245 (100.0%)</td>
<td>2.04</td>
<td>1.294</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Participate in student clubs, societies and associations</th>
<th>Female</th>
<th>42 (51.2%)</th>
<th>33 (40.2%)</th>
<th>5 (6.1%)</th>
<th>0 (0.0%)</th>
<th>2 (2.4%)</th>
<th>82 (33.5%)</th>
<th>1.62</th>
<th>0.811</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td>86 (52.8%)</td>
<td>68 (41.7%)</td>
<td>7 (4.3%)</td>
<td>0 (0.0%)</td>
<td>2 (1.2%)</td>
<td>163 (66.5%)</td>
<td>1.55</td>
<td>0.695</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>128 (52.2%)</td>
<td>101 (41.2%)</td>
<td>12 (4.9%)</td>
<td>0 (0.0%)</td>
<td>4 (1.6%)</td>
<td>245 (100.0%)</td>
<td>1.57</td>
<td>0.731</td>
<td></td>
</tr>
</tbody>
</table>

According to Table 14 most students did no voluntary work. Additionally, most of them (44.1%) spent no hours in a residence dormitory or hostel group. Further, most students (52.2%) did not participate in student clubs, societies or associations.

Table 15: Time spent on studying and on academic work

<table>
<thead>
<tr>
<th>Very Little (%)</th>
<th>Some (%)</th>
<th>Quite a bit (%)</th>
<th>Very Much (%)</th>
<th>Total (%)</th>
<th>Mean</th>
<th>Std.Dev.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Female</td>
<td>4 (4.5%)</td>
<td>4 (4.5%)</td>
<td>21 (23.9%)</td>
<td>59 (67%)</td>
<td>88 (100%)</td>
<td>3.53</td>
</tr>
<tr>
<td>Male</td>
<td>2 (1.2%)</td>
<td>13 (7.8%)</td>
<td>70 (41.9%)</td>
<td>82 (49.1%)</td>
<td>167 (100%)</td>
<td>3.40</td>
</tr>
<tr>
<td>Total</td>
<td>6 (2.4%)</td>
<td>17 (6.7%)</td>
<td>91 (35.7%)</td>
<td>141 (55.3%)</td>
<td>255 (100%)</td>
<td>3.43</td>
</tr>
</tbody>
</table>

From Table 15 it is evident that most students (55.3%) claimed to spend most of their studying and academic work (mean=3.43) with a larger proportion of females students (67.0%) doing so than their male counterparts (49.1%)
Table 16: Intention to work with an instructor

<table>
<thead>
<tr>
<th></th>
<th>Did not work (%)</th>
<th>Worked (%)</th>
<th>Total (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Female</td>
<td>56 (68.3%)</td>
<td>26 (31.7%)</td>
<td>82 (100%)</td>
</tr>
<tr>
<td>Male</td>
<td>118 (69.8%)</td>
<td>51 (30.2%)</td>
<td>9 (100%)</td>
</tr>
<tr>
<td>Total</td>
<td>174 (69.3%)</td>
<td>77 (30.7%)</td>
<td>251 (100%)</td>
</tr>
</tbody>
</table>

According to Table 16, most students (69.3%) had not worked or did not plan to work before they graduated with an instructor on a research project outside of the course or programme requirements.

From Table 17 it is evident that 51.1% of students reported that their parents covered all the costs of their studies. More male students (55.8%) than their female students (43.4%) reported that this was the case.

Table 17. Contribution of parents to cost of studies

<table>
<thead>
<tr>
<th>% contribution</th>
<th>Total</th>
<th>Males</th>
<th>Females</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Frequency</td>
<td>%</td>
<td>Frequency</td>
</tr>
<tr>
<td>0</td>
<td>14</td>
<td>6.0</td>
<td>8</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>0.4</td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td>2</td>
<td>0.9</td>
<td>0</td>
</tr>
<tr>
<td>5</td>
<td>7</td>
<td>3.0</td>
<td>5</td>
</tr>
<tr>
<td>10</td>
<td>16</td>
<td>6.8</td>
<td>8</td>
</tr>
<tr>
<td>15</td>
<td>4</td>
<td>1.7</td>
<td>2</td>
</tr>
<tr>
<td>20</td>
<td>12</td>
<td>5.1</td>
<td>8</td>
</tr>
<tr>
<td>30</td>
<td>10</td>
<td>4.3</td>
<td>6</td>
</tr>
<tr>
<td>40</td>
<td>3</td>
<td>1.3</td>
<td>1</td>
</tr>
<tr>
<td>45</td>
<td>2</td>
<td>0.9</td>
<td>1</td>
</tr>
<tr>
<td>50</td>
<td>13</td>
<td>5.5</td>
<td>6</td>
</tr>
<tr>
<td>60</td>
<td>5</td>
<td>2.1</td>
<td>5</td>
</tr>
<tr>
<td>70</td>
<td>4</td>
<td>1.7</td>
<td>2</td>
</tr>
<tr>
<td>80</td>
<td>8</td>
<td>3.4</td>
<td>6</td>
</tr>
<tr>
<td>85</td>
<td>2</td>
<td>0.9</td>
<td>2</td>
</tr>
<tr>
<td>90</td>
<td>6</td>
<td>2.6</td>
<td>5</td>
</tr>
<tr>
<td>92</td>
<td>1</td>
<td>0.4</td>
<td>0</td>
</tr>
<tr>
<td>95</td>
<td>3</td>
<td>1.3</td>
<td>3</td>
</tr>
<tr>
<td>97</td>
<td>1</td>
<td>0.4</td>
<td>0</td>
</tr>
</tbody>
</table>
From Table 18 (53.1%) of students did not have any scholarship or bursary to cover the costs of their studies. More males (57.6%) than their female counterparts (44.9%) reported having no scholarships and bursaries.

Table 18. Contribution of scholarships and bursaries to cost of studies

<table>
<thead>
<tr>
<th>Contribution</th>
<th>Total</th>
<th></th>
<th>Males</th>
<th></th>
<th>Female</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Frequency</td>
<td>%</td>
<td>Frequency</td>
<td>%</td>
<td>Frequency</td>
<td>%</td>
</tr>
<tr>
<td>0</td>
<td>71</td>
<td>53.1</td>
<td>49</td>
<td>57.6</td>
<td>22</td>
<td>44.9</td>
</tr>
<tr>
<td>1</td>
<td>2</td>
<td>1.5</td>
<td>2</td>
<td>2.4</td>
<td>0</td>
<td>0.0</td>
</tr>
<tr>
<td>10</td>
<td>2</td>
<td>1.5</td>
<td>1</td>
<td>1.2</td>
<td>1</td>
<td>2.0</td>
</tr>
<tr>
<td>15</td>
<td>1</td>
<td>0.7</td>
<td>1</td>
<td>1.2</td>
<td>0</td>
<td>0.0</td>
</tr>
<tr>
<td>20</td>
<td>2</td>
<td>1.5</td>
<td>2</td>
<td>2.4</td>
<td>0</td>
<td>0.0</td>
</tr>
<tr>
<td>30</td>
<td>4</td>
<td>3.0</td>
<td>2</td>
<td>2.4</td>
<td>2</td>
<td>4.1</td>
</tr>
<tr>
<td>40</td>
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<td>0.7</td>
<td>1</td>
<td>1.2</td>
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<td>0.0</td>
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<td>5.9</td>
<td>5</td>
<td>5.9</td>
<td>3</td>
<td>6.1</td>
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<td>0</td>
<td>0.0</td>
</tr>
<tr>
<td>60</td>
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<td>1.5</td>
<td>1</td>
<td>1.2</td>
<td>1</td>
<td>2.0</td>
</tr>
<tr>
<td>70</td>
<td>5</td>
<td>3.7</td>
<td>3</td>
<td>3.5</td>
<td>2</td>
<td>4.1</td>
</tr>
<tr>
<td>80</td>
<td>11</td>
<td>8.1</td>
<td>7</td>
<td>8.2</td>
<td>4</td>
<td>8.2</td>
</tr>
<tr>
<td>87</td>
<td>1</td>
<td>0.7</td>
<td>0</td>
<td>0.0</td>
<td>0</td>
<td>0.0</td>
</tr>
<tr>
<td>90</td>
<td>5</td>
<td>3.7</td>
<td>3</td>
<td>3.5</td>
<td>2</td>
<td>4.1</td>
</tr>
<tr>
<td>95</td>
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<td>2.2</td>
<td>2</td>
<td>2.4</td>
<td>1</td>
<td>2.0</td>
</tr>
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<td>98</td>
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<td>0.7</td>
<td>0</td>
<td>0.0</td>
<td>1</td>
<td>2.0</td>
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<tr>
<td>100</td>
<td>15</td>
<td>11.1</td>
<td>5</td>
<td>5.9</td>
<td>10</td>
<td>20.4</td>
</tr>
<tr>
<td>Total</td>
<td>135</td>
<td>100</td>
<td>85</td>
<td>100</td>
<td>49</td>
<td>100</td>
</tr>
</tbody>
</table>

From Table 19 (61.5%) of students reported that they did not have any loans to pay for their studies. More male students (62.0%) than their female students (60.5%) reported that they did not have any loans.

Table 19. Contribution of Loans to costs of studies
<table>
<thead>
<tr>
<th>Contribution</th>
<th>Total</th>
<th>Males</th>
<th>Females</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Frequency</td>
<td>%</td>
<td>Frequency</td>
</tr>
<tr>
<td>0</td>
<td>75</td>
<td>61.5</td>
<td>49</td>
</tr>
<tr>
<td>1</td>
<td>2</td>
<td>1.6</td>
<td>2</td>
</tr>
<tr>
<td>5</td>
<td>3</td>
<td>2.5</td>
<td>3</td>
</tr>
<tr>
<td>10</td>
<td>2</td>
<td>1.6</td>
<td>1</td>
</tr>
<tr>
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<td>2</td>
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<td>1</td>
</tr>
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<td>30</td>
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<td>0.8</td>
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</tr>
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<td>40</td>
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<td>7.4</td>
<td>1</td>
</tr>
<tr>
<td>50</td>
<td>9</td>
<td>0.8</td>
<td>4</td>
</tr>
<tr>
<td>54</td>
<td>1</td>
<td>0.8</td>
<td>0</td>
</tr>
<tr>
<td>60</td>
<td>1</td>
<td>1.6</td>
<td>1</td>
</tr>
<tr>
<td>70</td>
<td>2</td>
<td>4.1</td>
<td>1</td>
</tr>
<tr>
<td>80</td>
<td>5</td>
<td>2.5</td>
<td>3</td>
</tr>
<tr>
<td>85</td>
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<td>3.3</td>
<td>2</td>
</tr>
<tr>
<td>90</td>
<td>4</td>
<td>2.5</td>
<td>2</td>
</tr>
<tr>
<td>95</td>
<td>3</td>
<td>6.6</td>
<td>3</td>
</tr>
<tr>
<td>100</td>
<td>8</td>
<td>6.6</td>
<td>5</td>
</tr>
<tr>
<td>Total</td>
<td>122</td>
<td>100.0</td>
<td>79</td>
</tr>
</tbody>
</table>

From Table 20 (92.0%) of students reported that they did not use funds from on campus work to pay for their studies. More male students (92.4%) than their male students (91.2%) reported that they did not have any loans.

Table 20. Contribution of on campus work to costs of studies

<table>
<thead>
<tr>
<th>Contribution</th>
<th>Total</th>
<th>Males</th>
<th>Females</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Frequency</td>
<td>%</td>
<td>Frequency</td>
</tr>
<tr>
<td>0</td>
<td>92</td>
<td>92.0</td>
<td>61</td>
</tr>
<tr>
<td>1</td>
<td>2</td>
<td>2.0</td>
<td>2</td>
</tr>
<tr>
<td>2</td>
<td>1</td>
<td>1.0</td>
<td>0</td>
</tr>
<tr>
<td>4</td>
<td>1</td>
<td>1.0</td>
<td>0</td>
</tr>
<tr>
<td>5</td>
<td>1</td>
<td>1.0</td>
<td>1</td>
</tr>
<tr>
<td>15</td>
<td>1</td>
<td>1.0</td>
<td>1</td>
</tr>
<tr>
<td>50</td>
<td>1</td>
<td>1.0</td>
<td>1</td>
</tr>
</tbody>
</table>
From Table 21 (68.2%) of students reported that they did not use funds from their off campus work to pay for their studies. More female students (81.1%) than their male students (61.6%) reported that they did not use these funds.

Table 21. Contribution of off campus work to costs of studies

<table>
<thead>
<tr>
<th>% Contribution</th>
<th>Total</th>
<th>Males</th>
<th>Females</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Frequency</td>
<td>%</td>
<td>Frequency</td>
</tr>
<tr>
<td>0</td>
<td>75</td>
<td>68.2</td>
<td>45</td>
</tr>
<tr>
<td>1</td>
<td>3</td>
<td>2.7</td>
<td>2</td>
</tr>
<tr>
<td>3</td>
<td>1</td>
<td>0.9</td>
<td>1</td>
</tr>
<tr>
<td>5</td>
<td>2</td>
<td>1.8</td>
<td>2</td>
</tr>
<tr>
<td>8</td>
<td>1</td>
<td>0.9</td>
<td>0</td>
</tr>
<tr>
<td>10</td>
<td>10</td>
<td>9.1</td>
<td>8</td>
</tr>
<tr>
<td>20</td>
<td>5</td>
<td>4.5</td>
<td>5</td>
</tr>
<tr>
<td>30</td>
<td>2</td>
<td>1.8</td>
<td>1</td>
</tr>
<tr>
<td>40</td>
<td>3</td>
<td>2.7</td>
<td>2</td>
</tr>
<tr>
<td>50</td>
<td>4</td>
<td>3.6</td>
<td>3</td>
</tr>
<tr>
<td>90</td>
<td>1</td>
<td>0.9</td>
<td>1</td>
</tr>
<tr>
<td>100</td>
<td>3</td>
<td>2.7</td>
<td>3</td>
</tr>
<tr>
<td>Total</td>
<td>110</td>
<td>100.0</td>
<td>73</td>
</tr>
</tbody>
</table>

Students were required to indicate on a 5-point scale where 1=strongly agree; 2=disagree; 3=neutral; 4=agree; and 5=strongly agree to what extent they agreed with four statements about their perceptions of their instructors. Their responses are shown in Table 22. Students tended to agree to varying degrees that instructors at their university had high expectations for students like they were (mean=3.62). They were more neutral about their instructors holding them to high standards (mean=3.59), striving to ensure that they achieved the learning outcomes of each course that they taught (mean=3.58) and were approachable, helpful and understanding (mean=3.54). Male
students, however, were less neutral than their female counterparts about their instructors holding them to high standards, striving to ensure that they achieved the learning outcomes of each course that they taught and were approachable, helpful and understanding. Female students agreed more strongly than their male counterparts that instructors at their university had high expectations for students like they were.

Students were required to indicate on a 5-point scale where 1=strongly agree; 2=disagree; 3=neutral; 4=agree; and 5=strongly agree to what extent they agreed with three statements about their perceptions of other students. Their responses are shown in Table 23. Students tended to agree to varying degrees that students at their university worked hard to succeed...
academically (mean=3.81), had high academic aspirations (mean=3.57), and helped each other to succeed (mean=3.44). Female students agreed more strongly than their male counterparts that students at their university worked hard to succeed academically and had high academic aspirations. Male students, however, agreed more strongly than their female counterparts that students helped each other to succeed.

Table 23 Perceptions of other students

<table>
<thead>
<tr>
<th>Perceptions of other students</th>
<th>Strongly Disagree (%)</th>
<th>Disagree (%)</th>
<th>Neutral (%)</th>
<th>Agree (%)</th>
<th>Strongly Agree (%)</th>
<th>Total (%)</th>
<th>Mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Students at my university work hard to succeed academically</td>
<td>Female</td>
<td>2 (2.3%)</td>
<td>0 (0.0%)</td>
<td>24 (27.3%)</td>
<td>35 (39.8%)</td>
<td>27 (30.7%)</td>
<td>88 (100.0%)</td>
<td>3.97</td>
</tr>
<tr>
<td></td>
<td>Male</td>
<td>4 (2.3%)</td>
<td>5 (2.9%)</td>
<td>50 (29.2%)</td>
<td>88 (51.5%)</td>
<td>24 (14.0%)</td>
<td>171 (100.0%)</td>
<td>3.72</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>6 (2.3%)</td>
<td>5 (1.9%)</td>
<td>74 (28.6%)</td>
<td>123 (47.5%)</td>
<td>51 (19.7%)</td>
<td>259 (100.0%)</td>
<td>3.81</td>
</tr>
<tr>
<td></td>
<td>Students at my university have high academic aspirations</td>
<td>Female</td>
<td>0 (0.0%)</td>
<td>3 (3.4%)</td>
<td>34 (38.6%)</td>
<td>41 (46.6%)</td>
<td>10 (11.4%)</td>
<td>88 (100.0%)</td>
</tr>
<tr>
<td></td>
<td>Male</td>
<td>3 (1.7%)</td>
<td>9 (5.2%)</td>
<td>74 (43.0%)</td>
<td>40 (37.8%)</td>
<td>21 (12.2%)</td>
<td>172 (100.0%)</td>
<td>3.53</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>3 (1.2%)</td>
<td>12 (4.6%)</td>
<td>108 (41.5%)</td>
<td>106 (40.8%)</td>
<td>31 (11.9%)</td>
<td>262 (100.0%)</td>
<td>3.57</td>
</tr>
<tr>
<td></td>
<td>Students at my university help each other succeed</td>
<td>Female</td>
<td>7 (8.0%)</td>
<td>13 (14.9%)</td>
<td>27 (31.0%)</td>
<td>30 (34.5%)</td>
<td>10 (11.5%)</td>
<td>87 (100.0%)</td>
</tr>
<tr>
<td></td>
<td>Male</td>
<td>4 (2.3%)</td>
<td>14 (8.1%)</td>
<td>61 (35.5%)</td>
<td>72 (41.9%)</td>
<td>21 (12.2%)</td>
<td>172 (100.0%)</td>
<td>3.53</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>11 (4.2%)</td>
<td>27 (10.4%)</td>
<td>88 (34.0%)</td>
<td>102 (39.3%)</td>
<td>31 (12.0%)</td>
<td>259 (100.0%)</td>
<td>3.44</td>
</tr>
</tbody>
</table>

Table 24 Perception of university

<table>
<thead>
<tr>
<th>Perception of university</th>
<th>Strongly Disagree (%)</th>
<th>Disagree (%)</th>
<th>Neutral (%)</th>
<th>Agree (%)</th>
<th>Strongly Agree (%)</th>
<th>Total (%)</th>
<th>Mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Female</td>
<td>4 (4.5%)</td>
<td>5 (5.7%)</td>
<td>20 (22.7%)</td>
<td>36 (40.9%)</td>
<td>23 (26.1%)</td>
<td>88 (100.0%)</td>
<td>3.78</td>
<td>1.044</td>
</tr>
<tr>
<td>Male</td>
<td>2 (1.2%)</td>
<td>5 (2.9%)</td>
<td>37 (21.6%)</td>
<td>75 (43.4%)</td>
<td>52 (30.4%)</td>
<td>171 (100.0%)</td>
<td>3.99</td>
<td>0.864</td>
</tr>
<tr>
<td>Total</td>
<td>6 (2.3%)</td>
<td>10 (3.9%)</td>
<td>57 (22.0%)</td>
<td>111 (42.9%)</td>
<td>75 (29.0%)</td>
<td>259 (100.0%)</td>
<td>3.92</td>
<td>0.933</td>
</tr>
</tbody>
</table>

From Table 24 students tended to agree (mean= 3.92) that their university had a strong tradition of success for students like themselves. Male students (mean=3.99) agreed more strongly than their female counterparts (mean=3.78).
Table 25: Level of schooling of parents

<table>
<thead>
<tr>
<th></th>
<th>Female (%)</th>
<th>Male  (%)</th>
<th>Total (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>No Schooling</td>
<td>2 (2.3%)</td>
<td>2 (1.2%)</td>
<td>4 (1.6%)</td>
</tr>
<tr>
<td>Elementary</td>
<td>3 (3.5%)</td>
<td>5 (2.9%)</td>
<td>8 (3.1%)</td>
</tr>
<tr>
<td>Secondary</td>
<td>21 (24.4%)</td>
<td>34 (19.9%)</td>
<td>55 (21.4%)</td>
</tr>
<tr>
<td>College</td>
<td>22 (25.6%)</td>
<td>29 (17%)</td>
<td>51 (19.8%)</td>
</tr>
<tr>
<td>University</td>
<td>38 (44.2%)</td>
<td>101 (59.1%)</td>
<td>138 (53.7%)</td>
</tr>
<tr>
<td>Total</td>
<td>86 (33.5%)</td>
<td>171 (66.5%)</td>
<td>257 (100%)</td>
</tr>
</tbody>
</table>

From Table 25 the highest level of schooling of parents of students was mostly university (53.7%). A higher proportion of the parents of male students (59.1%) had completed university study than their female counterparts (44.2%). An additional (19.8%) of parents have obtained a college education. Therefore a total of (73.5%) of the parents had achieved tertiary education.

OBSERVATIONS AND CONCLUSION

This study sought to develop a baseline of student experiences in construction programmes in South African universities.

Students reported being active participants in lower order academic activities such as applying theories or concepts to practical problems or new solutions and analysing the basic elements of an idea, experience, or theory, such as examining a particular case or situation in depth and considering its components. However, they were less active in higher order academic activities of making judgements about the value of information, arguments, or methods, such as examining how others gathered and interpreted data and assessing the soundness of their conclusions and synthesizing and organizing ideas into new more complex interpretations and relationships. These are typical of inquiry-based approaches which place more emphasis on the higher order academic activities. With regard to assigned academic activities students reported that the amount of work that they were required to do was less than could be expected for studying at a university. Most students spent about 1 hour per day on preparing for their classes. Unlike inquiry-based approaches time spent with peers and
self-study was very low. The use of computers was in most cases about 1 hour per day. It is not known whether computers were used in a computer laboratory or whether the students had their own computers.

Students spent very little time working either on or off campus with most students not working more than 7 hours either on or off campus in a 7 day week. Of those students that did work, the majority did not work to pay for their studies or send money home. The work was related to their career paths though. Most of the students studies were paid by their parents.

Students claimed to spend most of their time on their studies. In addition the students spent very little time doing either extra-curricular activities.

Instructors at their university were perceived to have high expectations of them by holding them to high standards and striving to ensure that they achieved the learning outcomes of each course that they taught . Instructors were also perceived as being approachable, helpful and understanding. They had a positive regard for their universities.

REFERENCES


Evaluation of the Selection Procedure for Admitting Delegates to the Construction Management Programme (CMP)

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ABSTRACT

The Construction Management Programme (CMP) is a continued professional development programme presented on an annual basis at the University of Stellenbosch. It provides a four week personal development and educational programme for construction middle level managers, which includes the Building as well as the Civil Engineering Sectors of the industry.

Seeing that a limited number (about 45 to 50) delegates can be accommodated per annum, a formal selection procedure to select suitable candidates has been developed. The procedure has been in use for the past CMP events from 2008 to 2013. The selection process was designed using the Analytic Hierarchy Process (AHP), a multi-criteria decision making tool. The decision criteria for selection ranking of the delegates, is discussed. These criteria are based on personal attributes as well as other factors to ensure that a suitable mix of delegates for the programme, are selected.

The formal delegate performance assessment system used for the CMP provides a merit list of delegates at the end of the programme. The selection process candidate ranking based on the personal attributes of the candidates was correlated with the delegate programme performance merit list ranking for the years 2008 to 2013. The degree of correlation found between the two rankings is discussed. Statistical analysis of the correlation of the rank position in which a delegate is selected with the...
class position attained in the programme, found that suitable candidate selections can be made without subjecting the candidates to time consuming and costly entrance testing or selection interviews.

Keywords

Education & training; Statistical analysis

List of notations and acronyms

CMP - Construction Management Programme
RE – Resident Engineer
SANRAL – South African National Road Agency Limited

1 The Construction Management Programme (CMP)

The Construction Management Programme (CMP) is a programme designed to develop middle management for the South African construction industry. It is a four week residential programme which covers a wide range of modules dealing with personal development, the construction business environment, business management and project management.

The programme was started in 1976 at the Graduate School of Business at the University of Cape Town and has been presented on a regular biannual basis since then. Faculty members for presentation of modules (academics as well as practicing engineers and managers) are drawn from a selection of institutions in South Africa and around the world.

Since 1987 the programme has been presented at the University of Stellenbosch. The programme is being presented on an annual basis since 2008.

Candidates are typically proposed and sponsored by construction companies and their candidature needs to be endorsed by previous delegates (alumni).

Candidates supply the CMP secretariat with a completed application form containing the necessary information for input into the candidate selection process.

2 Selection requirements for delegates to the CMP

The basic biographic and job related data of the candidates is summarised in tabular spreadsheet form and forms the input into the data processing for the computation of an overall candidate selection score. The candidates are then ranked according to the score and the candidates with low scores
are reviewed before the final student complement for the CMP is finalised. The basic data used for candidate selection is listed in Table 1.

Table 1: Attributes used for CMP delegate selection

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Attribute type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>Personal</td>
</tr>
<tr>
<td>Qualifications</td>
<td>Personal</td>
</tr>
<tr>
<td>Job experience</td>
<td>Personal</td>
</tr>
<tr>
<td>Job description</td>
<td>Personal</td>
</tr>
<tr>
<td>Job experience range</td>
<td>Personal</td>
</tr>
<tr>
<td>Organisation</td>
<td>Other</td>
</tr>
<tr>
<td>Business discipline</td>
<td>Other</td>
</tr>
<tr>
<td>Working location</td>
<td>Other</td>
</tr>
<tr>
<td>Special attributes</td>
<td>Personal</td>
</tr>
</tbody>
</table>

For the 2014 CMP for candidates for which doubt existed in their ability to complete the programme a written entrance assignment was set and evaluated to determine their suitability for inclusion in the programme.

3 Attributes used for decision criteria

The candidate attributes used for selecting candidates fall into the category of 'personal attributes' and 'other' attributes not directly relating to the candidate as such. This is indicated in Table 1.

3.1 Personal candidate attributes used for decision criteria

The personal attributes used for selection listed in Table 1 are candidate age, job experience measured in time, qualifications, job description and spread of experience.

In the tables set out below the ranking for each of the options listed is given. The use of the rankings will be explained later.

The complete lists of weightings used are contained in Appendix A.

Table 2a – Candidate age weight ranking

<table>
<thead>
<tr>
<th>Age</th>
<th>Ranking</th>
</tr>
</thead>
<tbody>
<tr>
<td>Range</td>
<td>Weight</td>
</tr>
<tr>
<td>20-24</td>
<td>2</td>
</tr>
<tr>
<td>25-29</td>
<td>4</td>
</tr>
</tbody>
</table>

As shown in table 2a the preferred age of candidates fall in the 35 to 39 year age bracket. Young candidates (24 years and
younger) as well as older candidates (55 years and older) are given a low weight.

<table>
<thead>
<tr>
<th>Experience Range</th>
<th>Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>30-34</td>
<td>7</td>
</tr>
<tr>
<td>35-39</td>
<td>9</td>
</tr>
<tr>
<td>40-44</td>
<td>7</td>
</tr>
<tr>
<td>45-49</td>
<td>5</td>
</tr>
<tr>
<td>50-54</td>
<td>4</td>
</tr>
<tr>
<td>55-70</td>
<td>2</td>
</tr>
</tbody>
</table>

Table 2b – Candidate job experience measure in time ranking

Table 2b indicates that candidates with construction industry job experience ranging from 10 to 19 years are allocated the largest ranking weight.

<table>
<thead>
<tr>
<th>Experience Time</th>
<th>Job Experience Range</th>
<th>Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-4</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>5-9</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>10-14</td>
<td>9</td>
<td></td>
</tr>
<tr>
<td>15-19</td>
<td>9</td>
<td></td>
</tr>
<tr>
<td>20-24</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>25-29</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>30-35</td>
<td>4</td>
<td></td>
</tr>
</tbody>
</table>

The weighting for qualifications for candidates is assigned per table 2c. Academic qualifications carry more weight than technical qualifications. If candidates have additional applicable qualifications the weighting can be increased by 1.

<table>
<thead>
<tr>
<th>Qualification</th>
<th>Qualification ranking</th>
</tr>
</thead>
<tbody>
<tr>
<td>PhD</td>
<td>8</td>
</tr>
<tr>
<td>M Eng</td>
<td>8</td>
</tr>
<tr>
<td>B Eng / B Sc</td>
<td>7</td>
</tr>
<tr>
<td>B Tech</td>
<td>6</td>
</tr>
<tr>
<td>Diploma</td>
<td>4</td>
</tr>
<tr>
<td>Other</td>
<td>2</td>
</tr>
<tr>
<td>Additional+</td>
<td>1</td>
</tr>
</tbody>
</table>

Table 2c – Candidate qualifications ranking weight

The job description weighting is shown in table 2d. Senior job descriptions carry the largest weight while a special...
category caters for job descriptions which can improve the diversity of the candidate mix. A special category was used to accommodate candidates who come from e.g. the academic environment.

<table>
<thead>
<tr>
<th>Job Description</th>
<th>Job description ranking</th>
</tr>
</thead>
<tbody>
<tr>
<td>Director</td>
<td>8</td>
</tr>
<tr>
<td>Manager</td>
<td>7</td>
</tr>
<tr>
<td>Junior</td>
<td>6</td>
</tr>
<tr>
<td>Special</td>
<td>9</td>
</tr>
</tbody>
</table>

Table 2e Candidate job experience range weight

<table>
<thead>
<tr>
<th>Exp Range</th>
<th>Job Experience Range</th>
<th>Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wide</td>
<td>7</td>
<td></td>
</tr>
<tr>
<td>Medium</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>Narrow</td>
<td>3</td>
<td></td>
</tr>
</tbody>
</table>

Table 2f – Career specialisation fields

- Professional project management
- Planning and design of projects
- Field design supervision
- Site and construction management
- Management of multiple contracts
- Plant management
- Procurement
- Personnel management
- Financial management

3.2 Additional candidate attributes used for decision criteria

Attributes not directly linked to the personal attributes of candidates are also used for ranking. These include the number of delegates per organisation as well as the discipline which the candidate represents.
Table 3 shows the weighting allocated for multiple delegates from a given company or organisation. This weighting is used to prevent too many candidates from one company being represented on the programme.

<table>
<thead>
<tr>
<th>Company Delegate Count</th>
<th>Delegate Count Range</th>
<th>Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>9</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>10+</td>
<td>1</td>
<td></td>
</tr>
</tbody>
</table>

Groupings based on job discipline i.e. Building / Civil Engineering / Other discipline as well as geographical origin of candidates are only reported for candidate use in selection but are not weighted.

### 3.3 Special candidate attributes used for decision criteria

A ‘special’ category was added to the attributes used to assign weight to candidates with special attributes which warrant selection preference. A weight of 1 to 9 can be assigned to a candidate to indicate merit as far as designated preference groups, gender preference and special qualifications held by the candidate is concerned.

### 4 The Analytical Hierarchical Process applied to decision making

The Analytic Hierarchy Process (AHP) is a multi criteria decision making tool originally developed by Professor Thomas L. Saaty. (Saaty, 1988) The method is used to derive ratio scales from paired comparisons. The input can be obtained from actual measurements or from subjective opinion or preference.

The AHP therefore can accommodate some inconsistency in judgement associated with subjectivity. The ratio scales give an indication of the relative priorities of the alternatives amongst each another. (Triantaphyllou, & Mann, 1995)
4.1 Explanation of the Analytic Hierarchy Process

The AHP-process can be summarised in the following steps:

Step 1: Model the problem by clearly identifying a hierarchy of alternative selections of solutions.
Step 2: Establish the priorities of the different criteria by pair wise comparisons between each other.
Step 3: Establish the priorities of the different alternatives for each criterion separately by using pair wise comparisons. This is done by the calculation of the geometric mean of each row of the matrix. It then leaves one with a priority vector specific to each criterion.
Step 4: Synthesize the judgement priorities calculated under Step 2 to derive at a hierarchical set of overall priorities of the alternatives relative to each other.

The importance of the selection criteria is approximated in the AHP by the use of pair-wise comparisons. This is done by determining which of the two alternatives is the most important in respect of the criterion under consideration and how strong the importance of a criterion is on a scale of 1 – 9.
The Scale of Relative Importance (Saaty 2001) used for assigning relative weight between two alternatives for a specific attribute is shown in Table 4.
Table 4: Scale of relative importance of selection criteria according to the AHP (Source Bózoki, 2001)

<table>
<thead>
<tr>
<th>Intensity of Importance</th>
<th>Definition</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Equal Importance</td>
<td>Two activities contribute equally to the objective</td>
</tr>
<tr>
<td>3</td>
<td>Weak importance of one over the other</td>
<td>Experience and judgement slightly favour one activity over the other</td>
</tr>
<tr>
<td>5</td>
<td>Essential or Strong Importance</td>
<td>Experience and judgement strongly favour one activity over the other</td>
</tr>
<tr>
<td>7</td>
<td>Demonstrated Importance</td>
<td>An activity is strongly favoured and its dominance demonstrated in practice</td>
</tr>
<tr>
<td>9</td>
<td>Absolute Importance</td>
<td>The evidence favouring one activity over another is of the highest possible order of affirmation</td>
</tr>
<tr>
<td>2,4,6,8</td>
<td>Intermediate values between the two adjacent judgments</td>
<td>When compromise is needed</td>
</tr>
</tbody>
</table>

4.2 Aspects of the Analytic Hierarchy Process used for CMP candidate selection

For the purpose of delegate selection for the CMP programme the ranking weights tabulated in Table 1 were used indicating the relative importance of the various selection criteria applied. Note that the weighting employed implies that attributes are rated as of equal importance across categories according to weights assigned as shown in Appendix A. For each delegate an average ranking was calculated using the geometric mean of all the criteria selected.

5 Development of selection data and analysis of selected sample data

A summary of the candidate attribute data in tabular format with selected analyses of the data is set out below. The total number of delegates for 2009 and 2010 differ by one and two respectively from the number of...
delegates which attended, because not all delegate data was at hand when the analysis was done. The following sections contain a summary of the selection data. Full details can be found in the CMP reports (Strasheim, 2008-2013).

5.1 Summary of data analysed

Table 5 shows the age distribution of the delegates, table 6 the work experience of the delegates in years and table 7 the job descriptions / job levels of the delegates.

Figure 1 and 2 shows histograms of data and data analyses performed. The histograms show:

1. The age distribution of the delegates and
2. The experience of the delegates

Where data on work experience was not supplied estimates were made.

<table>
<thead>
<tr>
<th>Table 5</th>
<th>CMP Delegate age data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age Range</td>
<td>2008</td>
</tr>
<tr>
<td>&lt;20</td>
<td>0</td>
</tr>
<tr>
<td>21-25</td>
<td>0</td>
</tr>
<tr>
<td>26-30</td>
<td>8</td>
</tr>
<tr>
<td>31-35</td>
<td>8</td>
</tr>
<tr>
<td>36-40</td>
<td>16</td>
</tr>
<tr>
<td>41-45</td>
<td>9</td>
</tr>
<tr>
<td>46-50</td>
<td>5</td>
</tr>
<tr>
<td>51-55</td>
<td>1</td>
</tr>
<tr>
<td>56-60</td>
<td>0</td>
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<tr>
<td>&gt; 60</td>
<td>0</td>
</tr>
<tr>
<td>Total</td>
<td>47</td>
</tr>
<tr>
<td>Average age</td>
<td>37.9</td>
</tr>
<tr>
<td>Standard deviation</td>
<td>6.5</td>
</tr>
<tr>
<td>Standard deviation %</td>
<td>17.2</td>
</tr>
<tr>
<td>Maximum age</td>
<td>54</td>
</tr>
<tr>
<td>Minimum age</td>
<td>25</td>
</tr>
<tr>
<td>Experience Range</td>
<td>2008</td>
</tr>
<tr>
<td>------------------</td>
<td>------</td>
</tr>
<tr>
<td>0-5</td>
<td>3</td>
</tr>
<tr>
<td>6-10</td>
<td>8</td>
</tr>
<tr>
<td>11-15</td>
<td>14</td>
</tr>
<tr>
<td>16-20</td>
<td>14</td>
</tr>
<tr>
<td>21-25</td>
<td>6</td>
</tr>
<tr>
<td>26-30</td>
<td>1</td>
</tr>
<tr>
<td>31-35</td>
<td>1</td>
</tr>
<tr>
<td>36-40</td>
<td>0</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>47</td>
</tr>
<tr>
<td><strong>Average experience</strong></td>
<td>14.9</td>
</tr>
<tr>
<td><strong>Standard deviation</strong></td>
<td>6.5</td>
</tr>
<tr>
<td><strong>Standard deviation %</strong></td>
<td>43.8%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>CMP Delegate count by job level</th>
<th>2008</th>
<th>2009</th>
<th>2010</th>
<th>2011</th>
<th>2012</th>
<th>2013</th>
</tr>
</thead>
<tbody>
<tr>
<td>Director Level</td>
<td>7</td>
<td>5</td>
<td>6</td>
<td>2</td>
<td>8</td>
<td>7</td>
</tr>
<tr>
<td>Manager Divisional</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>6</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>Manager Senior</td>
<td>3</td>
<td>12</td>
<td>1</td>
<td>4</td>
<td>18</td>
<td>4</td>
</tr>
<tr>
<td>Manager</td>
<td>25</td>
<td>7</td>
<td>28</td>
<td>15</td>
<td>6</td>
<td>20</td>
</tr>
<tr>
<td>Site manager/ Engineer</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td>4</td>
<td>5</td>
<td>9</td>
</tr>
<tr>
<td>Site agent / Resident Engineer</td>
<td>4</td>
<td>6</td>
<td>7</td>
<td>8</td>
<td>4</td>
<td>0</td>
</tr>
<tr>
<td>Quantity Surveyor</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Estimator</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Surveyor</td>
<td>1</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Postgraduate student</td>
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<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>47</td>
<td>33</td>
<td>47</td>
<td>40</td>
<td>47</td>
<td>42</td>
</tr>
</tbody>
</table>

### 5.2 Additional delegate attributes

#### Number of delegates per organisation

The number of delegates per company is an attribute which is not directly related to personal qualities of a given delegate. This was added to the ranking weight calculation used for the ranking of delegates for selection for
the CMP to ensure that not too many delegates of any one company attend the CMP.

The distribution of delegates between sponsoring organisations is shown in table 8.

<table>
<thead>
<tr>
<th>Organisation</th>
<th>2008</th>
<th>2009</th>
<th>2010</th>
<th>2011</th>
<th>2012</th>
<th>2013</th>
</tr>
</thead>
<tbody>
<tr>
<td>Africon</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Afristruct Projects</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Aquatan Pty Ltd</td>
<td></td>
<td></td>
<td>2</td>
<td>1</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Aurecon</td>
<td></td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Auspex Project Solutions</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Aveng</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2</td>
</tr>
<tr>
<td>Bagale Consulting</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2</td>
</tr>
<tr>
<td>Basil Read</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>5</td>
<td>3</td>
</tr>
<tr>
<td>Bophelong Construction</td>
<td></td>
<td>1</td>
<td>1</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Botes &amp; Kennedy Manyano</td>
<td></td>
<td></td>
<td></td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Civcon Construction (Pty) Ltd</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Coega</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td>2</td>
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</table>

Table 8 (Continued)

<table>
<thead>
<tr>
<th>Organisation</th>
<th>2008</th>
<th>2009</th>
<th>2010</th>
<th>2011</th>
<th>2012</th>
<th>2013</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concor Engineering</td>
<td></td>
<td>1</td>
<td></td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Concor Roads</td>
<td>1</td>
<td>2</td>
<td></td>
<td>2</td>
<td></td>
<td>3</td>
</tr>
<tr>
<td>Cycad Pipelines</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Department of Water Affairs</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2</td>
</tr>
<tr>
<td>Eskom Holdings</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>ECMP</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Grinaker LTA</td>
<td></td>
<td>11</td>
<td>6</td>
<td>12</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Group 5</td>
<td></td>
<td>3</td>
<td>3</td>
<td>6</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Group 5 Building</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>5</td>
</tr>
<tr>
<td>Hatch Africa</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>3</td>
</tr>
<tr>
<td>Haw &amp; Inglis</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Hillary Construction</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Inyatsi Construction</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Liviero Civils / Building (Pty) Ltd</td>
<td></td>
<td></td>
<td></td>
<td>1</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Mphaphuli Consulting</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Martin &amp; East Pty Ltd</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Murray and Dickson Construction</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1</td>
</tr>
</tbody>
</table>
Delegate discipline field

Table 9 shows the civil engineering / building / other discipline allocation of the delegates.

<table>
<thead>
<tr>
<th>Year</th>
<th>Civil Engineering</th>
<th>Building</th>
<th>Other</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>2008</td>
<td>36</td>
<td>10</td>
<td>1</td>
<td>47</td>
</tr>
<tr>
<td>2009</td>
<td>27</td>
<td>6</td>
<td>0</td>
<td>33</td>
</tr>
<tr>
<td>2010</td>
<td>44</td>
<td>2</td>
<td>1</td>
<td>47</td>
</tr>
<tr>
<td>2011</td>
<td>40</td>
<td>0</td>
<td>0</td>
<td>40</td>
</tr>
<tr>
<td>2012</td>
<td>41</td>
<td>2</td>
<td>4</td>
<td>47</td>
</tr>
<tr>
<td>2013</td>
<td>35</td>
<td>5</td>
<td>2</td>
<td>42</td>
</tr>
</tbody>
</table>

Geographical origin of delegates

Table 10 lists the geographical origin of the delegates for reference purposes.
<table>
<thead>
<tr>
<th>Geographical Origin</th>
<th>2008</th>
<th>2009</th>
<th>2010</th>
<th>2011</th>
<th>2012</th>
<th>2013</th>
</tr>
</thead>
<tbody>
<tr>
<td>Botswana</td>
<td>1</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Eastern Cape</td>
<td>4</td>
<td>2</td>
<td>2</td>
<td>3</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>Free State</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Gauteng</td>
<td>23</td>
<td>19</td>
<td>30</td>
<td>28</td>
<td>28</td>
<td>24</td>
</tr>
<tr>
<td>Italy</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Kwazulu-Natal</td>
<td>9</td>
<td>3</td>
<td>1</td>
<td>4</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>Limpopo</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mocambique</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Mpumalanga</td>
<td>1</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Namibia</td>
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<td></td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Swaziland</td>
<td></td>
<td></td>
<td>3</td>
<td>2</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Western Cape</td>
<td>10</td>
<td>6</td>
<td>6</td>
<td>5</td>
<td>6</td>
<td>6</td>
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<tr>
<td>Zimbabwe</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>47</td>
<td>33</td>
<td>47</td>
<td>40</td>
<td>47</td>
<td>42</td>
</tr>
</tbody>
</table>
Figure 1 – CMP delegate age
Figure 2 – CMP delegate work experience
6 Delegate ranking weights computed.

The delegate ranking weights computed are summarised in Table 11. The geometric mean of the weights as well as the total weight computed is shown. As per the AHP approach the geometric mean was used to rank the candidates. The ranking made with the geometric mean differs from that based on the total weight due to the nature of the mathematical formulation of the geometric mean.

<table>
<thead>
<tr>
<th>Table 11</th>
<th>CMP Delegate ranking weight data summary</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ranking weight geometric mean</td>
<td>2008</td>
</tr>
<tr>
<td>Average mean</td>
<td>4.65</td>
</tr>
<tr>
<td>Standard deviation</td>
<td>0.68</td>
</tr>
<tr>
<td>Standard deviation %</td>
<td>14.7</td>
</tr>
<tr>
<td>Ranking weight total</td>
<td></td>
</tr>
<tr>
<td>Average total</td>
<td>37.9</td>
</tr>
<tr>
<td>Standard deviation</td>
<td>5.6</td>
</tr>
<tr>
<td>Standard deviation %</td>
<td>14.8</td>
</tr>
</tbody>
</table>

Figure 3 shows the delegate ranking weights as computed, in histogram form.
Figure 3 – CMP Delegate ranking weights
7 Correlation of delegate ranking and class position.

When the processing of the candidate selection criteria was done it was postulated that some correlation might exist between the candidate ranking and class position. This was however not found to be the case. Both the Pearson and Spearman rank correlation coefficients were calculated for the data and as can be seen in table 12 the results vary from year to year and mixed correlation was found.

The rank correlation coefficients shown in the table are inside the interval \([-1, 1]\) and assume the values:

- -1 if the disagreement between the two rankings is perfect; one ranking is the reverse of the other.
- 0 if the rankings are completely independent.
- 1 if the agreement between the two rankings is perfect; the two rankings are the same.

An increasing rank correlation coefficient implies increasing agreement between rankings.

The significance levels of the correlation coefficients shown in the table were calculated in accordance with the procedure outlined by Zar. (Zar, 1972)

Table 12 indicates that some correlation exists between the selection ranking for candidates and the CMP class position attained by a student.

Table 12: CMP candidate selection rank and class position correlation
8 Conclusion and recommendation.

The development of a formal selection process for delegates to the Construction Management Programme (CMP) has proved to be useful in rational decision making on the selection of candidates for the programme. Mixed correlation between the ranking of candidate delegates based on the selection process and the class positions of delegates determined by the weighted course programme marks of the delegates was found.

For the period 2008 to 2012 all CMP delegates achieved the required academic pass mark of 60%. In 2013 however one candidate failed to make the grade. This indicates that a set of suitable candidates were selected for the programme.

It is recommended that a study based on data gathered with follow-up questionnaires to CMP alumni be done to determine the career and job advancement after CMP completion of delegates and how this relates to delegate selection rank as well as class position rank.

9 References


Appendix A

Construction Management Programme
Ranking Criteria For Candidate Selection

Weighting 1-9 for geometric mean

<table>
<thead>
<tr>
<th>Weight factor</th>
<th>Age Weight</th>
<th>Experience Time Weight</th>
<th>Exp Range Weight</th>
<th>Exp Range Weight</th>
<th>Comp Delegate Count Weight</th>
<th>Weigh Delegate Count</th>
<th>Qualification Weight</th>
<th>Job Description</th>
<th>Job Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Range</td>
<td>Range</td>
<td>Range</td>
<td>Range</td>
<td>Range</td>
<td>Range</td>
<td>Range</td>
<td>Range</td>
<td>Range</td>
<td>Range</td>
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<tr>
<td>20-24</td>
<td>2</td>
<td>0-4</td>
<td>4</td>
<td>7</td>
<td>1</td>
<td>9</td>
<td>M Eng</td>
<td>8</td>
<td>Director</td>
</tr>
<tr>
<td>25-29</td>
<td>4</td>
<td>5-9</td>
<td>6</td>
<td>5</td>
<td>2</td>
<td>8</td>
<td>B Eng</td>
<td>7</td>
<td>Manager</td>
</tr>
<tr>
<td>30-34</td>
<td>7</td>
<td>10-14</td>
<td>9</td>
<td>3</td>
<td>3</td>
<td>6</td>
<td>B Tech</td>
<td>6</td>
<td>Junior</td>
</tr>
<tr>
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The GCC 2010 as a modern construction contract and the impact of alterations to clauses

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ABSTRACT

Purpose
The article relays the perception of the GCC 2010 as a modern construction contract and the impact that alterations to standard clauses have on the document bias

Design
This article explains key concepts of modern construction contracts and different approaches to contracting, as well as elaborating on different pricing and contracting strategies. A discussion on the development of the GCC 2010 is provided.

Results of the survey on the GCC 2010 as modern contract, as well as the impact that alterations to standard clauses have on the document bias are interpreted and discussed. Conclusions are drawn from literature and survey results.

Findings based on Empirical Research
Respondents perceived the GCC 2010 to be in good standing when measured against the modern construction contract and that alterations to clauses change the bias in favour of the Employer.

Research limitations
The survey was completed by 22 respondents. Therefore, results are not an accurate reflection of the industry as a whole.
KEYWORDS
general conditions of contract; modern contract; alterations to clauses; construction contract; GCC.

1 INTRODUCTION

The General Conditions of Contract for Construction Works (GCC) developed by the South African Institution of Civil Engineering (SAICE) is one of four standard procurement documents endorsed by the Construction Industry Development Board (CIDB).

Individuals drafting contracts that make use of the GCC sometimes alter standard clauses of the document to protect their own interests. By altering clauses, there may be potential consequences that are not fully realised at the time. These consequences may be detrimental to the success of the project.

An empirical study was done, by means of a survey, as part of a larger research study on comparing the GCC 2010 and the GCC 2004 to the principles of modern contracting. This paper draws from data gathered through the survey and explains the respondents’ perception of bias of the GCC 2010 for the cases with no alterations to clauses and for the case when alterations are made to standard clauses.

2 THE MODERN CONSTRUCTION CONTRACT

Modern construction contracts take place in an environment where risks are not necessarily only of a technical nature. Factors that apply pressure to contract success and thus increase risks include:

- The cyclical nature of infrastructure expenditure
- Diminishing skills
- Political impacts
- Increased expectation of profitability
- Exercising of rights rather than satisfying interests
- Economic aspects

In light of the continuously varying environment, modern contracting principles must also remain up to date to effectively manage risks generated by the abovementioned factors.

A study by Howell (1991) about aspects of general conditions in contracts which give rise to dispute found that procurement documents need to conform to the following requirements to reduce risks inherent to construction projects:

i. Clear and unambiguous explanation of the Employer’s intent.
ii. The intent of the contract must be to maintain an equitable balance between the Employer's and Contractor's interests.

iii. Clear and complete information about
   a. Scope and quality of the works
   b. Information on cost-affecting factors such as subsoil conditions
   c. Risk allocation
   d. Programme requirements with cost implications
   e. Restrictions on normal construction procedures
   f. Basis for interim payments

What can be drawn from the abovementioned results are that procurement documents should provide clear conditions explaining requirements, roles and responsibilities and payment conditions to keep risks to a minimum. In addition to providing clarity, the contract must divide the risks equitably between the Contractor and the Employer. The risk allocation must be balanced with the aim of keeping the contract fair. A fair contract promotes a successful project.

2.1 Three pillars of the modern construction contract

Lord et al. (2010) suggests that the foundation of modern contracts rest on the following three pillars: fairness, roles and functions of project participants and payment operating mechanisms. These pillars, as shown in Figure 1, are key to ensure a firm basis of a modern contract. The abovementioned pillars incorporate the requirements set out by Howell under broader terms, by focussing on the principles rather than individual issues.

![Figure 1 Three pillars of the modern construction contract](image-url)
2.2 Approaches to contracting

There are two approaches that can be adopted in contracting: A relational approach or a transactional approach. Both approaches can be applied to any contracting method; however certain methods are better suited to the different approaches.

Rahman and Kumaraswamy (2002) stated that cooperative attitudes of project participants are important for successful project delivery. Relational contracting is an effective way of creating a positive environment to encourage teamwork and trust, but must be integrated with efficient transactional principles.

2.2.1 RELATIONAL APPROACH

A relational approach to contracting is characterised by mutual trust, building a long term partnership and solving problems through cooperation (Duberley, 1997). In layman's terms it can be described as a “Gentleman’s agreement” in written form.

Relational contracts are potentially dangerous in the sense that dishonesty and self-interest may cause serious damages to the other party. When the focus shifts from project success to exclusively personal success, the risk of project failure drastically increases. As soon as the project is at risk, both parties are exposed to risks that were not anticipated when the contract was concluded. As Egan (1998) discusses, there must be an understanding of mutual interdependency on both sides.

2.2.2 TRANSACTIONAL APPROACH

On the other side of the spectrum, traditional contracts tend to have a transactional approach where operations are very distinct and formal in nature. Any relational aspect is kept to a minimum (Macneil, 1974). Roles, responsibilities and the allocation of risks are clearly defined, leaving little room for negotiation. Having a transactional approach to contracts may lead to conflict between parties resulting from adversarial attitudes, as stated by Walker and Davis (1999). Furthermore it may develop a culture of self-centredness, irrespective of the impact it may have on other parties.

2.3 Contracting and pricing strategies

The Construction Industry Development Board (CIDB) identifies five contracting strategies that can be applied to a construction project. Each strategy allocates risk and responsibility differently. As the Employer is usually the party responsible for setting up the contract, it is up to the
Employer to select the amount of risk that he is willing to take and how much risk would be allocated to the Contractor.

The level of risk that the Employer allocates to the Contractor directly influences the price that the Contractor will charge for the project. The higher the risk, the higher the price. A subsequent effect of allocating more risk (and in so doing more responsibility) to the Contractor, is that the Employer will have less flexibility and less influence on the outcome of the project.

Figure 2 is taken from the CIDB Best Practice Guideline #C2 and shows the relationship between risk and flexibility when selecting different contracting and pricing strategies.

![Figure 2: Contracting and pricing strategies (CIDB, 2010)](image_url)

The CIDB has endorsed a number of standard procurement documents that are recommended for use in the construction industry. The procurement document published by the South African Institution of Civil Engineering (SAICE), the General Conditions of Contract for Construction Works (GCC) is one of the documents that the CIDB endorses.

The criteria of endorsement are related to the principles of the modern construction contract as described earlier in the article.

3 SAICE GENERAL CONDITIONS OF CONTRACT FOR CONSTRUCTION WORKS

Over several decades, SAICE has published six editions of General Conditions of Contract for Civil Engineering Works. In 1972 the 4th Edition of the GCC was published with the 5th edition being published 10 years later in 1982. The 6th edition (GCC 1990) was modified by the Committee...
of Land Transport Officials’ and republished as the COLTO 1998 (SAICE, 2004).

The GCC 2004 was a replacement for both the GCC 1990 and the COLTO 1998, and satisfied the CIDB requirements for standard form contract. After six years of application in the industry, the GCC 2004 was revised.

The revised edition is known as the GCC 2010. The primary contracting strategy that the GCC 2010 is focussed on is “design by Employer”, however it is also suitable to be used for the “design and build” strategy (SAICE, 2010). The conditions of the document are set up in such a way that projects still follow a transactional approach to contracting.

4 SURVEY RESULTS

In this study a survey was conducted asking respondents to rate the GCC 2010 on the three pillars of the modern construction contract and the bias with and without alterations to a number of aspects.

The survey was distributed electronically to a sample group of 117 industry participants that included Contractors, Consultants and Employers.


The CMP is a middle management course presented annually over four weeks at Stellenbosch University to persons in the built environment.

4.1 Respondent demographic

The responses received were predominantly from Contractors and only a limited number of responses were received from Employers and Consultants. The sample group is small, and the results need to be considered with this in mind. Nevertheless, the purpose of the survey is investigative and the results are still meaningful and useful.

A total of 22 respondents completed the survey, the majority of which were Contractors. Figure 3 shows the distribution of respondents.
4.2 Respondent experience

There was a high level of experience in the respondent group with no respondents having less than 6 years of experience. The majority of respondents had more than 10 years of experience, as Figure 4 illustrates.

![Figure 4: Respondent experience (Years)](image)

4.3 The GCC 2010 as a modern construction contract

The survey required respondents to rate the GCC 2010 on the three pillars of the modern construction contract (refer to Section 2) according to a 5 point scale. The scale was worded as follows:

- Very poor (0%)
- Poor (25%)
- Adequate (50%)
- Good (75%)
- Very good (100%)

The percentage value in brackets was used during the analysis of the data to create the graph illustrated in Figure 5. The shown percentages therefore being an average of all responses received.
4.4 Impact of alterations to standard clauses

The survey required respondents to provide their perception of bias of the aspects shown in the following list:

1. Payments
2. Latent defects
3. Scope changes
4. Quality
5. Insurance and guarantees
6. Design responsibilities
7. Claims and disputes
8. Risk allocation
9. Delays

The results received on the aspects listed above were combined to correlate with the following headings in the GCC 2010 document. These categories are listed below.

1. Time and related matters
2. Payment and related matters
3. Quality and related matters
4. Risk and related matters
5. Claims and disputes

There were two sets of questions posed to respondents, asking them to indicate their perception of bias when “no alterations” had been made to the clauses, and the second set asking their perception of bias when “alterations had been made” to the clauses.

4.4.1 BIAS WITHOUT ALTERATIONS

For the investigation where no alterations were made to standard clauses, the following two categories, Payment and related matters, as well as Quality and related matters were deemed to be neutral by most of the
respondents. While in contrast Risks and related matters had a high number of responses of bias in favour of the Employer. This was also the case for Claims and disputes.

The perception of bias in favour of the Contractor was low across all categories. Figure 6 shows the results of perceived bias of all the categories of the GCC 2010 without alterations according to respondents. The figure shows the percentage responses of the perceived bias for each specific category.

![Figure 6 GCC 2010 bias without alterations](image)

By combining these five areas, the overall impression of respondents (shown in Figure 7) was that 65% of respondents believed the GCC 2010 to be neutral, 25% believed it to be in favour of the Employer and 10% believed there was a bias in favour of the Contractor.

![Figure 7 Overall bias without alterations to clauses](image)
4.4.2 *Bias with alterations*

For the investigation where alterations had been made to standard clauses by the employer, Figure 8 shows a dramatic increase of bias perception in favour of the Employer when standard clauses are altered in the GCC 2010. The most prominent categories are Payment and related matters, Risks and related matters and Claims and disputes. As before, the figure shows the percentage of respondents that chose a specific answer.

None of the respondents deemed that the Contractor was favoured when alterations were made to Quality and related matters or Claims and disputes.

The overall bias perception of respondents swayed significantly in favour of the Employer when alterations were made to clauses, with more than half of the responses being in favour of the Employer. 39% of responses were Neutral and only 4% were in favour of the Contractor, as seen in Figure 9.
5 CONCLUSION

5.1 Perception of the GCC 2010

The survey results showed that the overall perception of the GCC 2010 in terms of the three pillars was between “Adequate” and “Good”. There remains definite room for improvement across all three areas, especially in the payment operating mechanisms category. Efforts should be focussed on improving the neutrality of the Risks and Claims and disputes categories.

5.2 Impact of alterations

It must be noted that the majority of survey respondents were Contractors and that this may potentially have had an influence on the results of the study. However, if the results are not an accurate representation of actual trends, it does show the perception that Contractors have when procurement documents are altered.

If the perception and actual trends do differ, then an effort should be made to establish the reasons why Contractors perceive alterations to favour Employers strongly.
The survey results, shown in Figure 10, show that when alterations are made to standard clauses, the bias significantly moves in favour of the Employer. This may be because the Employer (or a representative of the Employer) is responsible for drafting the contract documents. Thus, any alterations made to the standard clauses would be to protect the interest of the Employer.

![Graph showing bias with and without alterations](image)

**FIGURE 10 GCC 2010 bias with and without alterations**

5.3 **General conclusions**

Major improvements to the GCC procurement document have been made by SAICE to improve the overall fairness of the document by reducing the bias in the underlying categories. Secondly, existing challenges found with preceding editions are addressed.

From the survey results, it can be concluded that parties responsible for the drafting of procurement documents (typically Employers or Consultants) may not understand the intent of (contract) publishers to improve the fairness of the document. There is still a tendency of altering standard clauses in favour of the Employer. However, a more extensive survey will have to test this statement, considering that the bulk of respondents in this survey were contractors.

Informing the parties responsible for the drafting of procurement documents, of the advantages of unbiased procurement documents, could potentially reduce delays and disputes in contracts and improve project success. A secondary benefit of unbiased procurement documents is that relationships between Employers and Contractors may be strengthened.
Relationships built on mutual trust, rather than contractual clauses may contribute to the successful completion of projects, on time and within budget. Successful projects in turn may provide a healthier industry, which would again aid in strengthening relationships and building trust between Employers and Contractors. This cycle is illustrated in Figure 11.

![Figure 11: Relationship cycle](image)

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Concurrent Engineering as a Procurement System: Barriers to its potential implementation in construction projects in KwaZulu-Natal

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ABSTRACT AND KEYWORDS

Purpose of this paper
The construction industry is considered to be fragmented in nature and it is therefore increasingly challenging for project participants to communicate and work efficiently as a team. Furthermore, current procurement systems do not effectively encourage such communication, cooperation and integration thus proving the inherent need for an innovative procurement approach that will improve the efficiency and manner of procurement within the construction industry. The researchers have therefore investigated the concept of concurrent engineering (CE), which is widely used in the manufacturing sector, as the basis for a new, integrative procurement system for commercial projects in the KwaZulu-Natal (KZN) construction industry. This paper aims to investigate the potential barriers for the implementation of CE into the construction industry.

Design/methodology/approach
Data was sourced qualitatively, by conducting interviews with 24 industry professionals. A qualitative approach was adopted in order to obtain a better understanding of this new area of research by exploring the viewpoints, encounters and emotions of the participants to ascertain whether the implementation of a concurrent engineering based procurement system can be implemented in KwaZulu-Natal.
Findings
The findings show extensive use of the traditional procurement systems and limited contractor integration. This research further highlights the seriousness of adversarial relationships which exist in the construction industry and note this as the most important barrier to the successful implementation of a CE-based procurement system.

Practical implications
The CE-based procurement system can potentially lead to effective communication and cooperation between the various parties and thereby improving the efficiency of the construction industry.

What is original/value of paper.
The CE-based procurement system can lead to a supportive culture when embarking on performance improvement programmes and better communication on projects.

Keywords: Barriers, Concurrent engineering, Construction industry, Procurement.

1. INTRODUCTION
The construction process is faced with a fleeting and fluctuating combination of role-players who often have conflicting aims and objectives and standard procurement processes are sometimes inefficient in coping with the complex relations and intricacies of a multi-disciplinary team (Gunasekaran and Love, 1998). This has seen the emergence of different frameworks of procurement methods such as construction management, management contracting and design-and-build (Morledge, Kashiwagi and Smith, 2006). Furthermore, these procurement systems do not effectively encourage communication, cooperation and integration (Aniekwu & Igboanugo, 2012; Love, Gunasekaran and Li, 1998) thus proving the inherent need for an innovative procurement approach that will improve the efficiency and manner of procurement within the construction industry. One such alternative procurement system is concurrent engineering an existing procurement method that is prevalent in the manufacturing industry as a possible means to overcome the shortcomings and disparate nature of currently implemented procurement systems. This study aimed to establish the potential barriers to the implementation of a concurrent engineering (CE) based procurement system in the KwaZulu-Natal (KZN) construction sector. In order to establish whether industry participants were aware of the concept of concurrent engineering and any potential barriers to its implementation, this study was limited to KZN so that the researchers could gather information that will be used for further research nationally.
2. CONSTRUCTION PROCUREMENT

Project procurement is described by Masterman (1992) as the organisational structure necessary for the design and construction of built environment projects for a particular client. Watermeyer (2004) described procurement as a process that is defined by a sequence of reasonably correlated activities that are carried out in a specific manner thereby culminating in the execution of a major outcome or the realisation of a milestone. De Valence and Huon (2011) defined the activities of procurement as being the set of actions required to design, manage and deliver the project objectives.

Fundamental to all procurement systems is the creation of a framework that distinctively ascertains the restrictions on the roles, relationships and responsibilities of the construction project stakeholders (de Valence & Huon, 2011). The multi-disciplinary arrangement of the parties, which includes the client, management consultants, designers, contractors and suppliers, means that each party has inherent risk allocated to them relating to time, cost and quality, which is often determined by the procurement system that is selected.

2.1 Procurement Processes in South Africa

The traditional procurement system (TPS) is predominantly used in non-residential markets, large projects and works for government institutions. The most important characteristic of the traditional process is that it is based on competitive tenders, uniform documentation and predetermined quantities (Hauptfleisch and Sigle, 2009). Under this strategy, the design needs to be completed before competitive tenders are invited and before the main contractor is chosen, as failure to do so results in excess variations, disruption of the works and, subsequently, time and cost increases (Franks, 1984). Additional procurement processes include:

- **Package type contracts** that are used in the residential, commercial and industrial markets that are relatively simple, repetitive buildings of modular building form, which results in reduced design time. Package deals are usually presented by the coordinator (usually a main contractor) to a likely employer at a particular cost that includes a construction contract; professional services; and on occasion also the site, resources and authorisation of the facility (Hauptfleisch and Sigle, 2009);

- **Design-and-build** in which one organisation takes full responsibility and carries sole liability for both design and construction. The client employs a contractor directly, who carries out the design and construction of the works (Ashworth, 2002; Hauptfleisch & Sigle, 2009);

- **Turnkey** processes, is used in industrial and engineering projects (Hauptfleisch and Sigle, 2009).
The **management method of procurement** includes project management, construction management, and management contracting. Project management is a process whereby the client appoints a project manager as a professional advisor, to select the appropriate design consultants and the contractor who would carry out the project itself (Ashworth, 2002). In the construction management process, a construction manager is appointed to co-ordinate the direct contracts entered into between the employer and each of the specialists and trade contractors. With construction management, the contractor is appointed early on in the project and becomes part of the design team, where he can contribute his construction knowledge and management expertise (Franks, 1984) and subsequently improve communication.

### 2.2 Shortcomings of Current Procurement Systems

The aforementioned procurement systems have tried to focus on the integration of all the different functional stakeholders of the construction project team - architects, quantity surveyors, engineers, contractors, and suppliers but this has proved unsuccessful (Aniekwu & Igboanugo, 2012; Ngowi, 1998, 2000).

Franks (1984) believes that the disadvantage of the TPS is the segregation of the design and construction processes, thus fostering a ‘them and us’ mind-set amongst contractors, consultants, and designers. This view was reinforced by Tenah (2001) who noted that the TPS does not create a unified team in which experience, feedback, and new ideas are openly shared. Consequently, the lines of communication were often tenuous, which deems this system substandard for some sizeable and involved projects that require sophisticated management skills, structures and systems.

Although the design-and-build procurement method has tried to incorporate all members of the project team, it still lacks complete success because: the client retains a set of consultants at the initial project stages, resulting in extra costs; existing procedures revealed that extensive rework and duplication were inherent; the time spent working on the preliminary design, often lead to delays that arise from the clarification of client requirements and coordinating these with the relevant consultants; the client’s brief and associated specifications are not well-defined from the beginning, this gives rise to considerable probability for disagreements and claims during the construction phase. There is also uncertainty with regard to expected performance; excessive costs associated with tendering as well as being inap for multifaceted projects (Anumba & Evbuomwan, 1997).

The primary shortcoming of the package deal approach is that the client does not have an independent team of professional consultants, hence if problems did arise the client is in an unenviable position as he is contractually on his own and costs for legal and expert advice often escalate drastically. The fact that detailed specifications and drawings are usually not...
available and the lack of comparative prices both complicate the issue of assessing the project’s value.

Because of the lack of innovation within the construction industry and the shortcomings of the currently implemented procurement systems, this study aimed to establish - in what way a concurrent engineering (CE) based procurement system can improve project procurement in the KZN construction sector with regard to the incorporation of a multifunctional team.

3. AN OVERVIEW OF CONCURRENT ENGINEERING

Concurrent engineering is a concept widely implemented in the manufacturing industries and can be defined as a "product development methodology where upfront abilities (such as manufacturability, serviceability and quality) are considered part of the product design and development process, ..... in order to meet all the customer requirements" (Prasad, 1996). CE consists of basic principles such as the use of multi-disciplinary work groups and encouraging innovation and early supplier involvement.

Clark and Fujimoto (1991) described an integrated problem solving approach as having simultaneous, overlapping activities and frequent upstream and downstream communication of information. Time and cost reductions are as a result of overlapping of activities (Prasad, 1996). Reduced development time means that products can be delivered to the market quicker and as such results in a competitive advantage against competitors increasing profits.

The benefits of CE are widely acknowledged (Badham, et. al., 2000; Love, et. al. 1998; Ngowi, 1998) and include:

- A better design process as the result of the consideration of all team members and the phases of the system life cycle;
- Concentration on time, cost and quality parameters;
- Emphasis is placed on what the customer wants rather than what the internal company wants;
- All possible alternatives are investigated in order to find the best solution;
- Better relations between employees as a result of horizontal communication;
- A dedicated team is appointed to the project and as such, they have a better understanding of the project from inception to completion; and
- Suppliers are involved from the start of the project and are thus an integral part to the design team.

The common organisational barriers are (Bhuiyan, et. al., 2006; Maddaux and Souder, 1993; Ngowi, 1998, 2000):

- Inadequate support from upper management;
- Lack of incentive/reward system;
- Inadequate control of project resource;
- Protective functional managers;
3.1 The Implementation Process

In order to implement a CE approach into the construction industry, industry practitioners need to move away from the conventional pyramid-shaped organisation and set into operation an organisation, which fosters open communication and overcomes the impediments to information flow (Love, et. al., 1998). The costs to implement change increases as the various stages of the building procurement process advances. The potential for savings occur when changes in design are made during the design phase in particular. In order for this to transpire, the various participants involved in the building procurement process, such as the architect, quantity surveyor, contractor, the various engineers, etc. must be introduced during the design phase (Gunasekaran and Love, 1998).

Love, et. al. (1998) listed some of the most basic ideologies and aims of CE that could be applied to construction:

- Detailed analysis of client requirements;
- Detailed analysis of the product life-cycle;
- Development of innovative design solutions that are simple to manufacture and construct;
- Integration and coordination of interdependent tasks;
- Integration of the design, production and manufacturing processes;
- Minimisation of downstream design changes (variations);
- Minimisation of non-value adding activities (waste);
- Implementation of a multi-disciplinary team; and
- Implementation of continuous process improvement.

It is proposed that applying the above principles can result in an improved understanding of the client’s requirements, a cohesive relationship between the project team members, enhanced communication, and a decrease in rework, project time and cost (Love, et. al., 1998).

The direct contractual relationship between the client and all the key players is believed to boost teamwork and allow key players will perform better if they have an opportunity to participate in the development stage of the project (Love, et. al., 1998).

4. RESEARCH METHOD

For purposes of this research, a qualitative research method was undertaken in order to adequately satisfy the research findings by exploring the viewpoints of the participants to ascertain whether the implementation of a
CE based procurement system can improve the way commercial projects are procured in KwaZulu-Natal (KZN) and subsequently be adopted. Although a quantitative approach could have been used the researchers wanted to adequately explore the participants viewpoints and gain an in-depth understanding and therefore the qualitative approach was selected.

Because the researchers opted for a qualitative-based research, which placed emphasis on in-depth investigation of a small number of construction project team participants, purposive sampling was used.

The qualitative study entailed a semi-structured interview that was designed to unearth the opinions of the various project participants. The interviews were solicited by email or telephone calls and conducted in person. The participants were selected via association with professional bodies in the built environment, namely: the Construction Industry Development Board (CIDB), Master Builders Association (MBA), Project Management South Africa, the South African Council for Project and Construction Management Professions (SACPCMP), the Association of South African Quantity Surveyors (ASAQS) and the South African Institute of Architects.

The data was analysed using thematic content analysis. After having transcribed the interview verbatim, the researchers read each transcript and made notes in the margins, this process was known as coding. Subsequent to the data coding, the researchers merged and identified connected patterns into themes which eventually formed the five barriers.

Table 1 indicates the number of construction stakeholders that were interviewed. The criteria used to select participants for the study included number of years of experience within the industry; experience with regard to working on commercial projects; localisation within the KwaZulu-Natal region; and the willingness of participants to speak freely with the interviewer.

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5. DISCUSSION OF FINDINGS
Only 21% of those interviewed were female as indicated in table 1. Majority of the interviews (33%) were conducted with individuals over 55 years of age. The researchers felt that this was an advantage as it provided responses that were based on many years of experience and as such, provided the researchers with realistic insights into the nature of the construction industry that they would otherwise not have had access to. The researchers also felt that the older interviewees were more forthcoming with the provision of suggestions and recommendations as to how the structure of the CE-based procurement system could be improved and adapted to more accurately suit the South African construction industry. The second highest number of interviewees (29%) formed part of the 21-35 age category. The 36-45 and 46-55 age groups made up 25% and 13% of the total interviewees respectively.

It was made apparent from the interviews conducted with the participants that the traditional procurement is still the most commonly used procurement system within the KZN construction industry, however a total of 67% of the interviewees agreed that there is a growing demand for the design and build procurement system, compared to 33% who believed it was in fact the construction management procurement system.

The interviewees identified the following disadvantages of the traditional procurement system:

- Lack of team coordination and communication, resulting in lack of information interchange at the required times, team conflict and distrust;
- Many industry perceptions exist which do not help alleviate the existence of adversarial relationships, such as the perception that the contractor is only there to make a profit, and that the only persons who look after the clients best interests are the consultants;
- Longer project durations in the traditional procurement system, inclusion of more preliminaries and long tender adjudication processes (which cannot decrease in time) places extraordinary pressure on other processes such as designs;
- Poor designs results in inaccurate bills of quantities, which in turn does not afford the client accurate price certainty;
- Consultants design without input from the contractor and these shortcomings can be seen in the glitches which appear during construction;
- The industry faces a decrease in the quality of services (which can be attributed to competitive fee structures as the client is very much price driven); and
- Although 75% of the interviewees felt that the traditional procurement system allowed for creative design solutions they were not easy to implement.

Interviewees were asked if they would accept a new procurement system, which integrates all the project participants by introducing them into the
project during the preliminary design phase to which 88% agreed. They agreed that the use of integrated design can result in the production of better quality buildings.

The researchers have found that the concept of concurrent engineering is not new to the construction industry, with 80% of the interviewees being aware of CE even though most times they had not given it a name/term, however its implementation is done by informally seeking advice from contractors and specialist suppliers from time to time rather than involving them in a fully inclusionary way.

Sixty seven percent of the interviewees believed that a CE-based procurement system could overcome the fragmented nature of the construction industry. The remaining 33% of interviewees did not believe a CE-based procurement system could overcome fragmentation, and provided valid arguments to support their opinions. The project managers who stated that CE would be unsuccessful in overcoming fragmentation because the CE approach engages too many people, too early in the overall construction process, which is not healthy (cost-wise) for the client; and because there are more structural problems in the South African construction industry, which is not mature enough, to support the successful implementation of CE thus prohibiting it from overcoming fragmentation. The reasons that the quantity surveyors provided for CE’s inability to overcome fragmentation ranged from the fact that Broad-Based Black Economic Empowerment (BBBEE) has created several problems within the industry to the fact that the early introduction of the specialist suppliers will result in them favouring their own product, thereby worsening the fragmentation.

Interviewees were prompted to give their opinions on whether they believed any barriers existed to the possibility of implementing a new procurement system which integrates all the project participants by introducing them into the project during the preliminary design phase. The following barriers were identified:

**Barrier 1:** Design time will increase if more project participants are included in the design phase. Twenty nine percent of interviewees believed that introducing more people into the design phase will increase the time involved in decision making and thereby increase the project’s duration. Four of the nine quantity surveyors felt that the inclusion of another party into the design phase would result in a longer phase duration and would make decision making that much more time consuming, as it is always difficult to reach group consensus. One quantity surveyor went on further to say that the client would need to be convinced that allowing the team more time to work on the design would ultimately result in cost savings.

**Barrier 2:** If the project does not go ahead as planned, the client could experience dire cost implications due to the additional members on the design team. A lack of competition and possible collusion were other factors which were identified as cost implications to the client. One engineer deemed the CE-based procurement system “anti-competitive” because under this system, the contractor would be selected without going out to tender.
The CE procurement model does not conform to the traditional, price-driven selection procedures as such procedures often limit the creativity of the designers and contractors. However, the interviewee responses have revealed that the negotiated tendering option that the CE approach conforms to could lead to a lack of pricing transparency. If a client chooses to negotiate a price with a single supplier, the competitive pressure is weakened and the client will not achieve all the possible cost-savings that he/she could have achieved under a competitive tendering process.

The CE approach is structured in a manner whereby the scope of the project opportunity is such that, working in isolation, a single provider would find it difficult to offer all of the services required. Therefore, an engineer made a recommendation that could overcome this cost-related barrier. He stated that before the design development phase commenced, the CE-based procurement system should allow for tender bids made by organisations that would like to work together in the form of a consortium. By allowing consortium tender bids, groups of companies can ensure that each service provider has specific expertise in their area thus complimenting all the other services being offered, and making the bid more attractive.

**Barrier 3:** With regard to team-related barriers, it was interesting to note that one architect, one quantity surveyor, one engineer and one project manager collectively felt that the contractor would not fit in suitably during the design phase, all stating that he would be confused. In turn, two of the three contractors noted the lack of tolerance by consultants towards other consultants as well as the contractor. One of the two contractors validated this by stating that he believed that the professionals in South Africa had a “chip on their shoulder” because they felt that they were better than the contractor and felt that “the buck stopped with them”. Hence these professionals would not take kindly to the contractor advising them or telling them what to do. One quantity surveyor felt that the under the CE-based model, the role of the consultants would be compromised because the contractor plays such a big role. It is likely that he may change the direction of the project to suit his needs, which are largely profit-driven. Research has shown that if the client implements non-traditional methods, then the consultants’ services are often limited, predominantly because of the induction of the contractor (Love et al., 2008: 230). An architect suggested that it would be “ludicrous for the contractor to advise the architects”. Of the various professions that were interviewed, it was evident that within the construction industry exists’ many adversarial relationships. The researchers believe that this will have dire implications on the implementation of a CE-based procurement system, as the research has shown that in order to fully implement the CE-based procurement system, there has to be ‘buy-in’ from all the parties concerned. If the consultants do not value the contractor, they will not advise the client on adopting the CE approach, which emphasises the contractor’s role in the project procurement process. Furthermore, teamwork is a vital aspect to its success. The traditional adversarial relationships that exist need to be put aside, and a cultural change is necessitated, if the CE-based procurement system is to be a viable option.
**Barrier 4:** Risk related barriers. It has been identified that getting the contractor to work on risk, that is not being guaranteed the project beyond an advising capacity, is a barrier the client may face in attempting to use the CE-based procurement system. Another risk that the client may encounter is that the specialist suppliers’ and contractors’ advice would be biased, in that they might promote the use of only their products and services.

**Barrier 5:** It was interesting to find that in some of the other procurement options, the client relied heavily on the project manager to carry the responsibility of ensuring that good communication existed between project participants and the client. What this meant was that, ultimately, the competence of the project manager was more of a determining factor as opposed to the actual choice of procurement system. The project managers that were interviewed were well aware of this responsibility that ultimately rested with them. Within the structure of a CE based procurement system, the project manager plays a vital role with regard to commencing and supervising process of the design. One architect agreed with this by stating that “the theory [behind CE] is good, but it is very dependent on the character of the project manager or development manager”. One architect felt the dominant role that the project manager played within the CE-based procurement system would actually be detrimental to the successes of this procurement system. He believed that the project manager would alienate the consultants from the client and cause communication breakdown. Very often, the most crucial decisions are made during the design process; therefore it is vital for the client to commission an experienced project manager who can efficiently arrange, coordinate, lead and manage the project from start to finish. Because he is the leader of the project, the project manager is faced with the challenge of attaining the most out of the project team whilst making sure not to imply any pecking order of sorts (Love, et. al., 1998: 379).

Apart from one contractor and one architect, all other project participants did not see any barrier relating to the implementation of a CE-based procurement system using current contract documentation. However it was highlighted that there could be possible problems due to the shortcoming of the current contractual documentation. Overcoming the barriers to the implementation of CE is important if one wishes to enjoy the full benefit of the CE concept. Maddaux and Souder (1993: 69) suggest five aspects managers must work through to foster CE:

- Making the cultural transformation;
- Effecting organization change;
- CE team building;
- Providing adequate support technologies; and
- Fostering role definition and interaction.

6. CONCLUSION
There needs to be a supportive culture when embarking on performance improvement programmes, such as a CE-based procurement system. CE will be successful, only if there is sufficient awareness regarding it. CE awareness initiatives should be introduced with support and coordination from established and structured organisations such as the Construction Industry Development Board, South African Association of Consulting Engineers and the Association of South African Quantity Surveyors. The CE method of procurement will be largely client-driven. Thus it is imperative that clients are informed of the possibility of decreasing the cost and time of their projects. Once clients have experienced the advantages of CE, then small and intermittent clients will follow suit. The involvement of people from all levels of the process is considered essential to bring about real improvement in construction procurement. Framework agreements based on trust and mutual respect and understanding should be developed and introduced across the industry in order to better prepare the industry for reception of innovative additions such as CE. Although CE holds immense, inherent advantages for the construction industry, the researchers have found that the KwaZulu-Natal construction industry may not be ready for the implementation of such an integrated procurement system, as it still has a long way to go in overcoming the adversarial relationships that exist.

7. REFERENCES


ABSTRACT

Purpose:

The construction industry has been seen as being contentious due to the prevailing problem of disputes. Claims have been identified as one of the major contributors to dispute occurrences. Unfortunately, there is no guarantee that claims can be avoided due to the fact that decisions are traditionally made on forecasts of future expectations, especially when the information needed to make those decisions is insufficient and incomplete, hence the need for proper claim management. The study therefore identifies the various factors that contribute to effective claim preparation and also assesses the impact of the identified factors on dispute resolution.

Methodology:

The methodology adopted to achieve the objective includes review of literatures on claim management and administration of a structured questionnaire to a targeted population. Data collection was carried out by administering of a questionnaire through purposive sampling. The research design adopted was generally quantitative, but made provision for qualitative data in the form of comments and a discussion with some of the stakeholders.
Findings:

The results reveal that proper record keeping, provision of adequate information to back up claims, and proper breakdown of claim causes are the three most prominent factors for producing an effective claim report. More importantly, the results show that proper management on claims can lead to better dispute resolution and improved performance in the industry.

Limitations:

The aspect of claim management studied and presented in this paper is limited to claim preparation. Other aspects of claim management like quantification and evaluation were not considered.

Value:

The study reveals that proper claim management influences dispute resolution. The findings provide a basis for reducing construction disputes through proper claims preparation and presentation. The findings are of value to clients, contractors and consultants when negotiating change and dispute.

Keywords: claims management, claims preparation, construction claims, disputes resolution.

1. INTRODUCTION

Construction contracts are rarely ideal. This is attributed to the fact that tenders are sought on inadequate design, insufficient information, inappropriate documentation and ill-defined schedule, all of which often result in construction claims (Davis, 2007). Consequently, claims for time extension or financial compensation often have to be made by one party or another (Khaled and Ignacio, 1990). The high incidence of disputes arising from construction contract claims has been widely reported on (Vidogah and Ndekugri, 1997; Tochaiwat and Chovichien, 2005). Unfortunately, there is no assurance that claims can be avoided due to the complexity of the construction process and nature of construction contracts, hence the need for proper claim management. Claims have been described to be natural, inevitable and indispensable as a result of the modern contract
The realisation of this fact calls for proper claims management practices. The purpose of good claims management is to ensure that claimants’ entitlement are identified and attended to on a regular basis through adequate management setup. However, Vidogah and Ndekugri (1997) note that there are problems of inadequate planning for claims management in the construction industry. The authors attributed the failure in claims management to not giving it the same importance as planning, scheduling and cost control. This often results in most establishments preparing claims in an ad hoc manner. Diekmann and Nelson, (1985) note that many claims submitted by contractors to employers are rejected due to lack of substantiation. Once claims are presented, it may result in negotiation between parties, or in turn resulting in a change order or modification, it may also result in a contract dispute, if rejected (David and Bhupendra, 1989). The consequence is often a breakdown in communication, polarisation of views, and the inevitable recourse to arbitration or litigation with their attendant delay and expense (Vidogah and Ndekugri, 1997).

Virtually all the contract documents made provision for claims but there is no evidence of obligations from the construction stakeholder to follow the provisions. For instance the aim of the GCC 2010 guide is to promote efficient and effective management of construction contracts to which it applies, with the view of having influence in the reduction of claims and disputes that may arise in the contract (Claassen, 2010). However, the objectives of the guide have not been fully realised as evidence suggests. The problem of claims submitted by contractors and the clients’ inaction or refusal to settle it has been reported to be one of the prominent causes of dispute in the South African construction industry (Bvumbwe and Thwala, 2011). One of the reasons for claim rejection is inadequate claim preparation which arises from lack of factual evidences to back up the submission. According to Wood (1975) lack of factual evidences is a prime cause of delayed payment and protracted dispute. Claims will continue to present problems except when they are properly managed. The study therefore identifies the various factors that contribute to effective claim preparation and also assesses the impact of the identified factors on dispute resolution.
Claims and disputes on construction projects

Semple et al., (1994) defined a claim as “a request for compensation for damages incurred by any party to a contract”. It is also defined as the seeking of consideration or change by one of the parties involved in the construction process (David and Bhupendra, 1989; Tochaiwat and Chowchien, 2005). The potential for a claim arises when the contractors incur additional cost and/or there is a delay. The claim is used as a tool to request more time and/or money. Claims can also originate from owners as assertion of right to payment arising under the contract for neglect or delay on the part of the contractor (George and Hartman, 1994). Claims may arise on a construction project for a number of reasons. Diekmann and Nelson, (1985) report that the most common causes for a contract claim are design errors and changes. Insufficient time for bid preparation, underestimation, inadequate site investigation, acceleration, inadequate bid information, poor project planning, deviation, change or increase in the scope of work are other factors that could cause a claim (Khaled and Ignacio, 1990; Semple et al., 1994; Chaphalkar and Patil, 2012). Further, owners also do have the right to claim in respect of issues that may harm them economically such as defective work, contractors’ late completion and when material is not according to specification.

Over the years, contractors have increasingly been concerned with claims, their associated costs, and the poor recovery of actual costs associated with their settlements (George and Hartman, 1994). Diekmann and Nelson, (1985) report that many contractors’ claims are rejected due to lack of substantiation. The reason for rejection is attributed to the fact that many contractors fail to protect their contractual right in keeping proper site records. George and Hartman, (1994) assert that memories are highly fallible and in the absence of written evidence, honest-intention claims have little chance of success. When there is no evidence, contractors will have to negotiate their claim from a position of weakness, often resulting in disputes. Therefore, there is need for a proper claim management procedure and identification of factors that enhance good practices when preparing claims.
2. RESEARCH METHODOLOGY

As previously mentioned, this paper assesses the impact of claim management on dispute resolution in the South African construction industry. The explorative nature of this study requires a combination of both quantitative and qualitative methods of data collection. The research design adopted is generally quantitative, but made provision for qualitative data in the form of comments and discussions. Data collection was carried out by administering of a questionnaire through purposive sampling. Data used for analysis is from a questionnaire survey which was administered through the face to face approach involving construction stakeholders in order to gather useful information and clarify any arising queries. The construction stakeholders’ targeted are experienced contractors, consultants, project managers, architects, quantity surveyors, and architects who regularly deal with construction projects.

Six factors contributing to effective claim preparation are identified based on the review of the existing studies (see Table 1). Respondents are requested to indicate the level of truthfulness of each factor on a grade scale. The grade scale measures a range of opinions from “strongly disagree” to “strongly agree”. Grade I indicates ‘strongly disagree’ and Grade V indicates ‘strongly agree’ with the other three grades in-between the two extremes. A total number of twenty six (26) completed questionnaires were received of which twenty five (25) were adjudged usable by the researchers.

To determine the relative ranking between the factors, the grade received from the questionnaire for each factor is transformed to indices based on the formula below (Tam et al., 2010):

\[
RII = \frac{\sum w_i}{A \times N}
\]

(1)

Where ‘\(w_i\)’ is the weight assigned to each factor by the respondents, ranging from 1 to 5, in which ‘1’ denotes “strongly disagree”; and ‘5’ “strongly agree”; ‘\(A\)’ represents the highest weight (\(A = 5\)); ‘\(N\)’ is the total number of respondents; and ‘RII’ the relative importance index, \(0 \leq RII \leq 1\). The higher the value of the RII, the more important the factor is to effective claim preparation.
3. DATA ANALYSIS AND DISCUSSION

This section presents analysis and discussion of findings obtained from the administered questionnaire. Table 1 reveals the demographic data of respondents. The analysis shows that respondents are involved in different construction sectors, 40% of the respondents are in the private sector, 12% are in the public sector and the remaining 48% are involved in both private and public sectors, thus their responses can be generalized for the construction industry. Table 1 also discloses that twenty four (24%) of the respondents have more than 20 years of working experience in the construction industry, 16% have between 16 to 20 years, 20% have between 11 to 15 years, 12% have between 6 to 10 years, and 28% have less than 5 years of experience. Eighty four percent of the respondents are involved in claim management processes in their respective organisation while only 16% are not involved in claim management at all. The analysis of demographic data shows that the respondents are well experienced in the construction industry and their information is therefore of high relevance to the study.

Table 1: The demographic data of respondents

<table>
<thead>
<tr>
<th>Profession of the respondents N = 25</th>
<th>Frequency</th>
<th>Percentage %</th>
<th>Cumulative Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Consultants</td>
<td>11</td>
<td>44</td>
<td>44</td>
</tr>
<tr>
<td>Contractor</td>
<td>06</td>
<td>24</td>
<td>68</td>
</tr>
<tr>
<td>Others</td>
<td>08</td>
<td>32</td>
<td>100</td>
</tr>
<tr>
<td>Working experiences</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1-5</td>
<td>07</td>
<td>28</td>
<td>28</td>
</tr>
<tr>
<td>6-10</td>
<td>03</td>
<td>12</td>
<td>40</td>
</tr>
<tr>
<td>11-15</td>
<td>05</td>
<td>20</td>
<td>60</td>
</tr>
<tr>
<td>16-20</td>
<td>04</td>
<td>16</td>
<td>76</td>
</tr>
<tr>
<td>Above 20 years</td>
<td>06</td>
<td>24</td>
<td>100</td>
</tr>
<tr>
<td>Construction industry sector</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Private</td>
<td>10</td>
<td>40</td>
<td>40</td>
</tr>
<tr>
<td>Public</td>
<td>03</td>
<td>12</td>
<td>52</td>
</tr>
<tr>
<td>Both</td>
<td>12</td>
<td>48</td>
<td>100</td>
</tr>
<tr>
<td>Involvement in claim management process</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Have been involved</td>
<td>21</td>
<td>84</td>
<td>84</td>
</tr>
<tr>
<td>Not been involved</td>
<td>04</td>
<td>16</td>
<td>100</td>
</tr>
</tbody>
</table>
Figure 1: The impact of claims management on dispute resolution

Table 2: The prominent factors for effective claims preparation

<table>
<thead>
<tr>
<th>Identified factors</th>
<th>I</th>
<th>II</th>
<th>III</th>
<th>IV</th>
<th>V</th>
<th>Total</th>
<th>RII</th>
<th>Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>Proper record keeping</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>7</td>
<td>18</td>
<td>25</td>
<td>0.944</td>
<td>1st</td>
</tr>
<tr>
<td>Provision of adequate information to back up claim</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>9</td>
<td>14</td>
<td>25</td>
<td>0.896</td>
<td>2nd</td>
</tr>
<tr>
<td>Proper breakdown of claim causes</td>
<td>0</td>
<td>2</td>
<td>3</td>
<td>9</td>
<td>11</td>
<td>25</td>
<td>0.832</td>
<td>3rd</td>
</tr>
<tr>
<td>Involvement of skilled /experience personnel</td>
<td>0</td>
<td>2</td>
<td>4</td>
<td>10</td>
<td>9</td>
<td>25</td>
<td>0.808</td>
<td>4th</td>
</tr>
<tr>
<td>Documentation of project activities</td>
<td>0</td>
<td>2</td>
<td>7</td>
<td>10</td>
<td>6</td>
<td>25</td>
<td>0.760</td>
<td>5th</td>
</tr>
<tr>
<td>Documentation of procedure and transaction</td>
<td>0</td>
<td>2</td>
<td>7</td>
<td>11</td>
<td>5</td>
<td>25</td>
<td>0.752</td>
<td>6th</td>
</tr>
</tbody>
</table>

Table 3: The impact of claims management on dispute resolution

<table>
<thead>
<tr>
<th>Identified factors</th>
<th>I</th>
<th>II</th>
<th>III</th>
<th>IV</th>
<th>V</th>
<th>Total</th>
<th>RII</th>
<th>Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>Documentation of record of performance on disrupted activities</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>9</td>
<td>14</td>
<td>25</td>
<td>0.896</td>
<td>1st</td>
</tr>
<tr>
<td>Availability of factual evidence</td>
<td>0</td>
<td>0</td>
<td>6</td>
<td>5</td>
<td>14</td>
<td>25</td>
<td>0.864</td>
<td>2nd</td>
</tr>
</tbody>
</table>
The prominent factors for effective claim preparation

Table 2 summarises the survey results of the prominent factors for effective claim preparation. The result shows that proper record keeping, documentation of procedure and transaction, documentation of project activities, involvement of skilled/experienced personnel, provision of adequate information to back up claim, and proper breakdown of claim causes are essential factors for effective claim preparation.

The highest RII received by proper record keeping is pointing to the fact that its importance cannot be underestimated. The failure of many contractors to keep adequate records often result in inability to provide factual evidences to support their claims. Once there is no evidence to support claim, such claim may be rejected, which may lead to dispute. This is in line with the findings of Wood, (1975) where lack of factual evidences was noted to be a prime cause of delayed payment and protracted dispute. George and Hartman, (1994) suggest that construction contractors should always file necessary records. In addition, Adrian, (1988) advocates the use of camera and other recording devices in recording important information on site. Therefore, proper knowledge of the contract and good record keeping are very important for effective claim preparation. Record of work progress, daily/weekly reports, change orders, site records, minutes of meetings can prove invaluable when problems arise on construction projects.

Provision of adequate information to back up a claim and proper breakdown of claim causes are both identified as important factors with RII
of 0.896 and 0.832 respectively. During the discussion with one of the surveyed practitioners, he lamented lack of adequate information to back up a claim and note that even where evidences are available they are often of poor quality, scanty, sketchy and non-comprehensive enough to substantiate the claim. This naturally results in claims being rejected and returned to the contractors. Contractors may become grieved and that usually results in disputes. Poor design of the recording system and poor resourcing of the claims management division in a contracting organisation are some of the reasons attributed to inability of the contractors to provide adequate information to back up their claim (Vidogan and Ndekugri, 1998).

Involvement of an experienced claim management expert is another significant factor which receives RII value of 0.808. According to Vidogan and Ndekugri, (1998) the level of skill and experience applied to the claims management function can determine the success or failure of a claim. Allowing an experienced claim expert to manage the claim process and taking responsibility for claim documentation, preparation and presentation could help in overcoming the problems of inadequate information when presenting the claim. It will also improve claim management process in the South African construction industry.

The impact of claim management on dispute resolution

The majority of the respondents as shown in Figure 1 agreed that proper claim management procedures have an impact on dispute resolution. On their perception of its impact, 18% of the respondents agreed that it has moderate impact, 36% agreed that it has high impact while 46% agreed that it has very high impact. It should be noted that none of the respondents agreed that claim management has no impact on the dispute resolution process. The result of the analysis in Table 3 shows the three most significant factors which are documentation of record of performance on
disrupted activities which ranked 1st, followed by availability of factual evidence which ranked 2nd, and involvement of experienced claim management expert which ranked third.

Although there are a considerable number of articles on different aspects of claim management, the reported cases of disputes resulting from a claim is pointing to the fact that the practices of the construction industry on claims management need more improvement. The result of the study indicates the importance of a proper claim management procedure. This supports the assertion of Kangari, (1995) which indicates that proper project activity documentation influences dispute resolution. Adopting the information provided in the study will assist the construction stakeholders to avoid possible disputes arising from claim. It will also provide a firm basis for providing convincing evidence during claim negotiation.

CONCLUSION
This paper has presented the most important factors that are responsible for effective claims preparation in the construction industry. The impacts of the factors are also discussed. The major findings in the paper are that, when negotiating changes and disputes, accurate record keeping, provision of accurate information to back up claims and proper breakdown of claim causes are the most important factors. Proper application of the factors identified will minimize the occurrence of disputes on construction projects. Furthermore, when presenting and defending claims, documentation of record of performance on disrupted activities, availability of factual evidence and involvement of skilled/experienced personnel are necessary.

RECOMMENDATION
In keeping with the conclusion, the following recommendations are made:
• There is a need to increase the knowledge and understanding of claim management procedures in the construction industry.
• There is a need to improve the wordings of standard forms of contract and strengthen the provision for claim management procedures.
• Inclusion of a claim expert at the onset of project to assist in proper claim documentation, preparation, and presentation throughout the life span of a project should be considered.

REFERENCES


Adverse impact of construction related factors on construction labour efficiency

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ABSTRACT

Purpose of this paper
Irrespective of significant relevance of construction industry to economic growth of developed and developing nations, labour efficiency in the construction industry remains relatively low to manufacturing industries. This paper aims at exploring adverse construction related factors contributing to the shortfall of construction labour efficiency in Western Cape Province, South Africa.

Design/methodology/approach
The study adopts quantitative research approach; administering closed ended questionnaires to construction professionals in Western Cape Province. Statistical Package for Social Sciences (Version 22) was used to analyse the data obtained.

Findings
Supervision delay by supervisors, communication ability of site managers, level of literacy of site managers, site manager’s coordinating skills and communication barrier between supervisors and construction labour are found as the predominant construction related factors affecting the efficiency of construction labour.
Research limitations/implications
This study is basically restricted to contractor, site supervisors and site managers’ related factors affecting the efficiency of construction labour in Western Cape Province.

Practical implications
Adequate application of findings presented in this study will significantly reduce the current prevalent construction time and cost overruns through an improved construction workforce performance.

Original/value of paper
Enhanced construction productivity is a product of construction labour efficiency that ensures achievement of construction project objectives and heightens contribution to national economic development.

Keywords: Construction productivity, Developing nations, Labour efficiency, National economic development, Project objectives.

1.0 INTRODUCTION
Irrespective of significant relevance of construction industry to economic growth of developed and developing nations, labour efficiency in the construction industry remains relatively low to manufacturing industries. Construction process requires the inputs of different construction participants (professionals and non-professionals). The quality of the inputs significantly determines the delivery outcome of construction projects. So far, substantial numbers of research conducted on construction workers productivity has made no exception of any construction participants being free from contributing to construction workforce efficiency challenges. Though, several groups and numbers of construction participants contribute to construction labour ineffectiveness, however, this study is limited to contractors, site supervisors and site managers’ related factors. Thus, the study explores construction related factors that adversely affect construction workers efficiencies and subsequently rank the factors to prioritize the severity of the factors.

2.0 CONSTRUCTION CONTRACTORS, CONTRACT SYSTEMS AND LABOUR EFFICIENCY DURING PRODUCTION PROCESSES
The term building construction contractor originates as a legal agreement between client and builder, based on contract negotiated and agreed to be
executed on specific conditions (Knutson, Schexnayder, Fiori, & Mayo 2009). Noteworthy, contractor's roles and responsibilities is significant in adequate management of construction workforce and the resources available in the construction industry to enhance efficient delivery of construction projects. As emphasised by Haseeb, Lu, Bibi, Dyian & Rabbani (2011), delay and loss of construction productivity could exhibit contractor's inefficiency, incapability and/or inability to effectively utilize the viable construction human resource (workforce). As construction contractors are involved in construction project to enhance a successful delivery of construction project and stakeholders’ objectives during production processes, thus, the contractors’ workforce efficient management is paramount. To achieve an improved performance of construction human capital, the contractor is required to effectively implement management knowledge areas, principles and practices during the production processes, (APM, 2006; PMBOK, 2005). As a result, a well-planned, effectively monitored and controlled project result to successful delivery of any contract and determines the pinnacle of contractor's profit realisation, (Harris and McCaffer, 2001). Therefore appropriate selection of contractors is principal for client and client’s professionals during contract procurement process, (Palaneeswaran & Kumaraswamy, 2001). Synonymously, the simply consideration of construction cost without adequate consideration of the contractor's and the workforce potentials habitualy affect quality of construction project delivery. Hence, Wong (2004) and Fapohunda & Omoniyi (2011) suggested that, adequate efforts should be made at conception stage of a construction to ensure the contractor are potentiality, selected to engage qualified contractor; and prevent poor performance and inability to deliver the project successfully. In addition, the contractors are significantly responsible to effectively deliver construction projects to stakeholders' satisfaction by efficiently manage construction resources (workforce, materials and machinery), construction constrains (cost, time and quality) and the probable sub-contractors and suppliers (Mincks & Johnston, 2011; Fapohunda, et al., 2007). Baloyi and Bekker (2011) emphasised that the fundamental factors that adversely affect projects delivery, cost and time through contractors are shortage of skill workers, poor resources planning, poor performance of sub-contractors, inefficient site management and poor labour productivity. Besides Baloyi and Bekker (2011) standpoints, Assaf and Al-Hejji (2006) noted ineffective planning and scheduling, shortage of construction workforce and difficulty in adequate finance by contractors as additional factors that adversely affect contractors and perpetuate workers inefficiency during production processes. Other main factor that affects construction product delivery and workers efficiency in the construction industry are types of contract systems employed

Based on a single system of contract, construction clients award the execution of the entire project to a single prime or general contractor. Thus, the specific general contractor employs different professionals, groups and
resources inputs for the project execution in compliance with contract documents. Hence, contractor is completely responsible to the client in single system of contract. However, in a separate system of contract, several independent contractors work on the project without being under a single coordinated system. Each prime contractor is responsible for the allocated section of work, and directly responsible to the client, (Sears, Sears, & Clouch, 2008). During construction project execution, a separate system of contract enables individual contractor to plan, coordinate and control workforce and other construction resources, in addition to progress monitoring and proactive plan of the construction processes (Harris & McCaffer, 2001) towards achieving an improved workers performance and satisfactory construction products.

General contractors often employ specialty or sub-contractor to accomplish specific sections of construction phase such as; plumbing, electrical work, earthmoving etc. Knutson et al. (2009) stated that specialty contractor on a project could be more than twenty and consequently represent the largest portion on construction projects. However, a specialty contractor employed by the client to carry out a project might employ a general contractor who executes some portions of the project. In respect, the specialty contractor becomes the general contractor while the general contractor becomes the sub-contractor on the particular project (Nunnally, 2011). Hence, in this contractual system, the specialty contractor is responsible to the client for project completion within specified time, budgeted cost and expected quality. Considering the impact of construction sub-contracted work on construction workforce productivity, Egbu, Ellis and Gorse (2004) claimed that contractors only have a direct influence over labour employed by contractor. Egbu, Ellis & Gorse (2004), further noted that sub-contractors could pose unfavourable different challenges on overall construction productivity. Hence, construction contractor can make a substantial effort to afford a favourable working condition for the sub-contractor. Although, contractor’s effort may not improve construction productivity unless sub-contractors own management makes supportive efforts.

3.0 RESEARCH METHOD, PRESENTATION OF FINDINGS AND DISCUSSION OF RESULTS

3.1 Research Method
The study adopts questionnaire survey, designed to elicit the perceptions of construction professionals on site supervision, site management and contractors related factors that largely affect the efficiency of construction workers. The study identified and investigated eleven contractor’s related factors, ten site supervisor’s related factors and nine site manager’s related
factors. Due to vast growth of construction activities in Western Cape Province, the study was undertaken in Western Cape Province, South Africa. The questionnaire was designed as closed ended questions, and adopts level of agreement with five point scale. Research questionnaire was administered to respondents by both hand delivery and survey monkey approaches. The study respondents are required to indicate the level of agreement on each of the identified thirty factors affecting the performance of construction workers. The questionnaire was piloted among population of construction professionals to ensure validity of research instrument, while cronbach's alpha reliability test was adopted to ensure reliability of research (Table 1). A total number of two hundred and forty five questionnaires were administered. Sixty-two (25.3 %) questionnaires were retrieved and analysed with Statistical Package for the Social Sciences (SPSS) version 22. Data for the study was gathered from professionals in the South African construction industry that include architect, quantity surveyor, project manager, contract manager and site manager.

3.2 Presentation of Findings and Discussion of Results

Majority of survey respondents (87.1 %) work with contractor's firm, 3.2 % work with architectural firm, 8.1 % with project management firm and 1.6 % work with quantity surveying consultant firm. The study respondents are male dominant with 82.3 % male and 17.7 % female.

21 % of survey participants are below 26 years of age, 50 % are between 26 and 35 years of age while 29 % are 36 years and older.

48.8 % respondents have one to five years working experience in the construction industry, 22.6 % have six to ten years construction working experience and 30.6 % respondents have eleven to forty years experience.

6.5 % respondents are architect, 12.9 % are quantity surveyors, 17.7 % are site managers, 21 % are project managers, 11.3 % are contract manager and 30.6 % are site managers. Majority of survey respondents (72.6 %) have been working in this position between one to five years while 27.4 % between six to forty years.

Table 1: Reliability of the research

<table>
<thead>
<tr>
<th>Factors</th>
<th>Group of factors</th>
<th>Number of items</th>
<th>Cumulative</th>
<th>Cronbach's alpha coefficient values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Contractors’ factors</td>
<td>11</td>
<td>11</td>
<td>0.78</td>
<td></td>
</tr>
</tbody>
</table>
The Cronbach's alpha coefficient using Statistical Package for Social Sciences software (version 22) was used to ascertain the reliability of research. Table 1 presents the summary of reliability tests conducted on scale questions. The results of the Cronbach's alpha co-efficient tests are found satisfactory in term of the requirements of reliability test, (>0.5).

Table 2 presents the findings of factors affecting construction labour efficiency in Western Cape Province. Supervision delay by trade supervisors with a mean value of 4.80 emerges the most severe factor affecting the efficiency of construction labour in Western Cape construction sites (Table 2).

Table 2: Factors affecting construction labour efficiency

<table>
<thead>
<tr>
<th>Site supervisors’ factors</th>
<th>10</th>
<th>21</th>
<th>0.86</th>
</tr>
</thead>
<tbody>
<tr>
<td>Site managers’ factors</td>
<td>9</td>
<td>30</td>
<td>0.89</td>
</tr>
</tbody>
</table>

Table 2: Factors affecting construction labour efficiency
Serpell and Ferrada, (2007) noted that training of site supervisor's is capable of improving supervisors supervisory responsibilities on construction sites. Communication ability of site manager is noted the second most significant factor affecting construction labour performance on Western Cape construction sites. Literacy level of site manager is identified as notable and significant factors affecting the efficiency of construction labour on Western Cape construction sites, while site planning ability of contractor is identified as the sixteenth factor impinging on the efficiency of construction labour. Rework due to construction error, inadequate co-ordinating ability of workforce and site manager's coordinating skills emerge the twenty-first, twentieth and forth factors affecting construction labour efficiency in Western Cape construction sites respectively (Table 2). Fraser (2000) noted that

<table>
<thead>
<tr>
<th>WESTERN CAPE CONSTRUCTION SITES</th>
<th>Mean</th>
<th>Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supervision delay by supervisors</td>
<td>4.80</td>
<td>1</td>
</tr>
<tr>
<td>Communication ability of site managers</td>
<td>4.47</td>
<td>2</td>
</tr>
<tr>
<td>Level of literacy of site managers</td>
<td>4.40</td>
<td>3</td>
</tr>
<tr>
<td>Site manager's coordinating skills</td>
<td>4.36</td>
<td>4</td>
</tr>
<tr>
<td>Communication barrier between supervisors and construction labour</td>
<td>4.31</td>
<td>5</td>
</tr>
<tr>
<td>Planning ability of site managers</td>
<td>4.31</td>
<td>5</td>
</tr>
<tr>
<td>Construction skill of trade supervisors</td>
<td>4.31</td>
<td>5</td>
</tr>
<tr>
<td>Technical skill of site managers</td>
<td>4.27</td>
<td>8</td>
</tr>
<tr>
<td>Decisions of site managers</td>
<td>4.27</td>
<td>8</td>
</tr>
<tr>
<td>Inadequate instructions from trade supervisors to labourers</td>
<td>4.27</td>
<td>8</td>
</tr>
<tr>
<td>Level of coordination of workers by trade supervisors</td>
<td>4.22</td>
<td>11</td>
</tr>
<tr>
<td>Recruitment of competent supervisors</td>
<td>4.22</td>
<td>11</td>
</tr>
<tr>
<td>Site managers relationship with project team</td>
<td>4.22</td>
<td>11</td>
</tr>
<tr>
<td>Contractors construction experience</td>
<td>4.22</td>
<td>11</td>
</tr>
<tr>
<td>Relationship between supervisors of different trades on site</td>
<td>4.20</td>
<td>15</td>
</tr>
<tr>
<td>Administrative experience of site managers</td>
<td>4.18</td>
<td>16</td>
</tr>
<tr>
<td>Inadequate instructions of site managers</td>
<td>4.18</td>
<td>16</td>
</tr>
<tr>
<td>Site planning ability of contractor</td>
<td>4.18</td>
<td>16</td>
</tr>
<tr>
<td>Relationship with sub-contractors</td>
<td>4.16</td>
<td>19</td>
</tr>
<tr>
<td>Inadequate co-ordinating ability of workforce</td>
<td>4.13</td>
<td>20</td>
</tr>
<tr>
<td>Rework due to construction error</td>
<td>4.07</td>
<td>21</td>
</tr>
<tr>
<td>Site supervisors absenteeism</td>
<td>4.07</td>
<td>21</td>
</tr>
<tr>
<td>Construction method adopted</td>
<td>4.02</td>
<td>23</td>
</tr>
<tr>
<td>Contractors delay of instruction to employee</td>
<td>3.98</td>
<td>24</td>
</tr>
<tr>
<td>Rework due to unclear instruction from supervisor</td>
<td>3.96</td>
<td>25</td>
</tr>
<tr>
<td>Inadequate facilities for construction workers</td>
<td>3.87</td>
<td>26</td>
</tr>
<tr>
<td>Access to construction sites</td>
<td>3.82</td>
<td>27</td>
</tr>
<tr>
<td>Poor relationship of supervisor with employer</td>
<td>3.82</td>
<td>27</td>
</tr>
<tr>
<td>Corruption and construction ethics</td>
<td>3.80</td>
<td>28</td>
</tr>
<tr>
<td>Profit intention of contractors</td>
<td>3.78</td>
<td>30</td>
</tr>
</tbody>
</table>
construction organizations should consider training and professional development of construction site managers for performance improvement. Communication barrier between supervisors and construction labour, planning ability of site manager, and construction skill of trade supervisors have the same impact on construction workers efficiency in Western Cape Province with the mean value of (4.31). This indicates a significant contribution of construction managers and site supervisors to poor performance of construction workers on Western Cape construction sites. Kines et al. (2010) contended that there is a regular communication between supervisors and workers on construction projects but emphasized the need to improve the effectiveness of site communication. Technical skill of site managers, decision of site manager and inadequate instructions from trade supervisors to labourers are ranked the eighth factors with the same level of impact on labour efficiency on construction sites. Considering the least factors with minimum impact on the performance of construction workers, inadequate facilities for construction workers, access to construction sites, poor relationship of supervisor with employer, contractor's financial problem and profit intention of contractors is perceived by respondents as the least factors affecting the performance of construction employee on the Western Cape construction sites.

Conclusions and Recommendation

From Table 2, it is evident that all the factors investigated significantly affect the efficiency of the workforce. However, supervision delay by supervisors, communication ability of site managers, literacy of site managers, site manager's coordinating skill, communication barrier between supervisors and construction labour, planning ability of site managers and construction skill of trade supervisors are the most critical factors affecting the efficiency of construction labour on Western Cape construction sites. Thus, reference to the critical factors affecting construction labour efficiency, the success of construction projects significantly hinges on the effectiveness of construction site managers and individual site supervisors. Fraser, (2000) suggested that construction organisations should consider training and professional development for performance improvement. Adequate training will enhance construction managers and site supervisors’ performance to ensure successful delivery of construction projects. Besides, communication issue on site is paramount subject to be addressed to enhance workers’ performance. Ability of site managers and site supervisors to effectively communicate project objectives to project team and effectively coordinate construction labour extends beyond working experience in the construction industry. Hence, construction site managers and site supervisors are
required to integrate practical knowledge acquired in the industry and management skills to effectively communicate project objectives to project team. To strengthen effective communication dissemination, skills and ability in the construction industry, consistent management trainings that include (communication, skill development and site coordination) are necessity on construction projects. Adequate application of the recommendation presented in this study will infallibly improve the efficiency of construction workers in Western Cape Province, reduce current prevalent construction time and cost overruns and ultimately increase stakeholders’ satisfaction in the construction sector.

References


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